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STUDIES IN CURRENCY SUBSTITUTION AND EXCHANGE RATE DETERMINATION

—THE CASE OF SOUTH KOREA AND TAIWAN—

By

Tzung-Ta Yen

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ABSTRACT

STUDIES IN CURRENCY SUBSTITUTION AND EXCHANGE RATE DETERMINATION
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Currency substitution refers to the fact that people demand foreign currency for different purposes. The essential insight of the currency substitution perspective is that financial developments abroad affect the domestic demand for money and thus affect its exchange rate.

The main purpose of this thesis is to study currency substitution and exchange rate determination. The first objective is to propose a quadratic function to test currency substitution. The second objective is to determine whether the noncirculation of foreign currency completely prevent currency substitution. A third objective is to investigate how financial dualism affects the empirical results of the test for currency substitution. Our final objective is to study exchange rate determinations based on the currency substitution model and to test the efficiency of foreign exchange markets in response to new information.

We apply the production function approach to currency substitution and derive the conditional money demand function based on the cost-minimization model. The estimation results for Korea and Taiwan during fixed exchange rate regimes show that banking regulations preventing the circulation of foreign currency have dampened currency substitution in both countries. However, when we including financial dualism in estimating the demand for money yields different policy implications

from the previous case, we find that banking regulation preventing the circulation of foreign currency is not a precondition for the existence of currency substitution.

The currency substitution version of exchange rate determination is set out in this thesis. Under rational expectations individuals efficiently use the information they have in forming these expectations, and the foreign exchange market is efficient. The study of the Granger causality in the efficient foreign exchange market implies either that the money supply does not cause exchange rate movements or that a contemporaneous relationship exist between them. Except for Taiwan's M1, the foreign exchange markets in both Korea and Taiwan efficiently absorb new information about unanticipated changes in the money supplies during flexible exchange rates.

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CHAPTER ONE

INTRODUCTION

During the last two decades several approaches have been developed in order to understand exchange rate movements. The Keynesian flow approach emphasizes equilibrium conditions in foreign exchange markets for flow of funds as opposed to equilibrium in the markets for stocks of assets. The monetary approach, with the assumption of perfect substitutes of assets and perfect capital mobility, stresses the role of the money market, purchasing power parity, and interest rate parity relations. The portfolio balance approach focuses on imperfect asset substitutability and implies that the exchange rate is determined by the condition that all asset markets clear, given the stock of wealth. Both the monetary and portfolio approach presume that the exchange rate is determined in the same manner as other asset prices. All these approaches, however, assume that people hold only domestic currency in their portfolios.

In recent years much attention has been paid to the theory of currency substitution, which examines the influence of foreign exchange considerations on the domestic money demand. Intuitively, since monies are assets, the decision to hold them depends on current relative costs (both domestic and foreign interest rates) and relative expected holding costs (expected exchange rates). People face a choice not only between domestic money and domestic bonds but also between foreign currency and domestic currency. So, in the presence of currency

substitution, financial developments abroad could influence domestic monetary policy through shifting money demand.

1.1 Statement of the Problem and Objectives

Since the late 1970s, many issues have been examined in the context of currency substitution, including the problems of economic autonomy, the instability of the demand for money, and exchange rate determination. The essential insight of the currency substitution perspective is that changes in either expected exchange rates or foreign interest rates affect the domestic demand for money and thus affect its exchange rate.

Several studies have applied the production function approach to currency substitution. This approach assumes that individuals choose the levels of foreign and domestic money that minimize the borrowing costs associated with a given level of monetary services. The CES function, assuming the cross-term between money inputs to be zero, has been applied to measure the elasticity of currency substitution.

Most empirical research has focused on the case of industrial countries, where currency substitution is mostly dominated by bond substitution or capital mobility. In contrast, few studies have dealt with developing countries, where the lack of a well-developed capital market limits the options for holding wealth to durable goods and to domestic and foreign money. Currency substitution is likely to operate especially in financially repressed economies, where foreign currency may be regarded as a readily obtainable foreign assets and is likely to become an important component of domestic portfolios.

In addition to the phenomenon of currency substitution, the financial system in developing countries is characterized by a dual

structure which consists of the official banking system and the unorganized money markets. Proponents of currency substitution have given no consideration to the influence of financial dualism in modeling money demand for developing countries. However, changes in interest rates in unorganized markets influence the cost of holding currencies and thus will influence domestic residents' choices through essentially the same mechanism that transmits changes in the quantity of domestic money to the economy.

Since the early 1970s, with its assumptions of a stable money demand function, purchasing power parity, uncovered interest-rate parity, and nonsubstitution between moneies, the monetary approach has added to our understanding of exchange rate movements. However, the lack of a well-developed capital market and the existence of capital controls in developing countries are incompatible with the assumptions made by monetary approach. Currency substitution models, which extend the standard monetary approach by allowing residents to hold both domestic and foreign currencies and which do not make strong assumptions, provide a theory of exchange rate determination.

The main purpose of this thesis is to develop a model to study currency substitution and exchange rate determination. The first objective is to propose a quadratic function to test currency substitution that includes the cross-effect between money inputs. The second objective is to determine whether the noncirculation of foreign currency and the presence of capital controls completely prevent currency substitution. The experiences of Korea and Taiwan are of interest because their banking structures have not allowed for the circulation of foreign currency and they have imposed capital controls

on foreign exchange. These economies might provide some evidence as to whether regulatory constraints are necessary preconditions for currency substitution. A third objective is to investigate how financial dualism affects the empirical results of the test for currency substitution. The intent is to incorporate both phenomena into a unified explanation of money demand behavior in developing countries. Our final objective is to study exchange rate determinations based on the currency substitution model and to test the efficiency of foreign exchange markets in response to new information.

1.2 Scope and Methodology

This thesis provides both a theoretical analysis and empirical evidences of currency substitution and exchange rate determination. It uses as case studies Korea and Taiwan, which no research to date has examined in the light of our stated objectives.

In chapter II, the literature review, we introduce several approaches and show how currency substitution can be incorporated into economic analysis. We argue that currency substitution offers new insights to monetary policy and the demand for money, exchange rate determination, and stabilization policy. After summarizing the empirical evidence, we point out some shortcomings in the literature and discuss why our work seeks to reexamine currency substitution.

In chapter III, currency substitution, financial dualism, and the demand for money are examined. Instead of the C.E.S. function, we apply a quadratic function to estimate the elasticity of substitution. We apply the production function approach to minimizing the cost of holding a bundle of domestic and foreign currencies, subject to a given level of money services. Finally, to take both currency substitution

and financial dualism into consideration, we provide an analysis of money demand for developing countries. In the last section of chapter III, we estimate the value of the parameters of the model and the elasticity of currency substitution.

Chapter IV investigates exchange rate determination, efficiency, and causality. The model of exchange rate set out in this chapter is broadly based on the "currency substitution" version of recently developed asset market view of exchange rate determination. Under rational expectations, individuals use efficiently the information they have in forming these expectations, the foreign exchange market is efficient. The cross-correlation approach is applied to identify the Granger causality in the efficient foreign exchange market.

Chapter V presents a summary and offers conclusions.

Four appendices also are included. Appendix A discusses the properties of a quadratic function and presents mathematics related to cost-minimization behavior. Appendix B provides both a theoretical and empirical results on financial dualism in Korea and Taiwan. Appendix C shows a currency substitution model of exchange rate determination. Appendix D provides the data sources for the study.

CHAPTER TWO

REVIEW OF THE CURRENCY SUBSTITUTION LITERATURE

2.1 Introduction

Currency substitution refers to the fact that people may demand foreign currency for different purposes: to minimize transaction costs, to reduce exchange risk, and to obtain a more secure store of value.^[1] Proponents of this idea argue that it is not necessary for all individuals in an economy to hold more than one currency, but we can find certain subgroups with strong motives for holding foreign monies. Examples are importers, exporters, multinational corporations, frequent travelers, and border area residents.

The presence of foreign money within the domestic economy raises several issues of theoretical and empirical importance.^[2] In macroeconomic theory, for example, currency substitution may make the demand for money unstable or impede the implementation of stabilization policy. From an empirical standpoint, currency substitution raises such issues as the size of currency substitution elasticity and the movements in the income velocities of money.

The purpose of this chapter is to review the theoretical and empirical literature on currency substitution. Section 2.2 introduces several approaches to currency substitution that provide a basic framework to understand currency substitution. Section 2.3 examines the implications of currency substitution for monetary policy and the demand for money, exchange rate determination, and stabilization

policy. The discussion proceeds by examining, in section 2.4., empirical studies of currency substitution in both industrial and developing countries. In Section 2.5, the chapter concludes with a discussion of drawbacks in the literature and the need to reexamine currency substitution in this thesis.

2.2 Currency Substitution Models

Five different approaches are developed in the currency substitution literature. Each provides a framework for incorporating currency substitution into economic analysis. These approaches are discussed below.

2.2.1 The Production Function Approach

The production function approach regards domestic and foreign currency as two inputs to produce monetary services. Several economists follow this approach in studying currency substitution. In comparing fixed and flexible exchange rates, Chen (1973) challenges the monetarists' argument that flexible exchange rates guarantee monetary independence. Because of currency substitution on the demand side, flexible exchange rates may no longer provide a cushion against foreign shocks. However, the production function in Chen's model is of Cobb-Douglas form, which constrains the elasticity of currency substitution to unity.

Miles (1978, 1981) considers the problem of currency substitution, flexible exchange rates, and monetary independence. He criticizes Chen's model on the ground that the elasticity of currency substitution is an empirical question rather than a given. Instead, he sets a CES production function of money services as follows:

$$(2.1) \quad m_s = [\alpha m_d^{-\delta} + (1-\alpha) m_f^{-\delta}]^{-(1/\delta)},$$

where m_s - level of money services,

m_d, m_f - the holdings of real domestic and foreign
balances, respectively, and

α_1, α_2 - weights reflecting the efficiency of domestic
and foreign real balances in producing money services.

This production function directly relates the level of real balances to the level of monetary services. The asset constraint shows that M_o is the total of money assets that must be held to provide the money services of foreign and domestic currency. That is:

$$(2.2) \quad (M_o/P_d) = (M_d/P_d)(1+i_d) + (M_f/P_f)(1+i_f),$$

where M_d, M_f - the nominal quantity of domestic and foreign currency,
and P_d, P_f - the price of goods in terms of domestic and foreign
currency, respectively.

Maximizing the production function subject to the asset constraint provides the following first-order conditions:

$$(2.3) \quad \partial M_s / \partial M_d = \lambda(1+i_d);$$

$$(2.4) \quad \partial M_s / \partial M_f = \lambda(1+i_f);$$

$$(2.5) \quad \partial M_o / \partial r = M_d(1+i_d) + (1+i_f)eM_f,$$

where λ is the Lagrangian multiplier.

Dividing (2.3) by (2.4) and taking the logarithm of both sides, we have the following equation:

$$(2.6) \quad \ln(M_d/eM_f) = \sigma \ln [\alpha/(1-\alpha)] + \sigma \ln [(1+i_f)/(1+i_d)],$$

where $\sigma = 1/(1+\delta)$ is the elasticity of substitution between foreign and domestic currency and $e = P_d/P_f$.

Following this approach, Husted (1980) focuses on the transaction demand for foreign and domestic balances. He also introduces a speculative component into the model which allows for additional

holdings of foreign currency with a change in the expected rate of depreciation in the exchange rate. Miles and Stewart (1981) extend the model to include uncertainty of return and the effects of exchange rate risk.

To estimate the elasticity of currency substitution, all of these authors apply a procedure similar to the one employed by Chetty (1968) for measuring the nearness of near-monies. They estimate the optimal ratio of holding domestic to foreign currency as determined by equation (2.3) and (2.4). However, the problem with Chetty's procedure is that equation (2.6) does not consider the budget constraint, equation (2.2), and thus monetary services do not appear as an exogenous variable.^[3] From an econometric point of view, they do not simultaneously estimate the system of equations, and there is possible contemporaneous correlation among the residuals in the equations. These problems were not recognized in the papers just cited but were dealt with by Donovan (1978) and Marquez (1987).

Marquez sets his model as follows:^[4]

$$(2.7) \quad \text{Min.} \quad (1+i_d)(M_d/P_d) + [(1+i_f)/(1+x)] (M_f/P_f);$$

$$(2.8) \quad \text{s.t.} \quad M_s = [\alpha(M_d/P_d)^{-\delta} + (1-\alpha)(M_f/P_f)^{-\delta}]^{(-1/\delta)}.$$

where x is the expected depreciation of the exchange rate.

With the assumption of purchasing power parity and simultaneously solving all three first-order conditions, Marquez derives the conditional demand for domestic currency, that is :

$$(2.9) \quad M_d = (1 + [(1-\alpha)/\alpha]^\sigma [(1+i_d)(1+x)/(1+i_f)]^{\sigma-1})^{(\sigma/1-\sigma)} \alpha^{(\sigma/1-\sigma)} M_s,$$

In order to solve the unobservable variable M_s , money services or nominal (aggregate) level of money holdings, he assumes there exists a behavioral relationship between the unobservable variable (money

services) and an observable variable (nominal income).^[5] The demand for domestic money is expressed not only as a function of domestic interest rate and income but also as a function of foreign interest rates and the expected exchange rate.

2.2.2 The Portfolio Balance Approach

The portfolio-balance approach justification for currency substitution reasons that when the domestic inflation rate is expected to rise or the exchange rate is expected to depreciate, individuals will avoid the domestic currency and prefer foreign currency. The existence of currency substitution implies that foreign currency may serve as a store of value for domestic wealth.

Girton and Roper (1981) develop a model that contains two money demand functions (defined by currency, not by country) with exogenous money supplies and nonmonetary assets. The model can be expressed as follows:

$$(2.10) \quad M_1/P_1 = \theta_1(w) \exp[a_1(i_1 - i) + \sigma_1(i_1 - i_2)] \quad a_1, \sigma_1 > 0,$$

$$(2.11) \quad M_2/P_2 = \theta_2(w) \exp[a_2(i_2 - i) + \sigma_2(i_2 - i_1)] \quad a_2, \sigma_2 > 0.$$

where M_1, M_2 - the nominal quantity of currencies one and two,

P_1, P_2 - the price of goods in terms of monies one and two,

i_1, i_2 - the anticipated real returns on monies one and two,

i - the anticipated real return on the nonmonetary asset,

a_1 - the coefficient of substitution between money one and the nonmonetary asset,

σ - the coefficient of substitution between monies one and two,

w - real wealth.

They assume that coefficients of interest rates and substitution between two currencies are equal, that is, $a_1 = a_2 = a, \sigma_1 = \sigma_2 = \sigma$.

The exchange rate between the two monies then can be expressed in logarithmic form:

$$(2.12) \quad \ln e = \ln [(M_1/\theta_1)/(M_2/\theta_2)] - a(i_1 - i_2) - 2\sigma(i_1 - i_2),$$

where e is the exchange rate, $e = P_d/P_f$.

This equation reveals two implications for exchange rate determination. First, currency substitution will cause exchange rate instability. The greater the degree of currency substitution (the larger the value of σ), the larger will be the changes in exchange rates. Second, perfect currency substitution implies that the exchange rate is indeterminate.

Following this approach, Cuddington (1983) criticizes the empirical results of the existing literature for failing to distinguish the effect of changes in the net return of foreign bonds (which reflect the presence of capital mobility) from changes in the return on foreign money (which is the currency substitution per se). He proposes to estimate the following equation:

$$(2.13) \quad \ln (M_d/P_d) = g_0 + g_1 \ln y + g_2 i_d + g_3 (i_f + x) + g_4 x,$$

where M_d = the nominal quantity of domestic money,

P_d = the price of goods in terms of domestic currency,

y = the domestic income,

i_d = the domestic interest rate,

x = the expected rate of depreciation of the domestic currency.

According to (2.13), coefficients g_3 and g_4 are additions to the traditional standard money demand function. g_3 reflects a capital mobility coefficient because $i_f + x$ is interpreted as the opportunity cost of holding domestic currency balances rather than foreign bonds, while g_4 is regarded as the opportunity cost of holding domestic rather

than foreign cash balances.

In the presence of currency substitution, g_4 must be a statistically significant negative coefficient. If domestic and foreign bonds are perfect substitutes, g_3 can be set equal to zero and still identify currency substitution with g_4 ; the domestic interest rate will now capture the capital mobility effect.

In contrast, if domestic and foreign bonds are not perfect substitutes but it is assumed that g_3 equals zero, then g_4 indirectly shows evidence of currency substitution because at the same time it is capturing the effect of the change on the bond yield. The reason is that either currency substitution or the capital mobility effect would cause changes in the expected exchange rate to enter with a significant negative effect into a money demand equation's other explanatory variables.^[6]

The portfolio approach usually applies the reduced form as an estimation equation for testing currency substitution.^[7] Cuddington (1983), Batten and Hafer (1984), and Fasano-Filho (1985) directly examine how the domestic money demand is affected by currency substitution, whereas Ortiz (1983) and Ramirez-Rojas (1985) focus on the ratio of foreign currency deposits in the domestic financial system to domestic money supply and how that ratio is affected by the expected change in the exchange rate. However, a shortcoming with the statistical data is that it is not always possible to identify whether the foreign currency deposits are held by foreigners or by domestic residents.

2.2.3 The Utility Maximization Approach

Several economists, including Liviatan (1981), Bordo and Choudhri

(1982), Kim (1985), and Calvo (1985), examine the currency substitution problem within the framework of utility maximization. In this approach, they assume that money yields a flow of nonobservable services that enter into individual utility functions. The services flow is assumed to be derived from the observable stock of real cash balances, and individuals maximize utility subject to a budget constraint. The resulting demand function for real cash balances thus depends upon real income and the prices of substitutes and complements.

Liviatan (1981) includes the liquidity services provided by holding currencies in the utility function to account for differential demand for domestic and foreign currency. He assumes that the consumer maximizes the instantaneous utility function, separable in consumption of ordinary commodities and liquidity services, subject to the asset constraint. One of his findings is that an increase in the rate of monetary expansion has the effect of creating a real appreciation of the exchange rate and a deterioration in the balance of payments.

Bordo and Choudhri (1982) assume that the domestic and foreign currency (m_d and m_f), along with goods (g), enter a utility function. That is:⁽⁸⁾

$$(2.14) \quad U = f(m_d, m_f, g).$$

Under the assumptions that all income is spent in each period and that there is a perfect interest rate arbitrage, the budget constraint can be expressed as follows:

$$(2.15) \quad y = g + i_d m_d + i_f m_f,$$

Based on an optimization process, the demand for domestic and foreign money can be derived as a function of income (y), domestic interest rate (i_d), and foreign interest rate (i_f). The money demand

functions then are specified as follows:^[9]

$$(2.16) \quad \ln m_d = \beta_0 + \beta_1 \ln y + \beta_2 i_d + \beta_3 i_f ;$$

$$(2.17) \quad \ln m_f = \pi_0 + \pi_1 \ln y + \pi_2 i_d + \pi_3 i_f .$$

If there is no currency substitution, the term β_3 and π_2 (representing cross-substitution effects) in equation (2.16) and (2.17) are equal to zero.^[10]

Following this approach, Calvo (1985) employs the same utility function as Liviatan. Calvo points out that Liviatan's result is based on the assumption that the two currencies are "cooperant" factors in the utility function.^[11] But Calvo argues that the "cooperancy" assumption is not sufficient to obtain Liviatan's results. Calvo concludes that increasing the rate of expansion of money supply will cause the real exchange rate devaluation that depends crucially on the elasticity of substitution between consumption and liquidity services and between the two currencies in the "production of liquidity."

Kim (1985) examines the labor-supply decisions of workers when they can diversify their portfolio in home and foreign currencies. Under a specific utility function Kim shows that the workers' output is an increasing function of the weighted average rate of return on two currencies, and maximizing the workers' expected utility is equivalent to maximizing the workers' output function. The existence of substitutable assets resulted in a close interaction between portfolio management and labor-supply decisions. Kim concludes that, under floating rates, risk-averse workers enhance their welfare through currency substitution. The expected depreciation of the exchange rates and the expected domestic inflation rate affect the intemporal terms of trade. These in turn influence the level of total production.

2.2.4. Over-lapping Generations Approach^[12]

A few economists adopt an over-lapping generation model to understand how the currency substitution phenomenon affects exchange rates. Kareken and Wallace (1981) argue that the laissez-faire regime - that is, free trade in goods, unrestricted portfolio choice (or no capital controls), and floating or market-determined exchange rates- is not economically feasible and that equilibrium exchange rates are indeterminate. As noted, Kareken and Wallace believe money demand is derived in an environment where there is no reason for the private sector to discriminate between monies, and as a result the currencies are perfect substitutes. The virtue of their analysis is that it avoids having to postulate the behavioral rules of economic agents; those rules, including asset demand functions, are derived from optimizing behavior. Then, as long as currencies are perfect substitutes, the exchange rate must be invariant over time.

By adopting this approach, Lapan and Enders (1983) employ the intergenerational model to derive the demands for domestic and foreign currencies from microeconomic optimizing behavior. In the absence of government policy, they obtain the Kareken and Wallace result that exchange rates are indeterminate. They discuss why nations may find it in their interest to impose capital controls and consider the situation in which governments may randomly impose such controls. They also provide insight into the underlying determinants of currency substitution and into the relationship between the degree of currency substitution and the determinants of the exchange rate. Finally, they show that any government action which causes individuals to discriminate between currencies will entail a modification of the

Kareken and Wallace results. This approach provides a framework for understanding why governments usually need to impose capital controls when there is currency substitution.

2.2.5. Summary

The production function approach, which regards domestic and foreign monies as inputs to the production of money services, extends the domestic near-money literature to foreign currency. The portfolio approach views domestic and foreign moneies as one aspect of portfolio selection, and the demand for foreign currency as similar to the demand for domestic currency. This approach sees the demand for money as a direct extension of the conventional theory of demand for any durable good. The resulting demand function for real cash balances thus depends upon real income and the prices of substitutes and complements. The utility maximization approach assumes that the domestic and foreign money, along with goods, enter a utility function to generate liquidity services. Finally, the overlapping generation model always assumes that the two currencies serve only as a store of value; it derives currency demand in an environment where there is no reason for the private sector to discriminate between monies. Thus, no country-specific money demand functions are postulated.

Many researchers question the measurement of the degree of currency substitutability. Measurements have been attempted in two different models. The production function approach has attempted to estimate the elasticity of substitution between domestic and foreign money by estimating directly the parameters of the production function; Hicks-Allen partial elasticities have been cited as evidence of the substitutability between currencies. In contrast, the cross-elasticity

estimates have been derived from the portfolio approach,^[13] which examines the estimated interest cross-elasticity, derived from the regression coefficients of the money demand function, as a measure of the degree of substitutability of currencies.

However, the elasticities of substitution are not directly comparable to cross-elasticities.^[14] Marquez (1987) argues that the cross-partial elasticities of reduced-form money demand specifications do not always permit identification of the extent to which currency substitution occurs. Therefore, it is possible to accept the null hypothesis of no substitution when it is false. In order to avoid this identification problem, the production function approach provides an estimation based on the solution to an optimization problem. The portfolio approach usually applies the resultant reduced form equation as an estimation for testing currency substitution. However, the highly collinear nature of the rate-of-return variables makes it difficult to isolate individual effects.

In addition, the production function approach to currency substitution relates the level of real balances directly to the level of monetary services. Since foreign and domestic currency interact only through a real rather than through a financial channel, production function models, as Thomas (1985) has claimed, are likely to represent the phenomenon of currency substitution. In the next chapter, currency substitution will be modeled using the production function approach.

2.3 The Implications of Currency Substitution

Studies in currency substitution have added new insights to macroeconomics, including the instability of the demand for money, monetary autonomy and stabilization policy, exchange rate

determination, and other issues. These implications are discussed below.

2.3.1 The Instability of the Demand for Money

Traditionally, the demand for money is defined as a function of a scale variable and the opportunity costs of holding domestic money. With the presence of currency substitution, the expected exchange rate and foreign interest rates would be part of money demand function. These two factors can be used to explain the variance in the demand for domestic currency.^[15] Intuitively, one would expect foreign exchange considerations to influence domestic money holdings as a result of the greater integration of international financial markets. The disturbances arising from shifts in international currency demand that will affect the domestic demand for money through the money market.

Currency substitution undermines the monetarists' recommendation that each country pursue its own fixed monetary growth rule as if the demand for national monies were stable and independent. Movements in the income velocity of money induced by currency substitution challenge the monetarists' claim that the velocity of money in circulation is constant.^[16]

McKinnon (1982) argues that the national monies of industrial countries are highly substitutable on the demand side in response to anticipated exchange rate movements. Therefore, international currency substitution destabilizes the demand for individual national monies. To solve international currency instability, McKinnon proposes that the Federal Reserve should adjust its money growth policies in the light of money supply behavior in other leading countries.^[17] This brings into question whether the traditional literature on the demand for money,

which presumed that the services of money could be provided only by the "own" country's currency, is misspecified.

2.3.2 Monetary Autonomy and Stabilization Policy

The theory of currency substitution has policy implications for fixed and flexible exchange rates.^[18] The theoretical debate over the problem of these exchange rate regimes is associated with the argument of monetary autonomy. Under a fixed exchange rate system, the monetary authority loses its autonomy by making foreign currency a perfect substitute for domestic currency on the supply side. In contrast, under the flexible exchange rate system, monetary policy is independent; the central bank no longer guarantees the value of the currency, and currencies are not perfect substitutes on the supply side. The monetary independence argument of flexible exchange rates implicitly assumes that currencies are also nonsubstitutes on the demand side, that is, no foreign currency is held by domestic residents for different purposes.

Under an assumption of currency substitution, the promise of flexible exchange rates to yield monetary autonomy to each country is eliminated.^[19] Currency substitution makes it difficult for the monetary authorities to control domestic liquidity. It also causes difficulties in implementing a successful stabilization program whose main goal is to reduce the domestic inflation rate.^[20]

2.3.3 Exchange Rate Determination

According to the monetary approach, exchange rates are determined by the relative supplies of the two currencies, relative national income levels, and the interest rate differential between the two countries. Currency substitution extends the monetary approach by

allowing domestic residents to hold foreign currency.^[21] It shows that, in addition to the money supplies, income, and interest rates, exchange rate determination depends on another variable, the expected rate of depreciation. This explains why, during periods of floating exchange rates, most countries have experienced more volatility in exchange rates than can be explained by the monetary approach.

Miles (1978), Girton and Roper (1981), Kareken and Wallace (1981), Lapan and Enders (1983), Stulz (1985), and Marquez (1987) show how currency substitution causes instability in the exchange rate. They find that once two currencies become perfect substitutes, domestic agents are indifferent as to which one to hold, and the exchange rate is no longer determinate. The only way monetary authorities can preserve the exchange rate determination is to impose capital controls.

2.3.4 Other Issues

Currency substitution also has some implications for other issues: the optimum currency area, the free currency theorem, and the case of the "missing money."

First, currency substitution implies that money is a mobile factor in the world monetary system. According to Mundell's (1968) argument, exchange rates should remain fixed when factors are mobile between or among countries. Therefore, if two currencies are close substitutes, the two countries should be encouraged to coordinate their monetary policies in an "optimal currency area". Laney, Radcliffe, and Willett (1984) argue, however, that a single criterion is not sufficient for judging the desirability of alternative exchange rate systems. Among the many factors to be considered are the openness of the economy, patterns of economic disturbances, and policy preferences.

Second, under his free currency system, Hayek (1976) advocates that citizens be free to use foreign currency as a means of payment to put a check on national governments' tendency to rely on seigniorage for fiscal purposes. Being able to use foreign currencies makes the demand for domestic money more elastic, thus reducing the monopoly power of the government to inflate the money supply.

Finally, Cuddington (1983) argues that international capital mobility has received little emphasis in studies on money demand. For example, important papers by Goldfeld (1976) and by Enzler, Johnson, and Paulus (1976) do not even mention open-economy variables as possible determinants of money demand or as explanations of the case of the missing money occurring after the mid-1970s. Currency substitution provides a way to understand this issue.

2.4 Summary of the Empirical Evidence of Currency Substitution

Empirical research over the last several years has increased our understanding of the phenomenon of currency substitution. In this section, we provide an overview of that work.

2.4.1 Case from the Industrial Countries

Currency substitution refers to the switch from domestic currency and quasi-money into foreign currency. Including domestic currency (a noninterest-bearing asset), makes currency substitution differ from what is known in the literature as capital movement—since this concept looks at interest-bearing assets, particularly bonds. Currency substitution also stresses the difference in substitution between bonds and currencies. This is especially true for industrial countries, where the capital and money markets are highly integrated and transaction costs between these markets are relatively small. These two factors make it difficult to distinguish capital mobility from currency substitution.^[22]

Many economists have examined the experience of industrial countries, such as the United States and members of the European Economic Community. Miles (1978, 1981) adopted a production function approach and directly measured the elasticity of currency substitution. He regressed the relative demand for domestic and foreign currencies on the ratio of foreign to domestic interest rates to test currencies' substitutability. He found that it became larger for Canada, West Germany and Switzerland under flexible exchange rate regimes. He concluded that a preferable world monetary system is one that emphasizes coordination of monetary policy, such as a fixed exchange rate system.

Husted (1980) introduced the expected rate of change in exchange rates and emphasized transaction demand in currency substitution. When he tested the model with Canadian and United States data, he found that the estimates of the elasticity of substitution in the demand for these two monies were very low.^[23]

Bordo and Choudri (1982) claimed that Miles' estimation was misspecified. They found that the expected change in the U.S.-Canadian dollar exchange rate was not a significant factor in the Canadian demand for money. Their results are in conflict with those obtained by Miles.

Daniel and Fried (1983) reconciled these results. They argue that the effects of serious postal strikes in Canada during the period measured need to be considered. Once dummy variables are added for strike and nonstrike periods, the elasticity of currency substitution becomes significant. Thus, a properly specified money demand function does provide evidence for currency substitution between the Canadian and the U.S. dollar.

Cuddington (1983) points out that if domestic and foreign bonds are perfect substitutes, then we can successfully distinguish currency substitution from capital mobility. On the one hand, the hypothesis of perfect bond substitution states that the nominal interest rate differential between two similar bonds must equal the expected rate of change of the exchange rate. On the other hand, the hypothesis of perfect currency substitution says that the nominal interest differential on monies must equal the expected rate of change of the exchange rate.^[24] Cuddington (1983) shows that the statistical significance of expected depreciation in the money demand equation is

not a valid test of the presence of currency substitution. He did not find a significant elasticity of currency substitution for a group of industrial countries.

Laney, Radcliffe, and Willet (1984) have questioned this distinction between currency substitution and capital mobility. They argue that a high proportion of international substitution in the currency denomination of liquid assets takes the form of interest-bearing assets. This may conform more to the traditional concepts of international capital mobility than to narrow currency substitution. With the increase in interest-bearing demand deposits, the distinction between what should be labeled narrowly defined money substitution and what should be considered more traditional international capital mobility becomes even more difficult to draw.

Melvin (1985) added the "money quality" variable into the domestic money demand function using the inflation rate as a proxy for the quality. Changes in the quality of domestic money relative to foreign money should stimulate currency substitution. Batten and Hafer (1984) studied whether opportunity costs of holding foreign currency influences domestic money demand. They found that the effect of direct currency substitution was statistically insignificant.

Some economists have focused on indirect currency substitution, a phenomenon that links monetary markets among industrial countries through the demand side of the international capital and money markets. McKinnon (1982) used a simple reduced-form forecasting equation of U.S. inflation as a function of the U.S. money supply and as a function of the world money supply, separately. Through the indirect currency substitution between the demand for U.S. dollars and demand for other

countries' currency, the equation using the world money supply provided a better predictor of United States inflation.^[25]

Contrary to McKinnon's result, Goldstein and Haynes (1984) adopted regression equations of the St. Louis type and found that quarterly U.S. inflation during the 1970s can be explained well statistically by U.S. money growth, changes in energy and food prices, and dummy variables to capture the effects of wage and price controls. Therefore, they rejected McKinnon's indirect currency substitution hypothesis.

Others have provided evidence on the relation between currency substitution and movements in the income velocity of money. Brittain (1981) examined regularities in the movements of money's income velocity of circulation in major industrial countries. These movements are closely coincident, particularly since the beginning of floating exchange rates. Ahking (1984), who reexamined Brittain's portfolio model, used Haugh's test to show that the movements in the U.S. income velocity of money are mostly independent of the movements in other industrial countries. He then modified Brittain's specification to include a real income variable and to specify the regression in log-linear form. He concluded that the empirical results do not support the multicurrency portfolio model.

Recently, Joines (1985) has shown conditions under which international currency substitution destabilizes domestic money demands. His explanation hinged on the distinction between the elasticity of currency substitution and the cross-elasticity of money demand. Joines found little evidence that changes in the cost of holding foreign money exert an effect on domestic money demands.

Batten and Hafer (1985) tested whether currency substitution has affected the relationship between domestic money supply and changes in nominal income in the United States, Germany, and Japan. In their simple reduced-form model, an increase in the growth rate of the world money stock reflected a shift from domestic money or, equivalently, an increase in its velocity. They found little empirical support for the notion that foreign influences, measured by changes in foreign money supply measures, significantly affect the relationship between domestic money growth and income growth.

2.4.2 Cases from the Developing Countries

Compared with the empirical work on industrial nations, few studies have examined developing countries. In many of these, domestic residents do not have the opportunity to hold foreign assets, such as government bonds and stocks. The foreign currencies of the major trading partners are likely to become an important component of domestic portfolios. The relative holding cost of foreign currency depends, for a given level of exchange risk, on the expected rate of appreciation of the domestic currency and interest rates. Changes in the expected exchange rate or foreign interest rates can reflect the effect of currency substitution on domestic money demand.

The phenomenon becomes particularly significant during periods of rapid inflation, when the cost of holding money increases (owing to its loss of purchasing power). Domestic residents have incentive to keep a large portion of their wealth in foreign currency. "Dollarization" occurs,^[26] for example, in Latin America as the U.S. dollar replaces domestic currency due to domestic response to differential inflation rates. For most industrial countries, the domestic and foreign

interest rates are determined by market forces, and the differential between interest rates is a good indicator of the expected change in the exchange rate. In most developing countries, however, intervention by the monetary authorities results in a fixed nominal interest rate for long periods, regardless of the inflation rate. This highly negative real domestic interest rate exacerbates the phenomenon of currency substitution.

Ortiz (1984) analyzed the behavior of the U.S. dollar/ Mexican peso deposit ratio. He included an exchange rate risk (measured by the deviations of the real exchange rate from trend) and a political risk dummy to test currency substitution. He found that the behavior of the dollar/peso demand deposit ratio was influenced by devaluation expectations and other factors related to foreign exchange risk. However, since foreign interest rates did not significantly affect the demand for pesos, there was no evidence of currency substitution. He concluded that the instability of money demand associated with the currency substitution hypothesis has not been proven empirically in Mexico.^[27]

Fasano-Filho (1985) studied whether currency substitution was empirically significant in Argentina for the years when the country experienced a relatively higher inflation rate than the rest of the world. He found that the expected rate of devaluation coefficient was statistically significant for all definitions of money used except quasi-money. Policy makers can solve the currency substitution problem by reducing the relatively higher domestic inflation rate.

In addition, Ramirez-Rojas (1985) presented a simple model of asymmetrical currency substitution. He examined evidence of the size

of currency substitution in Argentina, Mexico, and Uruguay from 1970 through the early 1980s. His results support the importance of the role of the expected change in the exchange rate in the behavior of currency substitution in all three countries.

Recently, Marquez (1987) adopted the production function approach to measure the degree of currency substitution in Venezuela. Contrary to previous studies in which the banking structure allowed for the circulation of both domestic and foreign currencies, only domestic money is allowed to circulate in Venezuela. An interesting question investigated by Marquez was the extent to which banking regulations are a precondition for currency substitution. The empirical result for Venezuela showed that regulatory constraints preventing the circulation of more than one currency (domestic versus foreign) had not dampened currency substitution.^[28]

2.4.3 Summary

The empirical works on currency substitution can be divided into two categories. One is the symmetrical case, when residents and nonresidents simultaneously hold domestic and foreign money. Most industrial countries fall into this category because their monies are regarded as hard currencies. Changes in money supply, inflation rates, and interest rates are relatively modest. Besides, the capital and money markets of these countries are well organized, highly integrated, and relatively free of control. Symmetrical currency substitution has been the subject of studies by Miles (1978, 1981), Husted (1980), Bordo and Choudhri (1982), Cuddington (1983), and Joines (1985). Empirical results for symmetrical cases, or hard currency countries, have been controversial because of the difficulty in distinguishing capital

mobility from currency substitution.^[29]

Another category is the asymmetrical case, where foreigners do not hold the domestic currency. Most developing countries belong to this group, for their monies tend to depreciate continually against hard currencies. Usually they have thin capital and money markets which are vulnerable to destabilizing speculation. To avoid the eroded purchasing power of a weak currency, people have a strong incentive to hold foreign currency. Foreign money provides an attractive means of liquidity and financial savings when there are only few available domestic alternatives for holding wealth. However, possibly due to data collecting problems, little empirical evidence on developing countries is available. Even if information could be found on foreign currency ownership, it might only offer a glimpse of currency substitution because of exchange controls and black market activity.

The empirical evidence reflects a considerable lack of consistency among studies. To measure the degree of currency substitution, the procedure adopted by the portfolio approach is to estimate the interest cross-elasticity derived from the regression coefficients of the demand function for the domestic and foreign money. In other words, this approach relies on cross-partial elasticities of reduced-form money specifications. Within that framework, there is little agreement about how large a cross-elasticity estimate needs to be in order to constitute evidence of currency substitution. In addition, this approach assumes that the quantity of other balances is constant or that there is no prevailing constraint on the total quantity of money balances held.

In contrast, the production function approach proposes an

alternative method for determining the degree of currency substitution by directly measuring the parameters of the money production function substitutability between foreign and domestic currency. The focus is on the relative quantities of different money balances held within a limited overall quantity of balances. This is a general equilibrium approach because all quantities are permitted to change simultaneously within the overall constraint. In this thesis, we will adopt the production function approach to measure the elasticity of currency substitution.

2.5 Conclusion: Shortcomings and Reexamination

Despite the volume of research undertaken, the results are still inconclusive and suggest the need for further study. We now discuss the shortcomings of work to date and explain the need to reexamine currency substitution.

(1). Problems of Estimation and Functional Form

To estimate the elasticity of substitution, the production approach adopts a procedure similar to Chetty's (1968) model. However, the calculation of elasticity of substitution is not correct because of the failure to consider all the first-order conditions. Without considering the budget constraint, there is no guarantee that the estimated elasticity will be equal to the elasticity estimated by using all first-order conditions. The result of not using all these conditions is that the marginal cost of holding money is left unspecified for a given level of holdings.

The application of the CES production function to measure currency substitution does not consider the cross-term (cross-effects) between domestic and foreign money. Hence, the elasticity of substitution

measured by the CES production function will be different from that derived from another functional form. In this study, we apply a quadratic functional form to test currency substitution, which includes the cross-term or reaction parameter between the money inputs.

(2). The Data Problem

There is no consensus in the literature about the proxy data for foreign currency held.^[30] For example, Miles (1978, 1981), Husted (1980), and Bordo and Choudhri (1982) use data on deposits and other short-term claims payable in foreign currencies reported by nonbanking concerns in the United States. This has the serious limitation of counting foreign money held only by nonbank enterprises. Ortiz (1984) analyzed the behavior of the ratio of U.S. dollar and peso demand deposits held by the public in Mexican private financial institutions.^[31] However, it is difficult to identify whether the deposits were held by domestic residents or nonresidents, and no account is taken of deposits in banks abroad and of nonbank transactions.

Ramirez-Rojas (1985) used data on foreign currency deposits held abroad by domestic residents, obtained from the U.S. Treasury. Again, however, these data are only a partial estimate of total foreign currency deposits and probably would underestimate the effect of currency substitution. Alternatively, Fasano-Filho (1984) defined a proxy of the demand for foreign currency as the central bank's net purchase of foreign currency from authorized agencies or banks dealing in foreign exchange. Yet, these figures cannot be clearly identified with currency substitution per se and only reveal the trend in the substitution of domestic into foreign currency.^[32]

Data collecting problems are especially serious for developing countries. Because of black markets and capital controls, residents may hold significant foreign currency and deposits in banks abroad or outside the formal banking system. These situations complicate considerably the collection of data on the amount of foreign currency held by domestic residents. To avoid the serious difficulty of obtaining adequate data for domestic residents holdings of foreign currency as an input of monetary services, the dual approach can directly specify and provide estimates for the currency substitution model. We use an estimation method which does not need to rely on those data.

(3). Currency Substitution and Financial Institutions

Previous empirical studies have analyzed the experience of industrial countries, which have highly integrated well-developed money and capital markets and no foreign exchange controls. Their banking structures allow for holdings of both domestic and foreign currency, or even for the circulation of foreign currency (as in the European Economic Community). They provide other substitutes for depreciated currency. In addition, inertia and uncertainty make currency substitution unimportant at the relatively low rates of inflation normally found in most industrial nations.

In developing countries which have limited capital markets and few domestic investment outlets, a policy of maintaining a fixed nominal interest rate, and high inflation, exacerbates the phenomenon of currency substitution. Because of such situations, the real return on domestic financial assets declines relative to the real return on foreign currency. The latter is regarded as an attractive means of

liquidity and financial savings when there are few available domestic alternatives for holding wealth. Foreign currency increasingly becomes a more remunerative form of savings to avoid the losses associated with the deterioration in purchasing power parity. In addition, foreign currency is likely to be held in a stable proportion to the value of international transactions.

One interesting question is the extent to which banking regulations are a prerequisite for currency substitution. Kareken and Wallace (1981), Tanzi and Blejer (1982), and Lapan and Enders (1983) believe that nations may find it to their best interest to impose capital controls to prevent currency substitution. Governments may impose restrictions on the use of foreign currency in domestic transactions and regulate the stocks as well as the flow of foreign currency held by domestic residents.

Empirical research in developing countries has focused on the different banking structures. For example, Fasano-Filho (1985) studied Argentina, where foreign currency circulates in the domestic market and where there are capital controls. Oritz (1984) dealt with Mexico, where foreign currency is allowed to circulate and where there are no capital controls. Marquez (1987) investigated Venezuela, where there are no capital controls and no circulation of foreign currency.

However, if there are no severe controls or other types of deterrent to the holding of foreign currency, the transaction costs incurred in the exchange of the domestic for foreign money will be smaller than those involved in the exchange of money for goods. Therefore, a further bias is created in those economies toward the holding of foreign currency. Controls are unlikely to succeed because

economic agents have many channels through which they can adjust their portfolios. For example, exporters may under-invoice their exports or importers may over-invoice their imports to shift foreign exchange abroad. Despite attempts to diminish currency substitution and capital outflows, evidence has shown that the controls have been largely ineffective, and a black market for foreign exchange often flourishes.

This study also asks whether the non-circulation of foreign currency and capital controls completely prevent currency substitution. An analysis of Korea and Taiwan might be of interest because their institutional banking structures have not allowed circulation of foreign currency and have imposed capital controls on foreign exchange.

(4). Currency Substitution and Financial Dualism

The empirical studies of currency substitution in industrial countries implicitly assume that foreign currency held by domestic residents is highly liquid. The switch between domestic and foreign currency may be through either direct or indirect channels, as mentioned by McKinnon (1982).

For developing countries, the relative profitability of foreign exchange holdings is enhanced if widespread controls in domestic capital and money markets depress domestic yields. These controls would make the expected rate of exchange appreciation higher than the nominal rate of interest paid on time deposits and on other liquid assets denominated in domestic currency.

All empirical work to date assumes that domestic asset holders directly switch from domestic currency or time and savings deposits into foreign currency due to their response to differential return on alternative currencies. A weakness in the various approaches to

estimating the degree of substitution is that they consider only one foreign currency at a time in addition to the domestic currency. The movement of the currency-holdings ratio may reflect a shift between domestic and foreign currency or between one of them and other financial assets. Hence, the estimates of the coefficients are likely to be biased.

It is well known that financial repression or financial dualism, exists in most developing countries, including Korea and Taiwan. That is, organized (the formal banking system) and unorganized financial markets coexist, and interest rates in the latter are higher than those in the former. Given the higher interest rates of unorganized financial markets, we may consider the possibility that domestic residents switch from holding domestic currency into unorganized markets rather than directly shifting into foreign currency,

Since these two monetary phenomena are widespread in most developing countries, the conventional treatment in the literature is to investigate each separately. Yet, the consideration of both currency substitution and financial dualism has important implications for money demand in developing countries. Moreover, for these economies substitutability often extends to include unorganized money market balances. Hence, the interest rate in unorganized markets may be an opportunity cost of holding money. Changes in that rate affect the cost of holding currencies and will influence domestic residents' choices through the same mechanism that transmits changes in the quantity of domestic money to the economy.

Footnotes—Chapter II

1. Even if both currencies are equal in return and risk, risk-averse individuals will hold portfolios containing both currencies when returns are not perfectly correlated.

2. Ramirez-Rojas (1985) points out that the phenomenon of currency substitution covers a variety of possibilities. These include foreign currency deposits in the domestic financial system, foreign money held abroad by domestic residents, foreign currency be held onshore, and circulated in domestic.

3. Equation (2.6) is not a system of money demand equations in the sense of relationships expressing the endogenous quantity of money demand as a function of only exogenous costs (or monetary services).

4. According to Marquez (1987), the choice of a CES production function might be justified for two reasons. First, the space of parameter estimates is such that neoclassical properties of optimizing behavior are met globally. Second, alternative hypotheses about the extent of currency substitution can be tested depending on the value of the substitution elasticity.

5. Specifically, Marquez (1987) assumes there is a nonlinear version of the Cambridge equation $M = f(Y) = \alpha Y^{1/u}$, where Y represents nominal income and α represents the liquidity preference. The parameter u is the inverse of the income elasticity of aggregate money services. It is an ad-hoc procedure, but it is consistent with the idea that a given level of output requires a certain amount of money services.

6. Cuddington (1983) argues that the inclusion of foreign money leaves the usual asset demand functions unchanged, at least as far as the appropriate rate of return arguments and their signs are concerned. In other words, currency substitution is of limited importance in macroeconomics.

7. Several recent articles follow this approach. For example, Fasano-Filho (1985) argues that the demand for domestic money primarily responds to the level of real income, the inflation rate, and the expected rate of devaluation. Melvin (1985) adds the "money quality" variable into the money demand function, where the quality of money is proxied by the inflation rate. Thomas (1985) further demonstrates the conditions under which foreign and domestic monies are substitutes in demand. He contrasts the determinants of currency substitution with those of asset substitutability. He concludes that portfolio theory is useful to explain capital mobility but not currency substitution.

Along these lines, there has been some research on the relation between currency substitution and the movements of the income velocity of circulation in major industrial countries. Brittain (1981) presents the money demand function as taking account of internationally diversified portfolios. In response to this argument, Ahking (1984) modifies Brittain's specification in two directions, by including a

real income variable and by specifying the regression in log-linear form except for the uncovered interest rate differential variable. Contrary to Brittain's study, Ahking's results do not support the multicurrency portfolio model. Joines (1985) considers what the income velocity of money can tell us about the practical importance of international currency substitution. He argues that the cross-elasticity of money demand determines the degree to which domestic money demand is likely to be destabilized by international currency substitution.

8. Although Bordo and Choudhri (1982) classified the utility-maximization approach, they did empirical tests by using procedures similar to the portfolio approach.

9. Since they did not specify the form of the utility function, the optimization of the demand theory does not impose a particular functional form on the derived money demand function. They directly set the log-linear function of money demand.

10. To compare the above model with Miles's model, equation (2.6), they derive the reduced form equation as follows:

$$\ln (M_d/eM_f) = \phi_0 + \phi_1 \ln y + \phi_2 i_d + \phi_3 (i_f - i_d),$$

where $\phi_i = \beta_i - \pi_i$, $i=1,2,3$.

Based on the above equation, Bordo and Choudhri criticize two points in Miles's specification. First, it is not clear whether the coefficient of the interest rate differential $(i_f - i_d)$ represents a measure of the elasticity of currency substitution.^d Second, since ϕ_1 and/or ϕ_2 may not be equal to zero, omitting the influence of i_d and y would generally bias the estimate of ϕ_3 .

11. In Liviatan's sense the two monies are "cooperant" factors if the cross-partial derivative of the utility function with respect to the two monies is always positive.

12. Recently, Chand and Onitsuka (1985) have argued that the treatment of stocks and flows in portfolio balance models of exchange rate determination is inadequate and hampers the analysis of exchange rate dynamics. They point out that the satisfactory treatment of flows has long been recognized in a number of contributions which have attempted to assess the effect of current account balances on the exchange rate path. A proposed resolution is reworked into the currency substitution model. Contrary to Kouri's accelerationist (1976) hypothesis, they find that the deteriorating current account deficit can coexist with an appreciating exchange rate, and the portfolio-induced jumps in the exchange rate are linked to balance-of-payments flow influences on the evolution of the exchange rate.

13. However, for the simple two-money model it is possible to derive a relationship between substitution elasticity and the conventional own- and cross-elasticity. Feige and Pearce (1977) showed that the partial elasticity is always greater than the cross-elasticity

and thus might be regarded as an upper bound. Thus, within the context of the simple two-money model, a cross-elasticity representing a response is consistent with a large elasticity of substitution.

14. Brillembourg and Schadler (1979) suggest that one possible measure of the effect of currency substitution would be a comparison of the size of own-semielasticities with cross-semielasticities.

15. Calvo and Rodriguez (1977), Miles (1978), Girton and Roper (1981), and Bordo and Choudhri (1982), agree that the effect of the expected rate of foreign exchange on the demand for domestic currency may capture the effects of currency substitution. Brittain (1981) recognizes that currency substitution can explain the instability of income velocity in industrial countries.

16. This is the view of pure domestic monetarists. The constant velocity makes the LM curve vertical, which implies that money is a powerful and predictable tool in manipulating income.

17. In response to McKinnon (1982), Goldstein and Haynes (1984) reject his idea that shifts in international portfolio preferences indirectly destabilize the demand for domestic money. Instead, they propose an alternative view that governments often intervene to stabilize foreign exchange rates, allowing domestic money growth to vary in support, as a means of stabilizing the domestic price level.

18. However, Tower and Willett (1976) have pointed out that it has been well understood among international monetary economists for decades that, once international capital mobility is taken into account, flexible exchange rates cannot offer complete insulation from foreign macroeconomic developments.

19. However, Daniel (1985) agrees that monetary autonomy is maintained under currency substitution. This is done in the context of a two-country, two-currency model with perfect foresight, purchasing power parity, and steady state conditions.

20. For example, in a country in which the government engages in a policy of inflationary finance, domestic residents may expect the future inflation consequent on this policy and may substitute foreign for domestic money. Such currency substitution will produce an immediate deficit in the balance of payments, an instantaneous depreciation of the exchange rate, or both. In this case, financing of the deficit through the revenue from money creation will fall, and the base of the inflation tax will be reduced.

21. In fact, the term "currency substitution" has been used in two different senses in the literature. Calvo and Rodriguez (1977) refer to substitution between domestic and foreign currencies within a single small economy. The model typically assumes the absence of capital flows, so that importation of currency takes place through current account surpluses. Under the second approach, Bilson (1979) assumes that currency substitution occurs in a world of integrated capital

markets.

22. Brittain (1981), Ortiz (1984), and Ahking (1984) rely on the significance and sign of the foreign interest rate coefficients to yield inferential information on currency substitution. The foreign interest rate effects yielded by their studies may be the result of mixing the effects of substitutions between money and interest-bearing assets with substitutions between domestic and foreign money.

23. Laney, Radcliffe, and Willett (1984) argue that elasticity of currency substitution may turn out to be statistically significant; this does not mean it is economically significant as well.

24. McKinnon (1982) argues there are two forms of currency substitution. Direct substitution occurs when private agents change their desired relative holdings of currencies as a result of expected changes in relative returns. Indirect substitution address the general equilibrium conditions linking domestic and foreign money markets through international capital and money markets. Domestic and foreign money markets are connected through the international capital and money markets by the parity condition of the differential in interest rates and expected exchange rate changes. Indirect currency substitution implies that domestic and foreign money markets are indirectly related through the international capital and money markets.

25. According to McKinnon (1982), individual central banks would not pursue a fixed rate of monetary growth individually. Rather, they would stand ready to accommodate any swing in the demand for domestic money by nonsterilized intervention designed to protect fixed exchange rates. However, Spinelli (1983) argues that McKinnon's analysis misjudges the relative roles of domestic and world variables in the explanation of domestic inflation.

26. From the domestic monetary authorities' point of view, dollarization is an unwelcome phenomenon, and thus they will attempt to arrest it.

27. Ortiz concludes that foreign interest rates do not significantly affect the demand for Mexican pesos, so there is no evidence of currency substitution. However, this will be correct only if there is no expectation of an exchange rate change.

28. Marquez (1987) mentions that because the financial market in Venezuela is significantly less mature than the financial market in the United States and Canada, the C.E.S. function might provide a useful first approximation to the transaction technology in Venezuela. However, it is possible for that technology to be typified by some other functional form, and the sensitivity of his results to alternative transaction technologies ought to be further investigated.

29. Both Cuddington (1983) and Marquez (1987) agree that it is difficult to distinguish between currency substitution and capital mobility in industrial countries due to highly integrated capital and

money markets.

30. It is difficult to estimate the amount of foreign currency notes held by domestic residents because monetary authorities frequently have no effective control over the purchase or sale of these notes by domestic residents.

31. In response to a comment by Laney, Radcliffe, and Willett (1984), Miles (1984) agrees that the domestic holding of foreign money data series which he used for empirical work represents only a lower bound on foreign money.

32. Fasano-Filho (1984) argues that whenever the demand for domestic currency declines, meaning that there is an excess supply of domestic money, the net purchase of foreign currency by the central bank also declines. In other words, the demand for foreign currency rises.

CHAPTER THREE

CURRENCY SUBSTITUTION, FINANCIAL DUALISM, AND THE DEMAND FOR MONEY

3.1 Introduction

Currency substitution reflects the fact that people attempt to protect the value of their portfolio balances. It occurs either in deteriorating economic conditions that adversely affect the costs of holding domestic currency relative to foreign currency, or when political changes affect expectations regarding the value of domestic currency. The purpose of this chapter is to develop a model that allows us to analyze the phenomenon of currency substitution, to measure the degree of substitution, and to study money demand in the presence of both currency substitution and financial dualism in developing countries.

We begin by applying producer theory to currency substitution in section 3.2. Instead of the CES function, we use a quadratic function, in which the cross-term (reaction effects) between money inputs is not zero. We derive the conditional money demand function based on the optimizing cost-minimization model. Our hypothesis is that people act to minimize the holding costs of these balances subject to obtaining a desired level of "monetary services" from them. This provides an opportunity to examine how tests of the importance of currency substitution in the money demand function undertaken for developed economies are transferable to the case of developing economies that imposes foreign exchange restrictions.

Section 3.3 applies the model to study the effect of currency

substitution and financial dualism on money demand in developing countries. For those economies, money substitutability is often extended to consider the financial dualism, and hence the interest rate of unorganized money markets may be an opportunity cost of holding money. We incorporate two monetary phenomena into the model to see how they affect domestic money demand.

Section 3.4 proposes estimation forms of the model, discusses estimation procedures, and interprets the results of the estimation. A byproduct of this section is that the degree of currency substitution can be measured directly as a parameter of this model. Our tests are carried out with quarterly data from open economies, Korea and Taiwan, under a fixed exchange rate regime.

Section 3.5 offers a summary and conclusion of this chapter.

3.2 Optimizing Behavior and the Demand for Money

Two functional forms, the Cobb-Douglas and CES function, have been applied to the production function approach to currency substitution. The Cobb-Douglas function imposes a priori restrictions on patterns of substitution among currencies, and the elasticity of substitution is restricted to unity. The CES function allows a arbitrary constant elasticity of substitution which can differ from one. However, it also has the restriction that the elasticity of substitution between pairs of money inputs are the same (constant).^[1] It also assumes that the cross-term between inputs, which can be interpreted as a reaction parameter between the domestic and foreign money inputs, is zero.

It seems no particular reason to impose such a restriction (no cross-term between inputs) on a priori grounds. Thus, it is desirable to have a functional form for a production function that does not

incorporate this restriction. We apply the quadratic production function approach to currency substitution, since no research to date has examined in this functional form in the literature of currency substitution. Intuitively speaking, we would expect that as one moves along a given isoquant of monetary services, the elasticity of substitution changes if the reaction parameter of money inputs is considered. It turns out that the elasticity of substitution derived from the CES function is different from that derived from the quadratic form.

In the study of currency substitution, an important question has received attention. Primarily, interest has centered on the possibilities of substitution of domestic for foreign currency and in examining the degree of substitutability. Measurement of the elasticity of substitution between them is important for the design and implementation of monetary policy. If foreign currencies are close substitutes for domestic money, the financial intermediaries can, in principle, reduce the effectiveness of policy action designed to affect the domestic monetary aggregate. The high elasticities may lead to greater errors in setting monetary and exchange rate policies. If the elasticities of substitution are known and relatively small, then the authorities should be able to predict the consequence of a particular policy fairly well.

Typically, the central bank has a monopoly over the issue of the standard money into which monetary liabilities of all other banks must be converted. Currency substitution would undermine the monopoly position of central banks. Greater substitution would lead to unstable shifts in money demand. The argument here is not that monetary

authorities are incapable of achieving a certain monetary target, but that the attempt to do so causes the public to shift into other currencies, which diminishes the effectiveness of achieving the specified policy objective.

If this argument is important, knowledge regarding the magnitude of currency substitution (as well as its value) becomes significant. All studies to date assume that the degree of substitution can be measured by the Hicks-Allen partial elasticities of substitution.^[2] Our study also uses this measure to allow comparability with other research on this topic.

The purpose of this section is to derive the money demand function from an optimizing model. We examine how the behavior of money demand is influenced by foreign exchange considerations.^[3] The failure to recognize that influence might result in a misspecification of money demand behavior.

From the monetary authority's viewpoint, currency substitution is unwelcome. To prevent the displacement of the domestic currency, government can impose restrictions (or transaction costs) on the use of foreign currency in domestic transactions. Government also can attempt to regulate the stock and the flow of foreign currency held by domestic residents.

We assume an economy in which individuals' and firms' wealth is mainly made up of "money."^[4] The money can be held in either domestic or foreign currency. We also assume the lack of a well-developed domestic capital market and investment outlets, which limits the alternatives for holding wealth to durable goods and to domestic and foreign money. In such a situation, holdings of foreign currency may

become another form of savings because they avoid the losses due to the deterioration in purchasing power.

Since foreign currency is not circulated domestically, we assume that individuals and firms have foreign currency deposits either in domestic banks or abroad and that these can be exchanged for domestic currency and vice versa. Domestic firms are allowed to borrow funds from abroad and maintain balances in more than one currency. They manage the financing cost associated with a given level of output.^[5] Finally, despite numerous attempts to reduce monetary substitution and capital outflows through the imposition of exchange controls, evidence has shown that the controls largely have been ineffective, enabling a black market for foreign exchange to flourish. These assumptions are consistent with the institutional features of both Korea and Taiwan.^[6]

A few of the general points that emerge from the analysis are worth mentioning at the outset. First, in the literature on currency substitution, there is no consensus on how the cost function should be modeled. Miles (1978, 1981) and Miles and Stewart (1980) set the cost constraint to reflect the assumption that economic agents borrow their working capital in domestic and foreign markets at the beginning of the period; it costs $i_d m_d$ and $i_f m_f$, respectively. At the end of the period, economic agents are assumed to pay back both the principal and the associated interest, $(1+i_d)m_d$ and $(1+i_f)m_f$.^[7]

Marquez (1987) assumes that the cost of borrowing foreign money is modeled as the foreign interest rate adjusted by the expected fluctuations in the exchange rate. The cost of foreign borrowing is $[(1+i_f)/(1+x)]m_f$, where x is the expected exchange rate. Husted (1980) models the cost function as $i_d M_d + (i_f - x)eM_f$. The term x is subtracted

in the cost function because $x > 0$, as the home currency is expected to depreciate against the foreign currency.^[8] Similar to Husted's setting of cost, Saurman (1986) assumes that the firm's total opportunity cost of holding real stocks of the two currencies is given by $(r+\pi)m_d + (r+\pi^f)m_f$, where r is positive real interest rate, and π (π^f) is the anticipated rate of inflation in the domestic (foreign) economy.

Second, Kareken and Wallace (1981) and Lapan and Enders (1983) have explained why nations institute binding legal restrictions or capital controls in order to have equilibrium exchange rates. The domestic monetary authority not only imposes restrictions on the use of foreign currency in domestic transactions but also attempts to control the foreign currency held by domestic residents. The implementation of capital control measures reduces the convenience of holding foreign currency, and black markets in foreign exchange invariably develop.

Consider a technology for producing a single output, monetary services (m_s), using domestic real money balances (m_d) and foreign real money (m_f) as inputs. The rationale for regarding real balances in the production function relates, in part, to the increased productivity gains derived from using money. In Appendix A, we introduce properties of the quadratic function. A quadratic form is written as follows:^[9]

$$(3.1) \quad m_s = T(t) \left[\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right]^{(1/\beta)}.$$

where $i, j = d, f$ (domestic, foreign), m_s, m_d , and $m_f \geq 0$, and $\beta \neq 0$

This function is homogeneous of degree one in the money inputs m_d and m_f .^[10]

To determine the optimal levels of both domestic and foreign money

holdings, economic agents are assumed to minimize the cost associated with holding such currency, subject to a given level of monetary services. In order to isolate the effects of using a different form for our monetary services production function, we utilize a cost function that is similar to ones found in the existing literature. We may consider the following "cost minimization" problem of choosing m_d and m_f so as to

$$(3.2) \text{ Minimize: } C = i_d m_d + (i_f + \delta - x) m_f,$$

$$(3.3) \text{ Subject to: } m_i \leq T(t) (\sum_1 \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2})^{1/\beta}, \quad i, j = d, f,$$

where C is portfolio holding cost;

d, f denote the domestic and foreign country variables;

i_d is the domestic nominal interest rate;

i_f is the foreign nominal interest rate;

x is the expected depreciation of the exchange rate;

δ is the transaction cost (as a percentage of the total holdings) of maintaining foreign balances;

m_d, m_f are real balances of domestic and foreign money, which are defined as the nominal money stock (M_d, eM_f) divided by the price level (P_d, P_f), e is exchange rate; and

T is a shift parameter representing some index of transactions technology or a measure of the institutional framework within which currency substitution is possible.

The first term on the right-hand side of equation (3.2), $i_d m_d$, represents the cost of borrowing domestically; the second term, $(i_f + \delta$

- $x) m_2$, represents the cost of foreign borrowing. Here, the cost of borrowing one unit of foreign money is modeled as the foreign interest rate adjusted by the expected capital gains (or loss) resulting from expected fluctuations in the exchange rate. The inclusion of the expected rate of change in the exchange rate reflects the realization of capital gains on foreign money that clearly reduces the cost of maintaining these accounts.

δ is the per-unit transaction cost on the use of foreign money imposed by the domestic monetary authorities. It can be regarded as the opportunity cost of evading capital control measures. That cost includes fines or penalties borne by transactors who violate the controls and are discovered, or includes added costs which are necessary to meet government regulations.^[11]

$T(t)$, using CES function terminology, stand for the efficiency parameter, which also absorbs the neutral technical progress. $T(t)$ is independent of time, if technical progress is neutral; otherwise it is a function of time.

Assume that the monetary services production function is linear, homogeneous, and concave. Then the three first-order conditions for a unique optimum that describe money demand are from production theory, not financial theory. The marginal productivity of each monetary input into the monetary services production function equals its rental cost, the associated nominal rate. This production function approach to currency substitution relates the level of real balances directly to the level of monetary services.^[12] Since foreign and domestic currency interact only through a real rather than through a financial channel, production function models, as Thomas (1985) has claimed, are likely to

represent the phenomenon of currency substitution.^[13] This approach, similar to Stluze (1984) and Thomas (1985), rejects a financial channel for currency substitution and advances instead an explanation that depends on monetary services.

The difference between the CES and quadratic function is that the former assumes the cross-term, α_{df} , to be zero. The parameter α_{df} can be interpreted as a reaction parameter between inputs m_d and m_f . If we assume that $\alpha_{df} = 0$, it is a CES function, and the ratio of holding domestic and foreign money are

$$(3.4) \quad (m_d/m_f) = [\alpha_{ff} i_d / \alpha_{dd} (i_f + \delta - x)]^{1/(\beta-1)},$$

Equation (3.4) has been estimated by Miles (1978,1981), Husted (1980), Miles and Stewart (1981), Ortiz (1984), and Ramirez-Rojas (1985). One possible reason they only use equation (3.4) to estimate σ is that monetary services are unobservable since they depend on the unknown distribution parameters α_{dd} , α_{ff} , and substitution parameter β . However, the problem associated with their procedure is that equation (3.4) does not represent the solution to the associated first-order condition and does not consider the constraint condition. As Donovan (1978) and Marquez (1987) pointed out, the main consequence of their procedure is that the user cost of monetary services (the Lagrangian multiplier) is left unspecified, and an estimate of σ using equation (3.4) is inconsistent with the one given by solving all first-order conditions.

Optimization requires, first, that the value of marginal productivity of each type of money be equal to the opportunity cost of

borrowing monies and, second, that the resulting optimal money balances give a level of monetary services equal to m_s . The optimal demand equation for domestic money is derived by solving all first-order conditions (shown in Appendix A):

$$(3.5) \quad m_d = \alpha_{dd}^{-1/\beta} (1 + [i_d / (i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)})^{-2/\beta} m_s T^{-1},$$

$$M_d = M_d(i_d, i_f, x, \delta, m_s, T, P_d), \quad \text{where } m_d = (M_d/P_d).$$

Equation (3.5) is homogeneous of degree zero. This function provides the basis for the analysis of currency substitution. The optimal demand for domestic currency depends on domestic and foreign interest rates, the expected rate of depreciation, the measurements of capital controls, the given aggregate level of monetary services, and the shift parameter of technological change. In contrast to traditional demand for money, the introduction of currency substitution has added opportunity cost variables, foreign interest rates and expected exchange rates in money demand function.

The determinants of money demand in open economies discussed in this section are similar to the study by Arango and Nadiri (1981), which is derived from simplified portfolio model of the financial market. However, the money demand function in this study is derived from optimization behavior, and that function specifies the channels through which the influences of monetary elements abroad are transmitted to the demand for money in a particular country.

Compared with equation (3.4), there are some advantages to estimating equation (3.5). First, the parameters can be estimated,

taking into account all the first-order conditions for the portfolio allocation problem. Second, since data on holding foreign currency by residents were not available, the present analysis relies on producer theory. With equation (3.5), there is no need to depend on unreliable data about domestic residents' holdings of foreign currency to estimate parameters.

If data on monetary services were available, then one could estimate the parameters associated with the money demand function. However, monetary services are unobservable. Modifying the specifications by Marquez (1987) and Sims, Takayama, and Chao (1987) to measure the monetary services, we assume there exists a behavioral relationship between these unobservable monetary services and observable real income rather than nominal income.^[14] We set the relationship as $m_s = g(y) = y^{1/u}$, where y is real income, and u is the inverse of the income elasticity of aggregate money services m_s .

The comparative statics associated with equation (3.5) are

$$\partial m_d / \partial i_d = H(-2/2-\beta)(i_f + \delta - x)^{-1} < 0,$$

$$\partial m_d / \partial i_f = H(-2/2-\beta)(-i_d)(i_f + \delta - x)^{-2} > 0,$$

$$\partial m_d / \partial x = H(-2/2-\beta)(i_d)(i_f + \delta - x)^{-2} < 0,$$

$$\partial m_d / \partial \delta = H(-2/2-\beta)(-i_d)(i_f + \delta - x)^{-2} > 0,$$

$$\partial m_d / \partial y = m_d(uy)^{-1} > 0, \text{ and}$$

$$\partial m_d / \partial T = -T^{-1} m_d < 0,$$

$$\text{where } H = \alpha_{dd}^{-1/\beta} \left\{ 1 + \left[i_d / (i_f + \delta - x) \right]^{\beta/(2-\beta)} (\alpha_{ff} / \alpha_{dd})^{1/(2-\beta)} \right\}^{-(2+\beta)/\beta} y^{1/u} \\ T^{-1} (\alpha_{ff} / \alpha_{dd})^{1/(2-\beta)} \left[(i_d) / (i_f + \delta - x) \right]^{(\beta/2-\beta)-1}.$$

An increase in either the domestic interest rate or the expected depreciation of exchange rates reduces optimal domestic money balances because of the associated increase in the relative cost of borrowing domestically. Thus, in a two-money model, currency substitution will cause a decline in its own domestic money demand, and an increase in the demand for foreign currency. An increase in either the foreign interest rate or in the given level of monetary services raises optimal domestic money balances. These results are similar to Marquez (1987) and Thomas (1985).

Recent literature increasingly has recognized that capital controls should be incorporated into a theoretical and empirical study of the interest rate parity relation.^[15] Our model shows that an increase in the transaction cost of using foreign currency in domestic transactions will raise the demand for money.

Finally, technological change in the money market will decrease money demand. As a result of the increasing use of credit cards, the use of money substitutes, and more efficient payment mechanisms, economic agents have apparently decreased their money demands, given income and interest rates. The elasticity of money demand with respect to technological change is negative one ($\partial \log m_d / \partial \log T = -1$). It is assumed that technological change is neutral, which means there are no institutional changes that make one currency more attractive or

unattractive relative to another or that any change is neutral.^[16]

For these comparative-static results, the direction of effects of the domestic interest rate, exchange rate expectations, the degree of capital controls, and income on money demand are well known and need no further discussion. However, it is interesting to note the direction of effects of change in foreign interest rates on money demand. Based on this model, the optimal domestic balance increases in response to higher foreign interest rates, which differs from the implications of the portfolio approach, for example, in studies by Arango and Nadiri (1981), Cuddington (1983), and Melvin (1985). In that approach, since domestic money is the riskless asset with zero return, higher foreign interest rates increase the opportunity cost of holding such balances. Thus domestic residents are induced to increase their holdings of foreign assets which implies a decline in optimal domestic money balances.^[17] Domestic residents finance those increases by drawing down money holdings, decreasing their holdings of domestic securities (including the currency).

In this model, however, domestic and foreign money are held because they produce the monetary services needed to support a given level of transactions. If these two currencies are substitutes for each other, an increase in the cost of foreign money services leads to an increase in domestic demand for money.

Interestingly, similar to Otani's (1985) result, our model shows that increasing the degree of capital controls will discourage borrowing from foreign sources and encourage borrowing in domestic money markets through lowering domestic interest rates under given borrowing costs.^[18]

Traditional studies on demand for money often have ignored the influence of foreign monetary developments.^[19] The discussion on international capital mobility focuses only on the effect of adjustments in international reserves on a domestic money supply, with the assumption that demand for domestic money is inelastic with respect to foreign interest rates and changes in exchange rates. Specifically, Hamburger (1977) studied the behavior of money demand in Germany and the United Kingdom, finding that this behavior is strongly influenced by movements in foreign interest rates. Arango and Nadiri (1981) considered foreign interest rates and exchange rates as explanatory variables in modeling a money demand equation for different countries. They found empirical evidences for the inclusion of these foreign monetary variables in their specification.

Although those studies have examined the question of foreign exchange considerations in different ways, all of them directly rely on the specification of a log-linear demand function and estimated equations are not derived from optimization behavior. Currency substitution requires a respecification of the money demand to include foreign monetary factors. It shows that international monetary disturbances will affect the domestic demand for money through the money market. Only recently have foreign exchange considerations gained significant attention in empirical analyses of money demand behavior.

In this section, we derive the money demand function for an open economy from the optimal behavior of economic agents and specify the channels through which the influence of monetary elements abroad is transmitted to the demand for money. We explicitly take account of

foreign exchange considerations in explaining money demand behavior. We also consider the effects of capital controls and technological change on the demand for money. The failure to consider these influences might result in a misspecified money demand equation, which potentially could be responsible for the large errors in forecasting aggregate money demand.

3.3 The Effects of Currency Substitution and Financial Dualism on the Demand for Money

For developing countries, the relative profitability of foreign exchange holdings is enhanced if widespread controls in domestic capital and money markets depress domestic yields. These controls would make the expected rate of foreign exchange appreciation higher than the nominal rate of interest paid on time deposits and on other liquid assets denominated in domestic currency.

All previous empirical work on developing countries in the currency substitution area assumes that domestic asset holders switch directly from domestic currency, time deposits, and savings deposits into foreign currency due to their response to differential returns on alternative currencies. That is, the literature has been limited to substitution between domestic and foreign currency, without recognizing that unorganized money markets in developing countries can serve as substitutes for domestic money. A weakness in their approach to estimating the degree of substitution is that they consider the domestic currency and only one foreign currency at a time.^[20] The movement of the currency-holdings ratio may reflect a shift between the domestic and foreign currency, or between domestic or foreign currency and other financial assets. Hence, the estimates of the coefficients

are likely to be biased.

Given the higher interest rates of unorganized financial markets, we may consider the possibility that domestic residents switch from holding domestic currency to shifting balances into unorganized markets rather than directly shifting into foreign currency (as all empirical work thus far has assumed). Works by Wai (1957), McKinnon (1973), Shaw (1973), Van Vijnbergen (1983), Cole and Park (1983), and Chang (1986), they have discussed financial dualism (organized versus unorganized money markets) in developing countries. The nature and interplay of these two components of the financial system are important features of these economies. In Appendix B, we provide a theoretical analysis and empirical results of financial dualism in Korea and Taiwan. To consider other substitutes for domestic currency, we may incorporate monetary assets in unorganized money markets in developing countries simultaneously into the currency substitution model and estimate the parameters.

In developing countries, the monetary phenomena of currency substitution and financial dualism (the nonmarket allocation of credit) are widespread and coexistent. Work in each of these areas has enhanced our understanding of the behavior of money demand, but except Green (1987), the conventional approach has been to investigate them independently of each other. Proponents of financial dualism do not consider the influence of foreign variables in modeling money demand behavior, and the literature on currency substitution treats substitutability only between domestic and foreign currency. These studies ignore the potentially important interaction between these phenomena and the implications for the domestic demand for money.

Green (1987) adopted a simple two-sector model to analyze the implications of currency substitution for the sectoral distribution of output. He then analyzed the sectoral effects of various policy actions now being implemented or already undertaken in South Korea. His main conclusion is that currency substitution can reduce the effectiveness of sectoral credit allocation policies.

The major policy concerns for developing countries are the efficiency with which the financial system transfers funds from domestic and foreign sources to the most desirable investment projects and also the extent to which this system discourages currency substitution. Implications for these relationships are not addressed by conventional analysis, which does not simultaneously treat currency substitution and financial dualism in modeling the demand for money in developing countries.

Movements in foreign variables will affect the opportunity costs of holding foreign currency. This will influence domestic variables through the currency substitution mechanism that transmits changes in the quantity of domestic money to the economy. Those changes further affect the activity of unorganized money markets through financial dualism. Because of nonmarket allocation of credit and interest rate ceilings, an excess demand for money also might encourage the use of substitutes, and both unorganized money markets and foreign money sources are likely to be among the prime alternatives. By considering the interaction of these monetary phenomena, we can appropriately describe the behavior of money demand in developing countries.

In this section, we analyze currency substitution with financial dualism and consider the effects on the domestic demand for money.

Such study is likely to be relevant to South Korea, Taiwan, and many other economies. We assume that individuals and firms can borrow their working capital not only from domestic markets (both organized and unorganized) but also from foreign sources. To this end, we expand the framework of the previous section to examine a domestic money demand function for developing countries allowing for combining financial dualism and foreign exchange considerations. The model can be rewritten as follows:^[21]

$$(3.6) \text{ Minimize: } C = i_d m_d + i_u m_u + (i_f + \delta - x) m_f,$$

$$\text{Subject to: } m_s = T(t) \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta},$$

where $i, j = d, u$, and f .

Again, based on the minimization process, we can derive the optimal demand for domestic money in organized markets as follows:

$$(3.7) \ m_d = \alpha_{dd}^{-1/\beta} \left\{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \right. \\ \left. + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \right\}^{-2/\beta} y^{1/u} T^{-1}.$$

Equation (3.7) can be expressed as follows:

$$(3.8) \ M_d = M_d(i_d, i_u, i_f, \delta, x, y, T).$$

This expression reveals that the optimal demand for money in the organized market depends on both domestic markets (organized and unorganized) and foreign interest rates, as well as on the expected

rate of depreciation, the degree of capital controls, and income. The comparative statics associated with equation (3.8) are:

$$\partial m_d / \partial i_d = Q(-2/2-\beta) [R i_u^{-1} + S(i_f + \delta - x)^{-1}] < 0,$$

$$\partial m_d / \partial i_f = Q(-2/2-\beta) S(-i_d)(i_f + \delta - x)^{-2} > 0,$$

$$\partial m_d / \partial i_u = Q(-2/2-\beta) R(-i_d) i_u^{-2} > 0,$$

$$\partial m_d / \partial x = Q(-2/2-\beta) S(i_d)(i_f + \delta - x)^{-2} < 0,$$

$$\partial m_d / \partial \delta = Q(-2/2-\beta) S(-i_d)(i_f + \delta - x)^{-2} > 0,$$

$$\partial m_d / \partial y = m_d(uy)^{-1} > 0, \text{ and}$$

$$\partial m_d / \partial T = -T^{-1} m_d < 0,$$

$$\begin{aligned} \text{where } Q = & \alpha_{dd}^{-1/\beta} \{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \\ & + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \}^{(-2/\beta)-1} y^{1/u} T^{-1}, \end{aligned}$$

$$R = [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)}, \text{ and}$$

$$S = [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)}.$$

These results are similar to the previous model and need no further discussion. They can be used to analyze the effects of financial liberalizations policies now being implemented or already undertaken in

developing countries. Both by raising the interest rate in the official banking system and by liberalizing foreign exchange restrictions, economic agents respond to such liberalization by reducing money demand in the official banking system.

In view of the policy implications of currency substitution, we need to identify clearly the specific determinants of this phenomenon. The factors determining the ratio of holding currencies can be presented in our model. All first-order conditions of the domestic economic agent's optimization problem are taken into account here to discuss the determinants of the ratio of domestic to foreign money holdings. This function provides the basis for the subsequent analysis of the determinants of currency substitution. From Appendix A, the ratio of holding monies is as follows:

$$(3.9) \quad (m_d/m_f) = ((\alpha_{ff}/\alpha_{dd})^{1/2} [i_d/(i_f + \delta - x)])^{2/(\beta-2)},$$

Money stocks are chosen such that the relative reductions in transactions costs arising from holding the last units of the two monies equal the relative marginal opportunity costs. Equation (3.9) contains several variables that measure the opportunity cost of holding monies and a scale variable. This equation represents a quite general form of the currency substitution phenomenon than that given in other studies. The determinants of currency substitution have been sought by several economists. For example, Ramirez-Rojas (1985) believes the determinant of holding domestic relative to foreign money is only a function of the expected rate of depreciation of domestic money, a purely speculative motive for holding foreign currency.^[22] Saurman

(1986) shows that the ratio is a function of relative nominal interest rates. Stulz (1984) shows that the ratio of holding real domestic to foreign money balances does not depend on either the rate of time preference or coefficient of relative risk aversion. With specification of a reduced-form model of money demand, El-Erian (1988) presumes that the determinants are expectations of exchange rate changes, differential returns to the two holdings, and a term capturing political and institutional changes.

Equation (3.9) shows that money stocks are chosen such that the relative holding of the last units of the two monies equals the relative marginal opportunity holding costs. The determinants depend on interest rates, expectations of exchange rate depreciation, the degree of capital controls, and the coefficients of the monetary services function. Equation (3.9) also shows that the productivity of domestic real balances is an increasing function of the distribution parameter α_{dd} , since $\beta-2$ is negative, and the higher α_{dd} (lower α_{ff}) or the lower domestic interest rates i_d (higher foreign interest rates i_f), the higher is the economic agent's relative holdings of domestic real balances. The increase in (m_d/m_f) ratio caused by an increase in α_{dd} is an increasing function of the substitution parameter, β , that is, the degree to which currencies are substitutes for each other in the production of monetary services.

A change in technological progress that leaves nominal relative holding costs and the parameters of the production function of monetary services unchanged does not affect the ratio of holding monies. Since it is assumed that the scale variable in the domestic and foreign money demand functions are similar, and therefore plays no role in

determining the demand for domestic currency relative to that for foreign balances, the level of income does not appear explicitly in this function. In addition, a greater degree of capital control or a lower expected exchange rate will raise the holding of domestic money.

Since most developing countries face a shortage of foreign exchange, reducing the degree of currency substitution is an important issue. By altering the relative returns to money balances and their attractiveness, the monetary authority can influence the magnitude of currency substitution. One policy is to promote foreign currency bank deposits provided by the private sector in the domestic financial system to diminish the outflow of foreign currency. These deposits can be viewed by the government as a way of increasing the supply of foreign exchange resources.^[23]

In practice, the implications may be important for developing countries where foreign currency is in keen competition with domestic currency. In that case, this analysis presents a justification for some small open economies with a weak domestic currency to peg their value to a major and strong outside currency. Ramirez-Rojas (1985) argues that it is an illusion to think that by keeping foreign money at home the monetary authorities avoid and offset outflows of foreign exchange. The introduction of domestic deposits of foreign exchange does not change the extent of currency substitution. According to our analysis, except for interest rate policy, there are several other policy options to reduce currency substitution. The authorities may deal directly with the problem through exchange rate policy, the productivity of money service, and the measurement of capital controls.

Recently, currency substitution has increased significantly in

Korea and Taiwan, both of which have a large trade surplus with the United States. Both face growing U.S. pressure to revalue their exchange rates. In such a situation, domestic residents may reduce their demand for foreign money and increase their holdings of domestic real cash balances. These changes may be reflected as an increase in international reserve, an appreciation of the domestic exchange rate, or both. In order to reduce the official holding of foreign exchange and currency substitution, the Taiwan government has further decontrolled foreign exchange, which has been regulated since 1949, and has allowed residents to hold and manage foreign exchange. Knowledge of the extent to which foreign exchange considerations affect domestic money holding is important for the design of both monetary and exchange rate policy.

3.4 The Econometric Specification and Estimation Results

The plan of this section is to estimate the value of parameters of the money demand function and the elasticities of currency substitution using quarterly data for Korea and Taiwan under a fixed exchange rate regime.^[24] Our objective is to see whether this situation is compatible with the implications of our theoretical model. Equations (3.5) and (3.7), as they stand, make no allowance for dynamic short-run disequilibrium. We therefore adopt a simple distributed lag of the type adopted by Bisignano (1974) and Moroney and Wilbratle (1976). We consider that actual money holdings are adjusted to optimal money holdings, following a partial adjustment process. That is, dynamic adjustments are recognized here by adopting the widely used assumption that the difference between the actual demand for domestic money, $m_{d,t}$, and its desired level, $m_{d,t}^*$, is adjusted at a constant speed, τ , within the period of observation. We assume that the money demand does not adjust instantaneously to the desired level, but rather obeys the proportionate adjustment scheme.^[25] The introduction of a lagged term could mean that a short-run stock adjustment model is justified, given that the estimation is based on quarterly data. The general form of this partial adjustment process is as follows:

$$(3.10) \quad m_{d,t} = (m_{d,t}^*)^\tau (m_{d,t-1})^{(1-\tau)}.$$

Separately substituting equations (3.5) and (3.7) into equation (3.10) and adding an error term, v_t , yields a domestic money demand equation suitable for parameter estimation. That is,

$$(3.11) \quad m_d = \alpha_{dd}^{-\tau/\beta} \{ 1 + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \}^{-2\tau/\beta} \\ y^{\tau/\mu} T^{-\tau} (m_{d,t-1})^{(1-\tau)} + v_{1t}.$$

Equation (3.11) represents the demand for money in the presence of currency substitution, and equation (3.12) represents the demand for money in the presence of both substitution and financial dualism.

$$(3.12) \quad m_d = \alpha_{dd}^{-\tau/\beta} \{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \\ + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \}^{-2\tau/\beta} y^{\tau/\mu} T^{-\tau} (m_{d,t-1})^{(1-\tau)} + v_{2t}.$$

The stochastic disturbance terms, v_t , are introduced directly into the demand equations. The statistical properties of v_{it} , $i=1, 2$, are assumed to be $v_t \approx N(0, \sigma_v)$, $E(v_t) = 0$, and $E(v_t, v_{t-1}) = 0$. The elasticity of currency substitution, σ , can be obtained by using the estimated substitution parameter β . This procedure also determines the substitutability-complementarity by simply observing the signs and magnitude of σ .

Three difficulties arise in estimating the parameters associated with equations (3.11) and (3.12). First, the capital controls variable in the above equations is not directly measured. Studies by Otani and Tiwari (1981) and Otani (1983) examined capital controls and covered interest parity between Yen-denominated and dollar-denominated assets. They examined the difference between three-month Gensaki, which are repurchase agreements in Japan, and three-month Euro-Yen deposit rates. The authors explained deviations by episodes of capital controls instituted by the Japanese government. There are no comparable data for South Korea and Taiwan in Euro-markets, so we do not have a good

empirical measure of capital controls for both countries. However, several researchers have argued that when there are no severe controls or other type of deterrent to the holding of foreign currency, the transaction costs incurred in the exchange of domestic for foreign money will tend to be small.^[26] In the previous section, we showed that money demand depends on i_d , i_f , and x , given the existing set of capital controls. We focused on i_d , i_f , and x , because these factors have more implications for currency substitution than do capital controls. However, any changes in capital controls can be reflected in structural breaks in money.

Second, to estimate the model, we need to specify the empirical proxy to be used for the expected change in the exchange rate. Although there has been much research in this area, this literature reveals little consensus about the most appropriate expectation mechanism for exchange rates. There are several possible proxies for this variable.

One approach, adopted by Cuddington (1983) and Daneil and Fried (1983), is to assume future exchange rates can be assumed to be equal to today's forward exchange rate, $E_t(e_{t+1}) = e_t^f$. This expectation mechanism implies that the exchange risk is zero. Hansen and Hodrick (1980) cast serious doubts on the validity of the forward exchange rate as an expectation model. Baillie, Lippens, and McMahon (1983), using weekly observations on several currencies, test the hypothesis that the forward exchange rate is an unbiased predictor of the corresponding future spot rate. Their results show that the simple view that the forward rates contain all relevant information necessary to forecast future spot rates is inappropriate.

Another proxy candidate for changes in the expected exchange rate is the differential between the domestic and foreign interest rate. If these rates are freely determined by market forces, the differential between them may be a good indicator of the expected change in the exchange rate. However, the control of interest rates has been a common practice in Korea and Taiwan. In addition, the estimated equation already includes a domestic and foreign interest rate variable, so its use in constructing an empirical proxy may be misleading.

An alternative proxy is the current differential between inflation rates at home and abroad. It is obvious that such a measure is based on a purchasing power parity (PPP) notion of the exchange rate. A similar approach is presented by Blejer (1978) and Fasano-Fillho (1985), who set

$$x_t = \ln P_{d,t} - \ln P_{f,t} - \ln e_{b,t},$$

where P_d and P_f are the price levels, at home and abroad, respectively, and e_b is the black market exchange rate. We may call this the PPP-black market expectation mechanism. It implies that people form their expectation about future exchange rates by using information about the past behavior of prices and the black market exchange rate.^[27] In other words, people expect the official exchange rate to appreciate by the amount that the black market rate differs from PPP.

Recently, the predictive power of existing theoretical exchange rate models has been challenged by Meese and Rogoff (1983). They show that the model with the more accurate predictive power is one in which the exchange rate this period is expected to prevail in the future period^[28], that is, $E_t(e_{t+1}) = e_t$. Based on its superior forecasting

power, Marquez (1987) adopts this as the expectation mechanism. It might be appropriate to use the random-walk hypothesis as an expectation model for a country if its monetary authorities use large international reserves to maintain a fixed exchange rate system during the period under consideration.

A final approach, adopted by Symansky, Haas, and Hooper (1981) and Dooley and Isard (1982) rests on the rational expectation hypothesis, that is, today's expectations are unbiased predictors of future exchange rates (using the actual future spot rate as a proxy). In other words, $E_t(e_{t+1}) = e_{t+1}$, where e_{t+1} is the realized spot exchange rate in period $t+1$. However, using the actual spot rate as a proxy for the expected future rate involves an error-in-variables bias.

The institutional framework of Korea and Taiwan in the time period analyzed was one of interest rate ceilings, exchange controls and a black market, a lack of a forward exchange market, and the commitment of monetary authorities to support the fixed exchange rate system. In this thesis we adopt two expectation mechanisms. The first mechanism is the PPP-black market expectation mechanism. The other mechanism adopted is the random-walk hypothesis for exchange rate expectations. We should note that this thesis does not emphasize the virtues or defects of any expectation mechanism as an explanation of exchange rate changes. Our test involves a joint test for the hypotheses of currency substitution and for the validity of the model for exchange rate expectation. Although our analysis does not resolve this identification problem, we examine the sensitivity of the parameter estimates for these two expectation mechanisms.

Finally, equations (3.11) and (3.12) are complicated by intricate

nonlinearity in the parameters and are estimated using the nonlinear least squares method. The algorithm employed here is Marquardt's Method. Nonlinear estimation requires us to specify initial values for all parameters to be estimated. The more parameters there are, the greater is the danger that the selected initial values will lead to estimates which have converged to a local rather than a general minimum. For this reason we started the estimation with an abridged version of equations (3.11) and (3.12):

$$(3.13) \quad m_d = \{ 1 + [i_d / (i_f + \delta - x)]^{\beta / (2 - \beta)} (\alpha_{ff} / \alpha_{dd})^{1 / (2 - \beta)} \}^{-2\tau / \beta} \\ y^{\tau / \mu} T^{-\tau} (m_{d,t-1})^{(1-\tau)} + v_{1t},$$

Equation (3.13) represents the demand for money in the presence of currency substitution.

$$(3.14) \quad m_d = \{ 1 + [i_d / i_u]^{\beta / (2 - \beta)} (\alpha_{uu} / \alpha_{dd})^{1 / (2 - \beta)} \\ + [i_d / (i_f + \delta - x)]^{\beta / (2 - \beta)} (\alpha_{ff} / \alpha_{dd})^{1 / (2 - \beta)} \}^{-2\tau / \beta} y^{\tau / \mu} T^{-\tau} (m_{d,t-1})^{(1-\tau)} + v_{2t}.$$

Equation (3.14) represents the demand for money in the presence of both currency substitution and financial dualism.

In Appendix D, we list the data definitions and sources for different variables. We present nonlinear least-squares estimates using quarterly data for equations (3.13) in Table 3.1-3.2 and equation (3.14) in Table 3.4-3.5. These tables display the estimated parameters associated with conditional money demand functions for each of the four monetary aggregates (CC, DD, M1, and M2), and for each of the two exchange rate expectation mechanisms (random-walk model and PPP-black

market). Each monetary aggregate is deflated by the GNP deflator. The estimated equations are reported with the asymptotic t-value of each parameter estimate and the standard summary statistics, such as adjusted coefficient of determination, Durbin-Watson statistic, and F test. In addition, the estimated elasticities of substitution are calculated in Table 3.3 and 3.6. In the following section, we first discuss empirical results regarding the demand for money in the presence of currency substitution. We then report the case when currency substitution and financial dualism are considered in the demand for money function.

3.4.1 Empirical Results: The Demand for Money in the Presence of Currency Substitution

The Case of Taiwan

The estimation results for Taiwan, displayed in Table 3.1, indicate that all estimated parameters are always of the expected sign and have acceptable values, as suggested by our model; for example, the substitution parameter, $\beta \leq 2$, the speed of adjustments $0 \leq r \leq 1$, income elasticity μ , and the ratio of distribution parameters $\alpha_{ff}/\alpha_{dd} > 0$. When estimating equation (3.13) it is not surprising that the Adj R^2 are so high since m_d will certainly have a unit root and therefore be virtually perfectly correlated with $m_{d,t-1}$. The high values of the corrected R^2 (Adj R^2) together with the low-estimated t-value for the coefficients indicate multicollinearity. According to Table 3.1, the speed of adjustment, r , is statistically significant for all definitions of money used except M2. This implies that the "partial adjustment toward stock equilibrium" specification is appropriate. The

estimate of the speed of adjustment ranges from 0.48 to 0.96, implying that the adjustment to equilibrium is quickly achieved by the end of the current quarter. The estimates of inverse income elasticity, μ , are highly significant in most monetary aggregates. Income elasticities range from 2.21 to 2.89. Note that the ratio of distribution parameters α_{ff}/α_{dd} are always of the expected sign, but insignificant with low t-values. Similar problem was shown in Marquez's study (1987).

Table 3.1 reports the estimated substitution parameter β for different monetary aggregates. When exchange rate expectations rely on the random walk mechanism, we find that estimated substitution parameter β in both DD and M1 is statistically significant (t-values are 2.57 and 1.76, respectively). The estimated substitution parameter β in the other two monetary aggregates, CC and M2, is insignificant and has a low t-value. Again, if expectations are based on the PPP-black market mechanism, the estimated substitution parameter β in both DD and M1 is statistically significant (t-values are 2.71 and 2.75, respectively). The estimated parameter β in both CC and M2 is insignificant.

Table 3.3 shows elasticities of substitution of different monetary aggregates during 1965.I-1979.I. The elasticities range from 1.02 for demand deposits (DD) to 1.04 for M1, a relatively narrow range of variation. These values are slightly greater than one, the critical value above which currencies are said to be substitutes. In general, the results show weak evidence (in terms of low elasticity of substitution) of currency substitution in Taiwan.

The Case of Korea

Table 3.2 provides the estimated results for Korea. It shows that all estimated parameters β , τ , μ , and α_{ff}/α_{dd} are always of the expected sign and of acceptable values, as suggested by the theoretical model. Again, both the estimated speed of adjustment, τ , and inverse income elasticities, μ , are highly statistically significant in terms of their respective t-values. The slow adjustment to equilibrium takes place in a quarter, and the estimates of μ imply an income elasticity ranging from 1.34 to 2.49. The ratio of distribution parameters α_{ff}/α_{dd} are always of the expected sign, but insignificant with low t-values.

However, it is disappointing to find that the β substitution parameters of all definitions of money used in Table 3.2 is statistically insignificant for both expectation mechanisms. The β parameters for all monetary aggregates have low t-values, exceeding unity only for CC and M1. Elasticities of substitution of different monetary aggregates, shown in Table 3.3, range from 1.05 for CC to 1.66 for DD. In all cases of different monetary aggregates, however, elasticities of substitution are statistically insignificant. Thus, there is no evidence of currency substitution in the demand for CC, DD, M1, and M2 in the Korean case.

The policy implication, in contrast to Marquez's study (1987), is that banking regulations preventing the circulation of foreign currency have dampened currency substitution in Korea and Taiwan. The lack of distinct evidence, particularly in the Korean case, may arise from three sources. First, failure to consider the capital controls variable may have caused many statistically insignificant results. Perhaps there should be a proxy variable for transaction costs and capital controls. Second, the data for the explanatory variables are highly

correlated, and the resulting multicollinearity leaves unresolved the problem of disentangling the individual effects of each variable. Finally, the estimated equation (3.13) that we adopted in our empirical work may contribute to the negative results, because we did not consider how financial dualism affects the behavior of money demand in both countries.

**Table 3.1 Parameter Estimates for Conditional Money Demand:
The Currency Substitution Case, Taiwan, 1965.I-1979.I**

Expect- ations Mechanism	Dep Var	Estimated Parameter				Summary Statistics		
		β	r	μ	$(\alpha_{ff}/\alpha_{dd})$	Adj R^2	D. W.	F-test
Random- Walk Model	CC	0.017 (0.68)	0.510* (7.15)	0.452* (46.1)	0.010 (0.33)	0.987	2.469	1442
	DD	0.045* (2.57)	0.954* (11.3)	0.422* (65.9)	0.012 (1.27)	0.982	1.393	1041
	M1	0.035** (1.76)	0.811* (10.5)	0.432* (65.3)	0.005 (0.47)	0.986	1.493	1343
	M2	0.403 (0.14)	0.014 (0.23)	0.346 (1.38)	0.538 (0.10)	0.996	1.194	1211
PPP-Black Market	CC	0.048 (1.24)	0.484* (6.51)	0.451* (48.5)	0.015 (0.53)	0.987	1.785	1407
	DD	0.055* (2.71)	0.959* (12.9)	0.415* (84.1)	0.026 (1.15)	0.985	1.437	1261
	M1	0.079* (2.75)	0.779* (10.5)	0.429* (75.1)	0.040 (1.11)	0.987	1.472	1422
	M2	0.376 (0.76)	0.063 (1.09)	0.389* (9.83)	3.706 (0.22)	0.996	1.087	1484

Note: Dep Var is the dependent variable,
Adj R^2 is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level,
** indicates significance at the 10 % level.

Table 3.2 Parameter Estimates for Conditional Money Demand:
The Currency Substitution Case, Korea, 1965.I-1979.IV

Expect- ations Mechanism	Dep Var	Estimated Parameter				Summary Statistics		
		β	r	μ	$(\alpha_{ff}/\alpha_{dd})$	Adj R^2	D. W.	F-test
Random- Walk Model	CC	0.089 (1.42)	0.202* (5.72)	0.402* (8.13)	0.0655 (0.63)	0.933	2.368	275
	DD	0.632 (0.09)	0.083* (3.37)	0.746* (4.30)	0.015 (0.10)	0.972	2.314	672
	M1	0.159 (0.90)	0.170* (6.82)	0.608* (9.89)	0.052 (0.53)	0.968	2.327	583
	M2	0.308 (0.47)	0.122* (7.02)	0.634* (10.0)	0.021 (0.38)	0.989	2.316	462
PPP-Black Market	CC	0.095 (1.41)	0.300* (10.5)	0.538* (15.8)	0.089 (0.64)	0.952	2.565	387
	DD	0.797 (0.42)	0.083* (3.42)	0.715* (4.63)	0.264 (0.63)	0.973	2.233	670
	M1	0.239 (1.31)	0.168* (6.81)	0.593* (10.2)	0.199 (0.66)	0.969	2.411	607
	M2	0.368 (0.77)	0.121* (7.00)	0.619* (10.2)	0.081 (0.50)	0.989	2.345	709

Note: Dep Var is the dependent variable,
Adj R^2 is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

**Table 3.3 Estimated Elasticities of Substitution
in Currency Substitution.**

Country ----- Monetary Aggregates	Taiwan -----		Korea -----	
	Random-Walk Expectations	PPP-Black Mkt Expectations	Random-Walk Expectations	PPP-Black Mkt Expectations
CC	1.01	1.02	1.05	1.05
DD	1.02	1.03	1.46	1.66
M1	1.02	1.04	1.09	1.14
M2	1.25	1.23	1.18	1.23

Source: Table 3.1-3.2

Note: The elasticity of substitution in a quadratic function is $2/(2-\beta)$

Table 3.4 Parameter Estimates for Conditional Money Demand:
The Currency Substitution and Financial Dualism,
Taiwan, 1965.I-1979.I

Expect- ations Mechanism	Dep Var	Estimated Parameter					Summary Statistics		
		β	r	μ	α_{uu}/α_{dd}	α_{ff}/α_{dd}	AdjR ²	D. W.	F-test
Random- Walk Model	CC	0.194** (1.70)	0.354* (4.22)	0.456* (27.3)	0.026 (0.46)	0.300 (0.62)	0.983	1.964	847
	DD	0.288* (3.09)	0.660* (6.23)	0.439* (34.9)	0.030 (0.66)	0.590 (0.98)	0.972	1.682	495
	M1	0.602 (0.59)	0.103 (0.76)	0.396* (4.34)	1.888 (0.27)	2.885 (0.14)	0.960	2.703	337
	M2	0.421 (0.14)	0.012 (0.20)	0.315 (0.87)	0.273 (0.12)	1.316 (0.11)	0.996	1.192	115
PPP-Black Market	CC	0.363 (1.08)	0.217** (1.84)	0.524* (6.67)	3.816 (0.24)	1.701 (0.16)	0.963	1.690	362
	DD	0.499* (2.13)	0.430* (3.56)	0.421* (23.5)	4.190 (0.41)	2.566 (0.41)	0.962	2.106	359
	M1	0.577** (1.75)	0.294* (2.57)	0.427* (18.4)	4.172 (0.29)	3.040 (0.38)	0.970	2.350	449
	M2	0.519 (0.58)	0.052 (0.88)	0.387* (7.94)	4.504 (0.15)	1.068 (0.11)	0.996	1.190	353

Note: Dep Var is the dependent variable,
Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.
** indicates significance at the 10 % level.

**Table 3.5 Parameter Estimates for Conditional Money Demand:
Currency Substitution and Financial Dualism,
Korea, 1965.I-1979.IV**

Expect- ations Mechanism	Dep Var	Estimated Parameter					Summary Statistics		
		β	r	μ	α_{uu}/α_{dd}	α_{ff}/α_{dd}	AdjR ²	D. W.	F-test
Random- Walk Model	CC	0.412* (2.43)	0.245* (5.78)	0.491* (6.28)	0.855 (0.79)	4.743 (0.36)	0.938	2.127	224
	DD	0.653 (0.86)	0.040 (1.36)	0.491 (1.58)	4.398 (0.19)	6.547 (0.42)	0.969	2.121	467
	M1	0.406* (2.19)	0.137* (4.37)	0.515* (4.93)	0.129 (0.31)	4.391 (0.36)	0.966	2.315	416
	M2	0.516* (2.38)	0.093* (4.21)	0.507* (4.82)	0.017 (0.13)	4.737 (0.40)	0.987	2.232	1145
PPP-Black Market	CC	0.330* (2.28)	0.251* (5.83)	0.484* (6.25)	0.300 (0.31)	3.609 (0.32)	0.942	2.310	240
	DD	0.704 (1.34)	0.053* (1.71)	0.521* (1.94)	5.038 (0.27)	5.231 (0.18)	0.971	2.237	496
	M1	0.432* (2.05)	0.135* (3.99)	0.501* (4.47)	0.351 (0.27)	4.094 (0.26)	0.966	2.356	421
	M2	0.464* (2.24)	0.091 (3.86)	0.488 (4.39)	0.117 (0.13)	4.277 (0.29)	0.987	2.233	1148

Note: Dep Var is the dependent variable,
Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.
** indicates significance at the 10 % level.

**Table 3.6 Estimated Elasticities of Substitution in Presence of
Currency Substitution and Financial Dualism**

Country	Taiwan		Korea	
-----	-----	-----	-----	-----
Monetary Aggregates	Random-Walk Expectations	PPP-Black Mkt Expectations	Random-Walk Expectations	PPP-Black Mkt Expectations
CC	1.11	1.22	1.26	1.20
DD	1.17	1.33	1.48	1.54
M1	1.43	1.41	1.25	1.28
M2	1.27	1.35	1.35	1.30

Source: Table 3.4-3.5

Note: The elasticity of substitution in a quadratic function is $2/(2-\beta)$

3.4.2 Empirical Results: The Demand for Money in the Presence of

Currency Substitution and Financial Dualism

In this section, we present the empirical results concerning the effect of currency substitution and financial dualism on money demand in Taiwan and Korea. For those economies, money substitutability often is extended to include financial dualism, and hence the interest rate of unorganized money markets may be an opportunity cost of holding money. We incorporate two monetary phenomena into the model to see how they affect the estimated parameters of domestic money demand.

The Case of Taiwan

Table 3.4 reports parameter estimates for conditional money demand in the presence of currency substitution and financial dualism. The estimated parameters, β , τ , μ , α_{uu}/α_{dd} , and α_{ff}/α_{dd} , shown in Table 3.4,

have the expected sign and acceptable, as suggested by section 3.3. Most parameters of the estimated speed of adjustment, τ , and inverse income elasticity, μ , are statistically highly significant in terms of their t-values. Income elasticities range from 1.91 to 3.17. Note that the ratio of distribution parameters α_{uu}/α_{dd} and α_{ff}/α_{dd} are always of the expected sign, but insignificant with low t-values.

In Table 3.4, t-values of the estimated substitution parameter β in both CC and DD are statistically significant (t-values are 1.70 and 3.09, respectively) under the random walk mechanism. This is also the case for DD and M1 (t-values of 2.13 and 1.75, respectively) when the PPP-black market mechanism is used. In addition, Table 3.6 reports the magnitude of elasticities when expectations follow a random walk model (1.11 for CC, 1.17 for DD, 1.43 for M1, and 1.27 for M2) and the PPP-black market mechanism (1.22 for CC, 1.33 for DD, 1.41 for M1, and 1.35 for M2). Each of these values is greater than one, the critical value above which currencies are said to be substitutes.

Compared Table 3.6 with Table 3.3, we find that magnitudes of elasticity in the presence of currency substitution and financial dualism are higher than in the presence of currency substitution alone. In sum, the evidence from Taiwan shows statistically significant currency substitution in CC, DD, and M1.

The Case of Korea

Table 3.5 reports estimation results of different monetary aggregates for Korea. The overall results are good in terms of the expected sign and the acceptable values; for example, $\beta \leq 2$, $0 \leq \tau \leq 1$, μ , α_{uu}/α_{dd} and $\alpha_{ff}/\alpha_{dd} > 0$. Again, all parameters of the estimated speed of adjustment, τ , and inverse income elasticity, μ , are highly

statistically significant in terms of t-value. Income elasticities range from 1.34 to 2.49. Again, the ratio of distribution parameters α_{uu}/α_{dd} and α_{ff}/α_{dd} are always of the expected sign, but insignificant with low t-values. When random-walk is assumed, the β substitution parameter of all definitions of money used, except for DD, is statistically significant. Under the PPP-black market mechanism, we also find that the β substitution parameters for CC, M1, and M2 is highly significant in terms of t-values. In Table 3.6, elasticities of substitution are 1.26 for CC, 1.48 for DD, 1.25 for M1, and 1.35 for M2, when the expectations mechanism is based on the random-walk hypothesis, compared to 1.20 for CC, 1.54 for DD, 1.28 for M1, and 1.30 for M2 if the PPP-black market mechanism is used. In sum, the evidence from Korea shows statistically significant currency substitution in CC, M1, and M2.

Comparing Table 3.5 with Table 3.2, it can be seen that both t-values of the substitution parameter β and the magnitude of β become significant and increase. Interestingly, similar to the Taiwan case, the magnitude of elasticities in the presence of currency substitution and financial dualism are higher than for currency substitution alone. The latter results are likely to be biased because the estimates of the coefficients do not recognize that unorganized money markets in Taiwan and Korea also can serve as substitutes for domestic currency.

All previous empirical work in this area assumes that domestic asset holders switch directly from domestic currency, demand deposits, M1, and M2 into foreign currency due to their response to differential returns on alternative currencies. That is, the literature has been limited to examining the substitutability between domestic and foreign

currency only, without recognizing that unorganized money markets in developing countries can serve as substitutes for domestic money. Given the higher interest rates of these unorganized markets, we consider the possibility that domestic residents switch from holdings of domestic currency to holdings in unorganized markets rather than directly shifting into foreign currency. We find that including the unorganized market's interest rate improves estimation results.

In addition, including financial dualism in estimating the demand for money yields different policy implications from the case presented in 3.4.1. Here, similar to Marquez's study (1987), we find, that banking regulation preventing the circulation of foreign currency is not a precondition for the existence of currency substitution, at least in Korea and Taiwan. However, elasticities of substitution in both countries are relatively small, the monetary authorities should be able to predict the consequence of a particular policy fairly well.

3.5 Conclusion

Traditional studies of the demand for money often have ignored the influence of foreign monetary developments. The purpose of this chapter has been to develop a model that allows us to examine currency substitution and measure the degree of substitution in developing countries. Instead of the CES function, we adopted a quadratic function. We applied producer theory to derive the conditional money demand function, based on the optimizing cost-minimization model.

The optimal demand for money in an open economy depends on domestic and foreign interest rates, the expected rate of depreciation, the degree of capital controls, the given aggregate level of monetary services, and technological change. An important point is that the introduction of currency substitution modifies the determinants of traditional demand for money. The modified function has added additional opportunity cost variables, foreign interest rates, and expected exchange rates. Interestingly, the direction and effects of changes in foreign interest rates on money demand are different from the findings of the portfolio approach. Our model shows that the optimal money demand will increase in response to higher foreign interest rates rather than decrease, as the portfolio approach expects.

Research to date has been limited to examining the substitutability between domestic and foreign money, without recognizing that unorganized money markets in developing countries can also serve as substitutes for domestic money. We have investigated the behavior of money demand in the presence of currency substitution and financial dualism in developing countries. The main conclusion is that conventional treatments consider these areas separately and thus ignore

potentially important implications for the demand for money in developing countries. The work on both currency substitution and financial dualism has enhanced our understanding of the behavior of aggregate money demand.

We provided empirical studies to estimate different parameters and elasticities of substitution for Korea and Taiwan under a fixed exchange rate regime. When only currency substitution is considered in the demand for money, the results show weak evidence of currency substitution in Taiwan and not support in the Korean case. These results are likely to be biased because their estimates of the coefficients do not recognize that unorganized money markets in Taiwan and Korea also can serve as substitutes for domestic currency. We then estimated the money demand function in the presence of both currency substitution and financial dualism. We found that magnitudes of elasticity in the presence of both are higher than in the presence of currency substitution only. Those values are greater than one, the critical value above which currencies are said to be substitutes.

In sum, the evidence from Taiwan shows statistically significant currency substitution in CC, DD, and M1. Korea also shows statistically significant currency substitution in CC, M1, and M2. We concluded that banking regulations preventing the circulation of foreign currency are not a precondition for currency substitution, at least in Korea and Taiwan. The empirical evidence also suggests that both foreign exchange considerations and financial dualism are important for modeling money demand behavior in Korea and Taiwan.

Footnotes—Chapter III

1. It is not possible to obtain a functional form for a production function which has an arbitrary set of constant elasticities of substitution if the number of factors is greater than two. This result is contained in the impossibility theorem of Uzawa (1962) and McFadden (1963). In the literature on money substitution, some economists use extensions of the C.E.S. function. Examples are Mukerji-Kurz C.E.S. function used by Chetty (1969), Boughton (1981), and Husted-Rush (1984), who are more concerned with measuring elasticities between a single type of pairs (that is, money and different assets).

2. There are three different concepts of elasticity of substitution in the literature: the direct, shadow, and Allen-Uzawa elasticity of substitution. For formal definitions of these, see Mundlak (1968).

3. There is still disagreement about the best way to model the demand for money. Alternatives include the overlapping generation approach, the money-in-the-utility-function approach, the cash-in-advance constraint approach, and the ad hoc money demand function approach.^[3] In addition, several researchers, such as Friedman (1969), Johnson (1969), Short (1979), and Stulz (1984), have attempted to understand the link between the real and monetary sectors of an economy. They argue that real money balances are a factor of production and should be included in the aggregate production function. In this thesis no attempt will be made to develop a model centering on the relationships between the real and monetary sectors. See McCallum (1983) and Kareken and Wallace (1980) for more discussion of the issues involved. Barnett (1980) argues that for a monetary aggregate to be economically meaningful, it must rest on economic optimization principles.

4. For simplifying purposes the production approach does not consider the capital stock as part of wealth.

5. For further discussion of this argument, refer to the studies by Stockman (1980) and Girton and Roper (1981).

6. In the past, individuals in Korea and Taiwan have been subject to tight restrictions on foreign currency holdings, while the restrictions on firms have been less severe. Without severe exchange controls or other deterrents to the holding of foreign money, the transaction costs incurred in the currency substitution will be relatively small, compared with the other means of holding wealth, thereby creating a further bias in these economies toward the holding of foreign money. Although the degree of currency substitution in Korea and Taiwan are difficult to measure, there is evidence that speculative currency substitution is quantitatively significant. Green (1987) quotes the empirical results of Kim (1985) and suggests that speculative currency substitution has been quantitatively significant in Korea since a crawling peg for the Won was instituted in 1980. The extent to which foreign currency has actually been used in transactions is difficult to determine. Nevertheless, it is useful to speculate that

significant currency substitution in Korea and Taiwan. In addition, according to Cole and Partick (1984), for many developing countries in the Pacific Basin, the U.S. dollar is used extensively outside national boundaries. They point out that the functions of holding foreign currency and deposits are store of value, transactions, speculation, and tax evasion.

7. One may argue that the opportunity cost between two currencies is the expected change in the exchange rate. Miles (1981) noted that the independent variable $\log(1+i_f) - \log(1+i_d)$ closely approximates $i_f - i_d$, which in an efficient market should equal the forward premium on foreign money. Bordo and Choudhri (1982) also argued that the uncovered interest differential $(i_f - i_d)$, which is approximately equal to Miles's $\log[(1+i_f)/(1+i_d)]$, equals the expected rate of depreciation when the interest rate parity condition is satisfied. If foreign balances were to depreciate vis-a-vis domestic balances while they are held, then the bearer faces increased total cost because of the additional assets that must be liquidated in order to maintain a constant level of transactions. If, however, these foreign balances are expected to appreciate in the short run, the holder can reduce the size of his domestic money holdings given any desired level of transaction.

8. Recently, Joines (1985) argued that by using $(1+i_f)/(1+i_d)$ rather than i_f/i_d as the relative cost of holding money balances, the variance of the former will be smaller than the variance of the latter, and hence the regression slope coefficient will be larger if $\log[(1+i_f)/(1+i_d)]$ rather than $\log(i_f/i_d)$ is used as the independent variable. However, since the use of $\log[(1+i_f)/(1+i_d)]$ inflates the standard error of the slope coefficient in the same proportion as the coefficient itself, it does not affect measures of statistical significance.

9. See Diewart (1971), Denny (1974), and Kadiyala (1972). The regularity conditions for this production function are : (1) it is a positive function; (2) it is a constant return to scale production function; and (3) it is a concave function.

10. If $f(x)=y$ is the production function of y by using input x , two restrictions imply that:

- (i). $f(x') \geq f(x)$ for $x' \geq x$,
- (ii). the set. $\{x : f(x) \geq y, x \geq 0\}$ is a convex set for every $y \geq 0$.

11. Although Husted (1980) considered the transaction costs of maintaining balances in domestic and foreign currency, he assumed that these costs are constant and can be ignored. Canto (1985) introduced transaction costs directly through the money demand function. In our model, we introduce this variable through the optimization process.

12. Notice that since real balances in both currencies are in goods units, there is no need for an exchange rate. However, for empirically estimating this relationship, it is desirable to express the production function in nominal cash balances and exchange rates.

13. However, Cuddington (1983) and Thomas (1985) criticize the production approach for exaggerating the likely size of currency substitution if the demand for domestic and foreign monies is not embedded in a more general model of asset choice.

14. While this is clearly an ad-hoc assumption, it is at least consistent with the idea that a given level of output requires certain monetary services. If $u = 1$, then it implies a constant velocity of circulation of domestic money holdings. Marquez (1987) shows that one could measure M as a divisia index of domestic and foreign currency, an index of which is a second-order approximation to any functional form. However, this procedure requires data on balances denominated in foreign currency. Also see Barnett (1980).

15. Capital controls can be represented by a transaction cost. For example, see Frenkel and Levich (1977), Otani and Tiwari (1981), Dooley and Isard (1980), and Otani (1983).

16. The practical implication of Hicksian neutrality is that the ratio of the marginal products of any two inputs is independent of time.

17. The monetary approach suggests that with no currency substitution there is a stable money demand function for each currency that is independent on external nominal shocks, such as a change in the foreign interest rate.

18. Otani (1983) showed that the effect on the domestic interest rate of capital controls is to discourage outflows of arbitrage funds and is expected to be negative, and the absolute value of the interest rate effect is less than the increase in the transaction costs.

19. Study of monetary linkage among countries is addressed in the literature on international capital mobility. This literature focuses on the effect of adjustments in international reserves on the domestic money supply, with the assumption that aggregate demand for money in the country is inelastic with respect to foreign monetary developments. Arango and Nadiri (1981) argue that when these international monetary factors are omitted, the empirical results point to significant misspecification biases in the traditional money demand function.

20. All the literature studies the quantitative measurement of currency substitution by focusing on the two-currency case (domestic and foreign), using the so-called "direct" elasticity of substitution. However, if there are only two factors in producer theory, each must be a substitute for the other, when output is constant.

In the two-money input case, the elasticity of substitution measures the proportionate change in the ratio of the holding of domestic and foreign monies per unit proportionate change in the ratio of the holding cost when scale variables (here, monetary services) are held constant. The two-currency case thus misses many of the important issues that arise and rules out possible complementarity between pairs

of currencies; for example, does an increase in the opportunity cost of borrowing funds from an unorganized money market in most developing countries raise or lower the demand for domestic money in organized markets? (It could do either.)

We therefore move to the three-currency case and develop the Hicks-Allen elasticities of substitution. Here, the latter measure the sensitivity of the quantity of money input j to changes in total cost when the latter is measured in units of factor j , if all inputs except i and j are held constant. We are interested in the size of the elasticities.

21. Including money borrowed from unorganized markets, one could set the model along the lines followed by Cuddington (1983), which would require specifying the demand for this money, including assumptions regarding the holding of domestic money (from unorganized markets) by foreigners. In Sundararajan's (1987) study, he sets the private investment function to incorporate the influence of the cost of capital on the dual financial system and of the substantial use of foreign currency debt by firms.

22. If i_1 and i_2 are freely determined, the difference between the two rates-adjusted² for country risk-will tend to equal the expected change in the exchange rate. However, in developing countries a policy of maintaining a fixed nominal interest rate for long periods exacerbates currency substitution.

23. Spinelli (1983) discusses these three conditions for reducing currency substitution. First, the expected return on domestic financial instruments must be increased. Second, to accomplish a rise in this return, a net monetary contraction is required. Finally, overall demand management policies must be consistent and credible. In addition, Tanzi and Blejer (1982) argue that to prevent currency substitution the rate of interest paid to lenders must equal the equivalent rate after adjusting for differential taxation and intermediation costs.

24. Although currency substitution was developed under a framework of flexible exchange rates, this does not mean that it may not appear under a fixed exchange rate regime. Expectations about the future behavior of exchange rates have certainly become more volatile with the implementation of flexible rates. It is sometimes claimed that currency substitution only arises under flexible rates and that under fixed exchange rates central banks make moneys perfect substitutes from the supply side. Husted (1980) assumed that central banks are, with certainty, expected to be able to maintain parities, with expectations vanishing in a fixed exchange rate system.

However, this is misleading. We recognize that under any regime a relevant question is: For how long will the central bank maintain a given parity? Currencies are only perfect substitutes in the fixed exchange rate case if private investors have complete confidence that the official exchange rate will be maintained indefinitely. It is inappropriate to assume that there are no expectations regarding fixed exchange rates. The fact that the exchange rate is "pegged" does not rule out the possibility of currency substitution. Expectations about

the future value of the exchange rate is more relevant to currency substitution. Ramirez-Rojas (1985) further discusses the relation between futures markets for foreign exchange and currency substitution. He argues that the futures market will reduce the uncertainty about the future exchange rate, but this does not necessarily cause an increase in the demand for money. In this chapter, the role of futures markets in currency substitution and related issues is not discussed.

25. This simple distributed lag is of the type postulated by Nerlove (1956). Bisignano (1974) argued that one limitation of this assumption is that the speed of adjustment is the same for all explanatory variables.

26. Cheng (1986) provides some descriptions of black exchange market in Taiwan, where people buy and sell foreign exchange at freely floating rates with neither sanction nor interference from the authorities. World Currency Yearbook (1986) also provides some information about black markets in Korea and Taiwan, where these have become officially tolerated. Under that condition, the exchange rate in black markets can provide a fairly good indication of the extent to which the currency in the official market is overvalued. Here, domestic and foreign price indexes and an exchange-rate index were constructed using the same year of each sample as base.

27. If the black market exchange rate is allowed to be freely determined by market forces, it may be expected that the rate of depreciation will closely follow the trend of the domestic inflation rate relative to foreign inflation. However, we observe discrepancies between actual black market depreciation and relative inflation. Such discrepancies may result from a variety of causes, mainly official intervention and other interference with the free functioning of the market.

28. The random walk model of exchange rate determination can be expressed as follows:

$$e_{t+1} = e_t + v_t, \text{ where } v_t \approx N(0, \sigma_v), E(v_t, v_{t-j}) \text{ for } j > 0.$$

However, this static expectation assumes the expected exchange rate is equal to zero and indicates that foreign interest rates exert a strong influence on the behavior of aggregate domestic money demand.

CHAPTER FOUR

A CURRENCY SUBSTITUTION MODEL OF EXCHANGE RATE

DETERMINATION AND EFFICIENCY

4.1 Introduction

The experience with floating exchange rates since the early 1970s has led to the reconsideration of how exchange rate determination may best be understood. The Keynesian flow approach focuses on the influence of current account flows and on parity adjustment as a mechanism for the correcting payment imbalances. In other words, the exchange rate is determined by the equilibrium in balance-of-payments flows, and the responsiveness of the current account to variations in competitiveness provides the crucial mechanism.

The monetary approach regards exchange rates as the relative price of national currencies.^[1] Under a floating rate regime, the exchange rate is determined by the interaction of supply and demand in foreign exchange markets. This approach adds to our understanding of equilibrium exchange rates, but to assume that currencies are not perfect substitutes in demand and parameters of money demand are equal across countries leads one to overlook sources of exchange rate movements. To the extent that those assumptions are untrue, the implications of the model regarding the movements of exchange rates will be misspecified.

The assumption that currencies are not perfect substitutes in demand seems unrealistic in a highly integrated and interdependent world where many groups of people might hold more than one currency for

a variety of reasons. These groups continually seek an optimum portfolio of currencies through the substitution of currencies, which to some extent provide the same money services. The consideration of currency substitution in the demand for money has important implications for exchange rate analysis. In addition, given the lack of well-developed capital markets and the existence of capital controls in developing countries, the assumptions of perfect capital mobility, the uncovered interest rate parity, and the behavior of asset substitutability seem unrealistic for those countries.

The objective of this chapter is to develop a model of exchange rate determination incorporating currency substitution behavior and to show how the degree of currency substitution can seriously undermine the "monetary independence" usually attributed to a flexible exchange rate regime. Since the exchange rates are the relative price of two assets and determined by expectations about future events, they are highly sensitive to new information. In this chapter we further consider different news from every possible channel which affects the exchange rate movements.

In addition, the efficient markets approach to exchange-rate determination usually relies on the assumption of perfect capital mobility to derive the result that the exchange rate quickly incorporates new information. This suggests that the implications of efficient-markets theory should not hold up in financially repressed economics. However, as we will show in this chapter, currency substitution is another way of arriving at some of the same results. We might therefore be able to motivate in this section as a test of whether currency substitution does, in some sense, act as a substitute

for capital mobility.

In section 4.2, money demand equations shown in the previous chapter are used to derive the exchange rate determination equation. The differences between the monetary approach and our model are contrasted and discussed. We also investigate the role of new information in the determination of exchange rate behavior. The resulting model permits the description of the relationship between innovations in the spot exchange rate and economic news in its driving variables.

In section 4.3 the cross-correlation approach developed by Pierce and Haugh (1977) is used to make inferences about the alternative hypotheses developed in section 4.2. We present empirical results regarding market efficiency and new information for exchange markets. The model is estimated using monthly data spanning the period from February 1980 to December 1985 for Korea and from February 1979 to December 1985 for Taiwan under a flexible exchange rate regime.

The final section presents conclusions.

4.2 Exchange Rate Determination, Expectations, and Currency Substitution

The monetary approach implicitly assumes that domestic residents do not hold foreign money. The elasticity of substitution of the demand between national money supplies is assumed to be zero. The currency substitution model presented in the previous chapter is used here to derive the equation of exchange rate determination. In appendix C a currency substitution model of exchange rate determination is shown (in logarithmic form) as follows:

$$(4.1) \ln e = \ln M_{sd} - \ln M_{sf} - [2/(\beta-2)] \ln((\alpha_{dd}/\alpha_{ff})^{1/2} [i_d/(i_f + \delta - x)]) + \xi_t.$$

where e is nominal exchange rate, M_{sd} and M_{sf} are supplies of domestic and foreign monies held by domestic residents, and ξ_t is a composite error term reflecting deviations from purchasing power parity.

Equation (4.1) makes it possible to assess the relationship between the degree of currency substitution and exchange rate movements. Our model shows different results from other analyses of currency substitution, such as those by Miles (1978, 1981), Husted (1980), Girton and Roper (1981), Stulz (1985), and Marquez (1987), who argue that the exchange rate is indeterminate if currencies are perfect substitutes. They assume that the monetary service production function is of CES form, the elasticity of currency substitution is $\sigma = 1/(1-\beta)$, then the coefficient of relative costs in equation (4.1) becomes $1/(1-\beta)$. When the substitution parameter $\beta = 1$, the elasticity of substitution of the two currencies in the production of monetary services is infinite, and the exchange rate is indeterminate.

Notice that the elasticity of substitution in our model is $\sigma = 2/(2-\beta)$. When the substitution parameter $\beta = 1$, the quadratic function becomes the generalized Leontief function and the elasticity of substitution is two, which does not imply indeterminacy of the exchange rate.

Canto and Miles (1983) reach a different conclusion about the elasticities of currency substitution and exchange rate determination. They show that the exchange rate is indeterminate if elasticity equals two. However, when β approaches negative infinity, σ becomes zero, and the two currencies become perfect complements; thus, the currency mix

does not respond to changes in relative holding costs. Our model show that when the substitution parameter β approaches zero, the elasticity of substitution is one, and this is the Cobb-Douglas function. The elasticity of substitution becomes infinite when the substitution parameter β is equal to two. This is the case of perfect currency substitution and the exchange rate is indeterminate.

The basic implications of equation (4.1) is that a significant degree of currency substitution would seriously undermine the ability of flexible exchange rates to provide monetary independence. Currency substitution would transmit the effect of monetary disturbances from one country to another.

To simplify our notation, let $\ln e_t = s_t$, $\ln M_{sd,t} = m_t$, $\ln M_{sf} = m_t^f$, and $\ln (\alpha_{dd}/\alpha_{ff})^{1/2} = k$. Under the assumption of rational expectations, equation (4.1), shown in appendix C, can be approximated by the following equation:

$$(4.2) \quad s_t = (1-\gamma) \sum_{j=0}^{\infty} \gamma^j E_t (m_{t+j} - m_{t+j}^f) + \gamma \sum_{j=0}^{\infty} \gamma^j E_t (i_{d,t+j} - i_{f,t+j}) \\ + (1-\gamma) \sum_{j=0}^{\infty} \gamma^j E_t \xi_{t+j} + \gamma \sum_{j=0}^{\infty} \gamma^j k - \gamma \sum_{j=0}^{\infty} \gamma^j E_t \delta_{t+j},$$

where $\gamma = -[2/(\beta-4)]$.

Since $\beta \leq 2$, $0 \leq \gamma \leq 1$, and the convergence assumption that $\lim_{j \rightarrow \infty} \gamma^j E_t s_{t+1} = 0$ is made here. Equation (4.2) clearly illustrates that the exchange rate depends on both current values and the expectation of all important driving variables (exogenous variables).

Although the theoretical framework of the monetary approach has served as the basis for many empirical studies, several economists, among them, Frenkel (1981 b) and Cumby and Obstfeld (1983), have

questioned the assumptions of purchasing power parity and uncovered interest rate parity. In this regard, it is noteworthy to point out several differences between equation (4.2) and that derived from the monetary approach.

First, in contrast to the monetary approach, which presumes that the services of money are provided only by the "own" country's currency, equations do not explicitly presume a preferred habitat view of money demand. That is, our model allows for the possibility of currency switching. There is no country-specific element in this model, whereas the monetary approach assumes one currency per country and that of different nations' currencies are not perfect substitutes on the demand side.

Second, the monetary approach suggests that the exchange rate is determined by the relative money supplies in the domestic and foreign country. Here, the definition of m^f is domestic holdings of foreign money rather than the total foreign money supply. Currency substitution distinguishes between the aggregate money supply of the foreign country (for example, the U.S. money supply) and domestic residents' holdings of foreign currency in determining exchange rates.

Third, the monetary approach assumes there are no barriers (such as transaction costs or capital controls) restricting capital markets, and that market forces are the overwhelming determinants of the exchange rate. Thus, there is no role for government in exchange rate determination. Our model analyzes the case in which the government imposes capital control measures. The monetary approach also assumes domestic and foreign assets are perfect substitutes even though the assets of different nations are not equally risky. Our currency

substitution model does not require the assumptions of perfect capital mobility and perfect substitution between bonds.

Fourth, in the monetary approach, the assumption of equal parameters of the money demand function across countries is adopted to avoid multicollinearity. While this parsimonious assumption is conventional, it is a potential source of misspecification. Makin (1981) and Haynes and Stone (1981) have noted that an econometric estimation of the monetary model contained restrictions on the coefficients and that these improper constraints bias the estimates. Our model avoids this shortcoming by specifying money demand equations that rely on the micro-theoretic results presented in the previous chapter.

Finally, the monetary approach assumes that domestic and foreign bonds are perfect substitutes, and that uncovered interest-rate parity exists.^[2] The discount factor (measuring the response of the current exchange rate or its expected rate of exchange) in the monetary approach is directly related to the interest semi-elasticity of the domestic demand for money. In our model, without making such assumptions, the discount factor in the exchange rate determination equation is related to the parameter of substitution elasticity.

Recently, the effect of economic news on exchange rate behavior and the distinction between anticipated and unanticipated movements in exchange rates have been explored by several researchers, including Dornbusch (1980), Frenkel (1981a), Mussa (1982), Hoffman and Schlagenhauf (1985), Hartley (1983), Edwards (1983), Isard (1983, 1987), and Baillie (1987). They believe that much of the variability in exchange rates reflects responsiveness to "news," and they argue

that the models of exchange rate determination need to be conducted in an "economic news" framework.

The notion that news (or shocks) has an effect on exchange rate behavior is directly derived from the fact that exchange rates are the relative price of two assets; as such, they are determined by expectations about future events. The major cause of exchange rate movements is news that could not have been anticipated. This suggestion has important implications for exchange rate models, particularly how well unanticipated changes in the explanatory variables account for changes in the spot exchange rate. These changes convey new information about present and future economic conditions that presumably alter the market's perception of equilibrium.

In Appendix C, we derive the "news" version of exchange rate movements, and show that The total change in the exchange rate can be decomposed into anticipated and unanticipated components.^[3] That is,

$$\begin{aligned}
 (4.3) \quad \Delta s_t &= s_t - s_{t-1} \\
 &= (s_t - E_{t-1} s_t) + (E_{t-1} s_t - s_{t-1}) \\
 &= \Delta s_t^u + \Delta s_t^a.
 \end{aligned}$$

A Δ denotes a first difference in the variable. The first term in equation (4.3) is the unexpected variation in the exchange rate. It is exclusively a function of new information accruing between time $t-1$ and t . The second term in equation (4.3) can be expressed as $E_{t-1} s_t - s_{t-1} = \Delta s_t^a$, which is the anticipated change in the exchange rate (based on information available at time $t-1$). This component contains past actual and expected future changes in the exogenous variables, all based on information available in time $t-1$.

The policy implications stemming from the effect of news on exchange rate movements are clear. For example, Hartley (1983) argues that if the monetary authorities were to follow an interest rate rule, then unanticipated shocks in interest rates might provide more relevant news than unanticipated innovations in the money stock. The opposite might be the case for a country following a money growth rule. If the authorities did not adopt a stable rule over the period examined, then it would be difficult to predict exchange rate movements. Therefore, it is important for the authorities to pay particular attention to macroeconomic variables that may capture news concerning the revision of expectations.

In sum, we have shown that exchange rates can be viewed as prices of durable assets and that current prices reflect the market's expectation concerning present and future economic conditions relevant for the determination of the appropriate values of these durable assets. Under rational expectations, individuals use efficiently the information they have in forming these expectations, and the foreign exchange market is efficient. With this new information, more accurate market forecasts about the future spot rate can be made. The exchange rate is affected by an influx of new information at once. We showed that news about several economic variables on which expectations are based leads to unobservable revisions in expectations and observable changes in exchange rates. We found that both unanticipated exogenous variables, and expected future exogenous variables are predicted to influence directly the path of the exchange rate.

4.3 Efficiency and Causality Test: A Cross-Correlation Approach

In the previous section we showed that unanticipated changes in exogenous variables, by conveying new information about economic conditions, affect exchange rate movements. The market forecasting error in the exchange market is explicitly related to unanticipated changes in exchange rate determinants. News is defined here as unpredictable and valuable information that arrives continuously about foreign exchange. Under the theory of rational expectations, economic agents use efficiently the information they have, and a major determinant of exchange rates is the amount of information they possess about current and future conditions.^[4] It is of interest to test how foreign exchange markets react to new information concerning the determinants of exchange rates.

To estimate this exchange-rate model requires an observable expression for the expectations term it contains. Hoffman and Schlagenhaufl (1983) and Finn (1986) adopt univariate time-series analysis to specify the stochastic processes of the exogenous variables and then estimate with the full-information-maximum-likelihood method. Following Hartley (1983), Edwards (1983), and Hoffman and Schlagenhaufl (1985), we could adopt this approach to measure the effect of news on exchange rate movements,^[5] but time-series data on countries' holdings of foreign currency are not available, and there are no appropriate proxy variables for capital controls.^[6] These limitations prevent direct testing of the above model.

Aside from lack of data, there are other possible problems with the econometric testing of this model. First, the data for the explanatory or independent variables are highly correlated, and the resulting multicollinearity produces in unstable coefficient estimates and

potentially misleading hypothesis testing.^[7] Second, it is difficult not only because of the general problem of identifying expectations but also because the component influences will be interrelated.

In chapter 4.2, the total change in the exchange rate can be easily decomposed into anticipated (systematic) and unanticipated (non-systematic) components. That is,

$$s_t - s_{t-1} = (s_t - E_{t-1} s_t) + (E_{t-1} s_t - s_{t-1})$$

The forecasting performance of exchange rate models has been the subject of enquiry of Meese and Rogoff (1983). Mussa (1979), Frenkel (1981a) and Meese and Rogoff (1983) have argued that nominal exchange rates follow a random walk. According to random walk hypothesis, $s_t - s_{t-1}$ is white noise meaning that both expected and unexpected changes in s_t are white noise. The unanticipated components is unpredictable and hence white noise. Only if the expected value of anticipated portion is zero, the exchange rate follows a random walk. Adams and Boyer (1986) found that only if the exogenous variables follow random walks will the exchange rate move unpredictably in a monetary model. They found that the Canadian-US exchange rates have followed a random walk.

Recently, Fratianni, Hur, and Kang (1987) have shown the robustness of the random walk hypothesis in five major exchange rates. They assessed their findings to be consistent with the notion that the five exchange markets under consideration are weak form efficient (that is, all information contained in the past history of exchange rates is already reflected in the current rate) inasmuch as random walk is not rejected. They further examine whether or not these markets are efficient beyond the weak form, or more to the point, that they are incrementally efficient.

The foreign exchange markets is said to be incrementally efficient,

defined by Caves and Feige (1980), with respect to some type of information, for example, money stock, if the use of that information cannot improve upon forecasts of the exchange rate which are conditional only on the history of the exchange rate. That is, the spot exchange rate already incorporate the systematic information contained in the past history of money supply disturbances. The history of money stock changes made no significant additional contribution to the forecast of current changes in the exchange rate, which in terms of time-series analysis translates into the statement that the history of money stock does not cause changes in current exchange rate in the Granger sense. They detected no evidence of monetary causality and thus could not reject the hypothesis of monetary efficiency.

From a technical standpoint, the empirical analysis used in Fratianni, Hur, and Kang (1987) study is along the lines used by Caves and Feige (1980), Makin (1981), and Wasserfallen and Kyburz (1985), to study monetary causality in efficient exchange markets. The concept of incremental efficiency is compatible with Granger causality. If, for example, the history of the money stocks were found to be Granger causal to exchange rates, the exchange rate market would not be money stock efficient. Caves and Feige (1980) found that the US dollar-Canadian dollar exchange market was efficient with respect to the history of money stock changes, that is, these do not cause changes in exchange rates in the Granger (1969) sense. Makin (1981) showed the cross-correlation between the exchange rate and the exogenous variables; he found feedback running from the dollar-DM exchange rate to the U.S. money stock. Wasserfallen and Kyburz (1985) used bivariate causality tests to calculate cross-correlation between the exchange

rate and the exogenous variables. They showed that the causality, in the Granger sense, is unidirectional from the exogenous variables to the exchange rate.

Our objective is to test how foreign exchange markets react to new information concerning the determinants of exchange rates and investigate to what extent, if any, money stock cause changes in the exchange rates in the Granger sense.^[8] In addition, the efficient markets approach to exchange-rate determination usually relies on the assumption of perfect capital mobility to derive the result that the exchange rate quickly incorporates new information. This suggests that the implications of efficient-markets theory should not hold up in financially repressed economies. However, as we show in this chapter, currency substitution is another way of arriving at some of the same results. We might therefore be able to motivate in this section as a test of whether currency substitution does, in some sense, act as a substitute for capital mobility.

The following empirical analysis concentrates on two basic hypotheses of the framework developed in the previous section. The first is the causal relationship between the exchange rate and the domestic money supply. Our model reveals that changes in the exchange rate are related to unanticipated changes in the domestic money supply. If the foreign exchange market is efficient and the currency substitution approach provides the correct exchange-rate model, then one would expect economic agents to process information in such a manner that the spot exchange rate always reflects all available information that could not be potentially useful to earn excess profits. We would expect to find either that money supplies do not cause exchange rate movements or that there is a contemporaneous

relationship exists between them. In this sense our study follows within the research interests of Caves and Feige (1980), Wasserfallen and Kyburz (1985), and Fratianni, Hur, and Kang (1987), who raised similar questions. This section complements the research undertaken by the authors mentioned above using a different data set and different econometric techniques.

An alternative view argues that in developing countries the monetary authorities intervene in foreign exchange markets by their own foreign reserve demand behavior. In effect, the authorities manage the foreign exchange rate by allowing the domestic money stock to respond endogenously to achieve a desired path for exchange rate movements. This suggests a causal relationship from the exchange rate to the domestic money supply, which implies that the authorities can determine the money stock through intervention in the foreign exchange market. This in turn implies that the exchange rate could be a useful policy instrument, since official intervention in the exchange market could change the domestic money supply.^[9]

The second hypothesis concerns the news form of the model, which argues that news about foreign money stock held by domestic residents, rather than the total foreign money stock, will affect the movement in exchange rates. In other words, currency substitution distinguishes between the aggregate money supply of the foreign country (for example, the U.S. money supply) and domestic residents' holdings of foreign currency in determining exchange rates. Again, we would expect either no causality or a contemporaneous relationship between exchange rate movements and domestic residents' holdings. Since time-series data on countries' holdings of foreign currency are not available. The domestic holding of foreign currency may be related to the total

foreign money supply with a fixed proportion. Instead we use the U.S. money stock as a proxy variable. We thus will test how foreign exchange markets efficiently absorb new information about unanticipated changes in the U.S. money stock.

Evidence in favor of either hypothesis may be obtained by looking at the estimated coefficients of cross-correlation between money supplies and exchange rates. The cross-correlation for lagged money supplies enable us to see whether any additional explanatory power remains once some relationship between the exchange rate and the money supply has been estimated. Cross-correlation between the exchange rate and leading values of money supply enable a check on feedback running from the exchange rate to later values of the money supply.

The cross-correlation analysis adopted here examines the causality between the \$NT/\$ and the \$Won/\$ exchange rate and money supplies under a flexible exchange rate regime. On the basis of work by Haugh (1976) and Haugh and Box (1977), Pierce and Haugh (1977) suggest a two-step procedure for implementing tests of causality. Each variable is transformed to have a constant unconditional mean and variance over the sample period. Then, univariate Box-Jenkins models are estimated for the transformed variables. The next step is to examine the cross-correlation between innovations derived from ARIMA models to yield conclusions about causality. The technique adopted here is to estimate ARIMA models for the series of different variables. The fitted values are taken to be the anticipated values for the variables in question, and the innovations or residuals in the series are taken to be the component of unanticipated changes.

The cross-correlation function between the prewhitened residuals of estimated ARIMA models for the money supply and exchange rate are

utilized to examine the causal relationship.

4.4.1 The Univariable ARIMA Models for the Different Variables

A necessary condition for the applicability of the cross-correlation function is that the assumption of serially uncorrelated variables be approximately accurate. In order to obtain this situation, we must transform each original series through the use of an appropriate filter to provide stationary time series values. In other words, each time series is converted into one with white-noise properties.

Different filtering methods have been suggested to obtain stationary time series. For example, Sims (1972) adopts a priori common filter; Williams, Goodhart, and Gowland (1976) suggest separate filters on time series empirically determined from the particular one under study.

The ARIMA process is described by the following model:

$$(4.14) \quad \phi(B) \Phi(B^s) \omega = \theta(B) \Theta(B^s) a_t$$

where $\phi(B) = (1 - \phi_1 B^1 - \phi_2 B^2 - \dots - \phi_p B^p)$ and is the nonseasonal

autoregression operator of order p ; B is lag operator;

$\Phi(B^s) = (1 - \phi_1 B^{1s} - \phi_2 B^{2s} - \dots - \phi_p B^{ps})$ and is called the

seasonal autoregression operator of order P ;

$\theta(B) = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q)$ and is nonseasonal

moving average operator of order q ;

$\Theta(B^s) = (1 - \theta B^s - \theta B^{2s} - \dots - \theta B^{Qs})$ and is called the

seasonal moving average operator of order Q ;

a_t = random shocks that are assumed to be statistically

independent of each other;

$\omega = \Delta_s^D \Delta^d Z_t$, and Δ_s^D and Δ^d are, respectively, the seasonal and

consecutive difference operators used to induce stationarity

in the series Z_t .

Alternatively, we can summarize equation (4.14) as ARIMA (p, d, q) x(P,D,Q)s. The Box-Jenkins approach involves the choice of a particular model for each series from the class described by equation (4.14), that is, selection of the appropriate order of (seasonal) autocorrelation parameter p (P), (seasonal) differencing parameter d (D), and (seasonal) moving average q (Q). Prefiltering the series by their estimated ARIMA representations would be the best criterion for reducing them to white noise.

The estimated ARIMA models are shown in Table 4.1. The estimates and the corresponding t-value of the parameters, sum of squares residual, standard error of regression, adjusted R^2 , and Box-Pierce Q statistics are reported. Two measures of money aggregates are used for each country (Korea and Taiwan): narrow money, m_1 ($m_1 = \ln M_1$), and broad money, m_2 ($m_2 = \ln M_2$). s is equal to $\ln e$, where e is the exchange rate). We also employ the money supply, M_1 , of the United States as the aggregate money supply of the foreign country to test the currency substitution hypothesis. Monthly data, February 1979 - December 1985 for Taiwan, January 1980 - December 1985 for Korea, are used. A complete description of the data and data sources is given in Appendix D.

Table 4.1 Univariate ARIMA Models for Different Time Series

Depend Variables	AR ϕ or SAR Φ	MA θ or SMA Θ	Summary Statistics			
			SSR	SER	Adj R	Q(24)
$\Delta\Delta_{12} m_1^{KOR}$	$\phi_2 = -0.339$ (3.49)	$\theta_1 = -0.849$ (-5.98)	0.1021	0.0434	0.489	15.079
$\Delta\Delta_{12} m_2^{KOR}$	$\phi_3 = 0.289$ (2.46)	$\theta_2 = 0.527$ (3.95) $\theta_1 = -0.501$ (-3.77)	0.0085	0.0125	0.276	19.553
$\Delta\Delta_{12} s^{KOR}$	$\Phi_1 = -0.377$ (-3.89)		0.0023	0.0071	0.251	22.866
$\Delta\Delta_{12} m_1^{US}$	$\Phi_1 = -0.545$ (-5.67) $\phi_1 = 0.294$ (2.26)		0.0028	0.0070	0.443	19.607
$\Delta\Delta_{12} m_1^{ROC}$	$\Phi_1 = -0.735$ (-6.74) $\phi_1 = -0.362$ (-2.90)		0.0037	0.0260	0.522	20.929
$\Delta\Delta_{12} m_2^{ROC}$	$\Phi_1 = -0.564$ (-5.68) $\phi_1 = 0.260$ (2.00)		0.0076	0.0113	0.335	24.017
$\Delta^2 s^{ROC}$		$\theta_1 = -0.988$ (-8.94)	0.0039	0.0070	0.510	14.259

Note: KOR: Korea; ROC: Taiwan; US: United States; t-values are in parentheses below the coefficient; SSR: sum of squares residuals; SER: standard error of regression; Adj R²: adjusted R-squared; Q(K): Box-Pierce Q-statistic with K period lag; $\chi^2(23) = 35.173$ at 95% level; $\chi^2(22) = 33.924$ at 95% level.

The models shown in Table 4.1 perform reasonably well in removing serial correlations from the respective series. In Table 4.1, for Korean data, M1 appears to be adequately represented by the autoregressive and seasonal moving average parameter, while M2 is represented by a slightly more complicated model, a seasonal autoregressive parameter, a seasonal moving average parameter, and an autoregressive parameter. The exchange rate can be described by an autoregressive parameter. In turn, M1 for the United States is represented by a seasonal autoregressive parameter and a first-order ordinary moving average parameter. As for the Taiwan data, both M1 and M2 appear to be modeled by both a seasonal autoregressive and an ordinary autoregressive average parameter. Finally, exchange rates in Taiwan can be represented by first-order moving average parameter.

4.4.2 Causal Structure between Exchange Rates and Money Supplies

To gain information describing the relationship between the exchange rates and money supplies, we calculate the simple cross-correlation function between exchange rates and money supplies, each of which is represented as a univariate ARIMA process. The disturbances in these processes constitute the prewhitened series, and the cross-correlation between them can be expected to yield information on the causality patterns sought since they are the components of exchange rates and money supplies that cannot be predicted from their own past.^[10]

If x_t and y_t denote the pre-whitened series, the sample cross-correlations are defined by

$$\rho_K(x_t, y_t) = E [(y_t - u_y)(x_{t+K} - u_x)] / \sigma_x \sigma_y,$$

where lag $K = 0, \pm 1, \pm 2, \pm 3 \pm 4, \dots$,

u_x and u_y are the means of the stationary x and y series,
respectively; and

σ_x and σ_y are the standard deviations of the x and y series,
respectively.

These cross-correlations characterize the various causality patterns. The essential features are as follows:

- (a) $\rho_K(x_t, y_t) \neq 0$ for some $K > 0$ indicates $x_t \Rightarrow y_t$, x cause y ;
- (b) $\rho_K(x_t, y_t) \neq 0$ for some $K < 0$ indicates $y_t \Rightarrow x_t$, y cause x ;
- (c) $\rho_0(x_t, y_t) \neq 0$ indicates contemporaneous causality, $x_t \rightleftharpoons y_t$;
- (d) $\rho_K(x_t, y_t) = 0$ for all K indicates x_t and y_t are independent,
 $x_t \nRightarrow y_t$ (y does not cause x and x does not cause y)

Haugh (1976) has shown that the asymptotic distribution of these cross-correlations, under the hypothesis that the innovations are normal and i.i.d, is the same as the asymptotic distribution of cross-correlations of the true innovations of the respective series. However, it should be acknowledged that the potential disadvantages with this technique that has been discussed by Schwert (1979) and Geweke (1984).

The cross correlogram showing the correlation between exchange rates and domestic money supplies is shown in Table 4.2 and 4.3 for Korea and Table 4.4 and 4.5 for Taiwan. We also show the relationship between exchange rates and the U.S. money supply (as a proxy for domestic holdings of foreign currency) in Table 4.6 (Korea case) and 4.7 (Taiwan case). The estimates at each lag K may be judged individually and lie within approximately two standard deviation limits.^[11] In addition, in Table 4.8 we compare causality results between Korea and Taiwan.

Table 4.2 Cross-correlation between the Prewhitened Values of Exchange Rates and M1, Korean Case.

K	$\rho(s, m_1(-K))$ lag	$\rho(s, m_1(+K))$ lead
0	0.054	0.054
1	0.187	0.052
2	-0.161	0.069
3	-0.054	-0.138
4	-0.222	0.213
5	-0.215	-0.101
6	0.195	-0.168
7	-0.282	0.169
8	-0.068	-0.141
9	-0.120	0.119
10	-0.200	0.164
11	-0.009	-0.058
12	0.036	0.124
13	0.145	0.051
14	-0.109	0.028
		S.E. 0.147

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

Table 4.3 Cross-correlation between the Prewhitened Values of Exchange Rates and M2, Korean Case

K	$\rho(s, m_2(-K))$ lag	$\rho(s, m_2(+K))$ lead
0	0.029	0.029
1	0.248	0.280
2	-0.029	0.052
3	-0.074	-0.006
4	-0.108	0.273
5	-0.029	-0.044
6	0.178	-0.225
7	-0.280	0.087
8	-0.023	-0.026
9	-0.029	0.115
10	-0.149	0.059
11	0.025	-0.012
12	-0.179	0.009
13	0.078	-0.028
14	-0.058	0.078
		S.E. 0.147

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

Table 4.4 Cross-correlation between the Prewhitened Values of Exchange Rates and M1, Taiwan case

K	$\rho(s, m_1(-K))$ lag	$\rho(s, m_1(+K))$ lead
0	-0.189	-0.189
1	0.098	-0.014
2	-0.078	-0.100
3	-0.009	0.046
4	0.077	0.271*
5	-0.066	0.191
6	0.031	-0.257
7	0.030	-0.045
8	-0.097	-0.020
9	-0.042	0.056
10	0.127	0.267*
11	-0.025	-0.003
12	-0.138	0.208
13	-0.087	0.121
14	0.014	0.054
		S.E. 0.131

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

* : significantly different from zero at the 95% confidence level.

Table 4.5 Cross-correlation between the Prewhitened Values of Exchange Rates and M2, Taiwan Case

K	$\rho(s, m_2(-K))$ lag	$\rho(s, m_2(+K))$ lead
0	-0.091	-0.091
1	0.254	0.038
2	0.007	-0.097
3	0.093	0.143
4	0.103	0.237
5	-0.025	0.249
6	-0.014	-0.189
7	0.049	-0.031
8	-0.113	-0.032
9	-0.031	0.108
10	0.131	0.228
11	0.012	0.044
12	-0.042	0.216
13	-0.086	0.075
14	-0.017	0.046
		S.E. 0.131

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

Table 4.6 Cross-correlation between the Prewhitened values of Exchange Rates and US M1, Korean Case

K	$\rho(s, m_1(-K))$ lag	$\rho(s, m_1(+K))$ lead
0	-0.092	-0.092
1	0.107	-0.289
2	0.030	0.167
3	0.072	-0.110
4	-0.020	0.137
5	0.062	0.149
6	-0.129	-0.011
7	-0.266	0.199
8	0.043	0.069
9	-0.099	0.118
10	-0.190	0.050
11	0.110	0.105
12	-0.207	0.005
13	-0.201	0.006
14	0.040	0.055
		S.E. 0.147

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

Table 4.7 Cross-correlation between the Prewhitened Values of Exchange Rates and U.S. M1, Taiwan Case

K	$\rho(s, m_1(-K))$ lag	$\rho(s, m_1(+K))$ lead
0	0.281*	0.281*
1	0.122	-0.141
2	0.092	-0.059
3	0.117	0.089
4	-0.179	0.043
5	0.076	0.022
6	0.094	-0.080
7	-0.083	-0.111
8	0.133	0.014
9	0.026	-0.077
10	-0.053	0.082
11	-0.058	0.169
12	-0.164	-0.151
13	-0.056	0.084
14	0.093	-0.055
		S.E. 0.132

Note: S.E: an approximate standard error $N^{-1/2}$, N is number of observations.

* : significantly different from zero at the 95% confidence level.

Table 4.8 Comparison of the Causality Pattern
between Korea and Taiwan

Country	Korea	Taiwan
	exchange rate	exchange rate
M1	⊥	←
M2	⊥	⊥
USM1	⊥	↔

Source: Tables 4.2 - 4.7

Note: $x \Rightarrow y$ - x cause y .

$x \Leftrightarrow y$ - x and y are contemporaneous causality.

$x \nmid y$ - no evidence of causality between the two series.

The results for the causality tests are displayed in Table 4.2-4.7. In the case of Korea, reported in Table 4.2 and 4.3, the individual cross-correlations are lower than two standard errors, from a lag of 14 periods to a lead of 14 periods. An insignificant value means that the hypothesis of no relationship between the exchange rate (s) and the money supply (M1 and M2) considered cannot be rejected. These two tables show that there is no spike in the sample cross-correlation from lag 14 periods to lead 14 periods implies that the exchange rate are not related to the money stocks, and money stocks do not lead exchange rate overtime. We find no causal relationship going from the domestic money supply, M1 and M2, to the exchange rate, and there are independence of the two series. This result agrees with our hypothesis that unanticipated domestic monetary news will not cause exchange rate movements. In other words, the money stocks series made not significant additional contribution to the forecast of current changes in the exchange rate. These results reveal that the concept of incremental efficiency corresponds directly with the Granger causal

statement the money stocks do not cause exchange rate.

In Table 4.4, the case of Taiwan, causality is found to move from exchange rates to domestic narrow money, M1. This finding is consistent with the hypothesis of government intervention in the foreign exchange market, and it implies that the exchange rate can be used as policy instrument by monetary authorities in Taiwan. Again, as shown in Table 4.5, no evidence of causality is found between exchange rate and broad domestic money, M2, in the case of Taiwan. In other words, the M2 cannot be used as a leading indicator.

Furthermore, in Table 4.6 and 4.7 we show the relationship between exchange rate and the U.S. money supply. In the case of Korea, no causal relationship is found between U.S. M1 and exchange rate (Table 4.6). In the Taiwan case, however, the coefficient of the cross-correlation between the s^{ROC} residuals and the U.S. M1 residuals reveals contemporaneous causality. This means that if the contemporaneous information about the U.S. M1 is included, then there is no time lag between exchange rate movements and the changes in U.S. M1. Since time-series data on countries' holdings of foreign currency are not available, we find that the U.S. money stock is a good proxy variable for these holdings. The foreign exchange markets in both Korea and Taiwan efficiently absorb new information about unanticipated changes in the U.S. money stock.

The monetary approach suggests that the money supply could be used to forecast exchange rates; that is, an observable causal relationship exists between exchange rates and changes in money supply. Gagliardi (1982) used cross-correlation analysis to test the monetary model and found causality between the Lira-D.M. exchange rate and the money supplies. Canto (1985) applied the same empirical method to his

exchange rate model and found a the causal relationship going from unanticipated changes in domestic money to exchange rate. Both authors failed to recognize, however, that one consequence of an efficient foreign exchange market is that economic agents process information in such a manner that the spot exchange rates always reflect all available information that potentially could be useful to earn excess profits. Either the money supply does not cause exchange rate movements or a contemporaneous relationship exists between them.

The findings presented in this section agree with the relevant literature, such as Caves and Feige (1980), Wasserfallen and Kyburz (1985), and Fratianni, Hur, and Kang (1987), - that the Granger causality test of an efficient foreign exchange market implies that either that the money supply does not cause exchange rate movements or that a contemporaneous relationship exist between them. Except for Taiwan's M1, we detected no evidence of causality between exchange rate and money supply. An unanticipated change in latter, or monetary news, does not cause the exchange rate movements in the Granger sense. The foreign exchange markets in both Korea and Taiwan efficiently absorb new information about unanticipated changes in the money supply.

4.4 Conclusion

In this chapter a model of exchange rate determination has been developed as a reduced-form solution to the production function approach to currency substitution. The basic implication is that currency substitution will cause exchange rate instability in the sense that shifts in the cost of holding currencies lead to larger exchange rate movements with a greater degree of currency substitution. In other words, currency substitution shows how the variance of the exchange rate is a function of elasticity of substitution across

currencies. This provides a theoretical rationale for the increased exchange rate volatility observed in recent years. Under rational expectations, the current exchange rate is related to the expected future rate via the optimal money balance choice (not the interest-parity condition) and to a set of exogenous or predetermined variables. We have shown that currency substitution distinguishes between the aggregate money supply of the foreign country (for example, the U.S. money supply) and the domestic residents' holdings of foreign currency in determining exchange rates.

In addition, we have extended the model to consider the distinction between anticipated and unanticipated movements in explanatory variables, and to examine the correlation of shocks in the theoretically suggested variables with unanticipated innovation in exchange rates. We have distinguished the effects of changes in expectations on exchange rates from the effects of changes in underlying determining variables apart from expectations. Our results essentially share the view of the asset approach that the exchange rate is a highly sensitive asset price affected by an influx of new information. In particular, our model implies that exchange rate determination should accompany anticipated and unanticipated changes in relative money supplies, interest rate differentials, and the degree of capital controls.

Finally, we have adopted a cross-correlation approach to examine the "news" model of exchange rate determination. We tested the hypothesis that if the foreign exchange market is efficient and the currency substitution approach provides the correct exchange-rate model, then one would expect economic agents to process information in such a manner that the spot exchange rate always reflects all available

information that potentially could be useful to earn excess profits. We would expect to find either that the money supply does not cause exchange rate movements or that a contemporaneous relationship exists between them. Except for Taiwan's M1, we detected no evidence of causality between exchange rate and money supply. An unanticipated change in the money supply, or monetary news, does not cause exchange rate movements. The foreign exchange markets in both Korea and Taiwan efficiently absorb new information about the unanticipated changes in the money supply.

Footnotes—Chapter IV.

1. See Kreinin and Officer (1978) and Frenkel and Johnson (1978) for a collection of recent articles and empirical tests. Recently, given the poor performance of existing exchange rate models, Isard (1987) questions using single-equation, semi-reduced-form approaches to explain the behavior of exchange rates empirically. He suggests that a better way is to take account of a complete system of macroeconomic relationships in order to capture the associations among exchange rates, interest-rate differentials, and other variables. In this chapter we will not consider this topic.

2. The assumption of uncovered interest-rate parity has been strongly challenged by recent work on exchange rate risk premiums.

3. According to the random walk model, $s_t - s_{t-1}$ is white noise, meaning that both expected and unexpected changes in s (exchange rates) are white noise. The unexpected component is unpredictable and hence white noise; the expected component also has the uncertainty that surrounds the values of anticipated components. Fratianni, Hur, and Kang (1987) also point out that even if there were an initial agreement on the value of the anticipated component, this value would change through competitive forecasting activities and price offers of traders.

4. This definition of market efficiency is the same as the definition of rational expectations given by Muth (1961) when the latter is applied to the case of homogeneous expectations, and the term market efficiency and rational expectations will be used interchangeably.

5. In the literature, three ways have been used to test empirically the effect of news on exchange rate behavior. The first, adopted by Dornbusch (1980) and Frenkel (1981a), directly incorporates unexpected changes of exchange rate determinants into the right-hand side of the traditional market efficiency equation. A second method was suggested by Hartley (1983), who used nonlinear full-information methods to test simultaneously for market efficiency and rational expectations. A third way was recently suggested by Edwards (1983), who applied seemingly unrelated regression methods.

6. In section 3.4 we discussed several reasons why it is difficult to obtain data about capital controls. For Korea and Taiwan, we can find data on the holdings of foreign currency deposits in domestic banks. However, in using such a figure, it is important to realize that no account is taken of deposits in banks abroad and of nonbank transactions. That is, this indicator will underestimate the degree of currency substitution if domestic residents hold significant foreign currency deposits overseas. Refer to El-Erian (1988).

7. Since this problem is inherent in the time series data, it cannot be neatly "fixed," leaving the problem of disentangling the individual effects of each variable. Imposition of prior constraints on the coefficient did improve the estimation.

8. There are several reasons why governments may want to manage exchange rates. First, they may try to "lean against the wind," that is, governments moderate the movements in exchange rates in order to stabilize their domestic economies and achieve more predictable exchange rates. Second, they may intervene to "buy time" for policy changes to take place without disruption of the exchange rates overacting. Third, governments may intervene to counter other "disorderly market conditions." Finally, they may try to devalue their currency to achieve an artificial trade advantage. The stock-flow version of the monetary model can also imply causation from exchange rates to money, or imply no causation. See Niehans (1977).

9. In the literature, there are several commonly used tests of causality, for example, Granger (1969), Sims (1972), and Haugh (1976). We do not discuss the theory underlying these tests, as it has been well documented.

10. One must be cautious about accepting the hypothesis about the basis of ARIMA cross-correlation of causality. Schwert (1979) makes two points: First, the statistical tests based on the residuals from estimated ARIMA models may too frequently accept the null hypothesis of series independence. Second, tests based on the cross-correlation approach between residuals series may have low power against plausible alternative hypotheses, especially when short measurement intervals, such as a week or a month, are used.

11. For more details we refer to Box and Jenkins (1976). Haugh (1976) also presents some Monte Carlo results showing that for large $1K1$, relative to N , the approximate standard error given by Standard error $= (1-1K1)^{1/2} / (N^{1/2})$ is more accurate than $1/(N^{1/2})$ in the sense that for finite N the asymptotic distribution results give a better approximation. However, most computer program packages, such as SAS, TSP, TS, and TSERIES, only calculate the latter.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Two issues have been addressed in this study.

One issue was whether the demand for money in Korea and Taiwan has been influenced directly by foreign monetary developments. We presented a model that allowed us to measure the degree of currency substitution. We applied producer theory to derive the conditional money demand function based on the optimizing cost-minimization model. We analyzed the demand for money in the presence of currency substitution and financial dualism.

The second issue was to explain the movement of exchange rates as related to currency substitution. We have shown the connection between the elasticity of substitution and exchange rate movements. Then we extended our model to address the importance of "news" (unanticipated shocks) in explaining exchange rate behavior. Finally, we test the efficiency of foreign exchange markets in response to new information.

This study has provided both a theoretical and empirical analysis of currency substitution and exchange rate determination for Korea and Taiwan. In particular, we found the following results:

(1) The optimal demand for money in an open economy, derived from the optimizing cost-minimization model, depends on domestic and foreign interest rates, the expected rate of depreciation, the degree of capital controls, the given aggregate level of monetary services, and a shift parameter for technological change. The introduction of currency substitution modifies the determinants of money demand. The

modified function has added additional opportunity cost variables, foreign interest rates, and expected exchange rates. Interestingly, the direction and effects of a change in foreign interest rates on money demand are shown to be different from the portfolio approach.

(2) Research on currency substitution in developing countries to date has been limited to the substitutability between domestic and foreign money, without recognizing that unorganized money markets in developing countries can also serve as substitutes for domestic money. In this study, we incorporated two monetary phenomena into the model. With this modification our model enhanced our understanding of the behavior of aggregate money demand.

(3) The evidence from Taiwan shows that currency substitution is statistically significant for currency substitution for CC, DD, and M1, and the magnitude of elasticities is higher than one. The experience of Korea also provides support for the currency substitution hypothesis. The policy implication is that banking regulations preventing the circulation of foreign currency have not dampened currency substitution, at least in Korea and Taiwan. In addition, we find that magnitudes of elasticity in the presence of currency substitution and financial dualism are higher than elasticity in the presence of currency substitution only.

(4) Our result showed how the variance of the exchange rate is a function of the elasticity of substitution across currencies. The larger the elasticity, the larger will be the effect of holding costs on the exchange rate. In addition, we extended our model to consider the distinction between anticipated and unanticipated movements in explanatory variables and to examine the correlation of shocks in the

theoretically suggested variables with unanticipated innovation in exchange rates. In particular, our model implies that exchange rate determination should accompany anticipated and unanticipated changes in relative money supplies, interest rate differentials, and the degree of capital controls. Furthermore, only unanticipated movements in the exogenous variables should lead to unanticipated movements in the exchange rate.

(5) We adopted a cross-correlation approach as an inferences about the efficiency of the "news" model of exchange rate determination. The results of the causality test showed no causal relation from M1 to exchange rates. This indicates that the currency substitution approach seems adequate in explaining exchange rate determination, and that foreign exchange markets efficiently absorb new information.

Further research is needed in the following three areas.

First, our conclusions with respect to the elasticity of substitution are related to our specification of the production function. It is possible that transaction technology can be typified by some other functional form, and the sensitivity of empirical results to alternative transaction technologies ought to be the subject of further investigation. The exchange rate model considered here is a reduced-form single equation, and it ignores the possibility of a simultaneous determination of the exchange rate along with macroeconomic variables. Alternative systems of joint estimation might lead to different inferences.

Second, measuring the elasticity of substitution involves a joint test for the theory of currency substitution and for the validity of the model for exchange rate expectations. Our empirical study was

conducted under the assumption of a random walk model and PPP-black market expectations, and our conclusions may be limited by these assumptions. In the future, we may examine the sensitivity of the estimated parameters to different expectation mechanisms. In addition, our nonlinear estimation rests on the assumption of classical properties for the error term. In further research, we need to apply several statistical diagnostics to test the assumptions for the error term.

Third, the cross-correlation function between exchange rates and the two money series is the data analysis tool employed here to identify the transfer function model. In the future, we may use the transfer function model to identify the relationship between money supplies and the exchange rate.

Appendix A: A Quadratic Functional Form and the Cost-Minimization.

In this appendix, first, the quadratic function is introduced and its properties is described. This function can be used as a second-order local approximation to most production functions.^[1] Then, the cost-minimization of the optimal problem is set.

Consider a production technology for producing a single output, monetary services (m_s), using domestic real money balances (m_d) and foreign real money (m_f) as inputs. A general quadratic form is written as follows:

$$(A.1) \quad m_s = T(t) \left[\sum_i \sum_j \alpha_{ij} m_i^{\beta\tau} m_j^{\beta(1-\tau)} \right]^{(1/\beta)},$$

where $i, j = d, f$ (domestic, foreign country), $m_s, m_d, m_f \geq 0$, $\alpha_{ij} \geq 0$, $\alpha_{ij} = \alpha_{ji}$, for all i, j , and $\beta \neq 0$.

This monetary services production function is monotonous, quasi-concave, and linear homogeneous (constant return to scale). Equation (A.1) is also called a quadratic mean of order β . For most of our purposes we will assume $\tau = 1/2$, since this condition introduces desirable symmetry among the money inputs, and many econometric studies have utilized the symmetry condition. It is only in the case where $\tau = 1/2$ that the major functional forms currently in use, such as CES, Cobb-Douglas, and Diewert (Generalized Leontief), Lu-Fletcher, and Sato-Hoffman forms, can be derived from this production function. The distribution parameters α_{ii} , α_{ij} , and α_{jj} are assumed to be non-negative. We assume, without loss of generality, that $\sum_{i=1} \alpha_{ii} + 2 \sum_{i \neq j} \alpha_{ij} = 1$.

With the $\tau = 1/2$ restriction, equation (A.1) can be written as follows:

$$(A.2) \quad m_s = T(t) \left[\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right]^{(1/\beta)}$$

This function is homogeneous of degree one in the inputs m_d and m_f . It can be quickly verified that the marginal products are non-negative. In the admissible space of the parameters the second partial derivatives are negative. This functional form can be used to derive other functional forms as its special case.^[2]

Case (I). If $\alpha_{ij} = 0$ for all $i \neq j$, equation (A.2) reduces to the CES form.

$$(A.3) \quad m_s = \left[\sum_i \alpha_{ii} m_i^\beta \right]^{1/\beta}, \quad i = d, f.$$

Case (II). If $\alpha_{ij} = 0$ for all $i \neq j$, β approaches zero, and $\sum_i \alpha_{ii} = 1$ to ensure constant returns to scale, equation (A.2) becomes the Cobb-Douglas form.

$$(A.4) \quad m_s = \prod_i m_i^{\alpha_{ii}}, \quad i = d, f.$$

Case (III). If $\beta = 1$ in equation (A.2), the Diewart (the generalized Leontief) form can be derived.

Case (IV). If $\alpha_{ii} = 0$, equation (A.2) becomes the Sato-Hoffman (1968) production function; $\alpha_{jj} = 0$, the Lu-Fletcher (1968) production function.

$$(A.5) \quad m_s = \sum_i \sum_j \alpha_{ij} m_i^{1/2} m_j^{1/2}, \quad i, j = d, f.$$

This quadratic function is weakly separable.^[3] In the empirical literature, Appelbaum (1979) uses parametric tests to discriminate among the translog (TLOG), generalized Leontief (GL) and square rooted quadratic functional (GSRQ) forms for production. He finds the latter two functions to be preferred choices for primal and dual representation of technology respectively. Berndt and Khaled (1979) noted that the generalized Box-Cox (GBC) form takes on the GSRQ, GL, and TLOG cost functions as special or limiting cases. They examined

whether the GBC model permits them to discriminate among the various flexible functional forms.

In the following section, we show the cost-minimization behavior by applying the quadratic function.

$$(A.6) \quad \text{Minimize: } C = i_d m_d + (i_f + \delta - x) m_f,$$

$$\text{Subject to: } m_s \leq T(t) \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta}, \quad i, j = d, f.$$

where C is portfolio holding cost;

d, f are domestic and foreign country indexes;

i_d is the domestic nominal interest rate;

i_f is the foreign nominal interest rate;

x is the expected depreciation of the exchange rate;

δ is the transaction cost (as a percentage of the total holdings) of maintaining foreign balances;

m_d, m_f are real balances of domestic and foreign money, which are defined as the nominal money stock (M_d, M_f) divided by the price level (P_d, P_f); and

T is a shift parameter representing some index of transactions technology or a measure of the institutional framework within which currency substitution is possible.

To solve the above optimal problem, we can set the following equation:

$$L = i_d m_d + (i_f + \delta - x) m_f + t \left(m_s - T \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta} \right),$$

$i, j = d, f$, and t is the Lagrangian multiplier.

It is difficult to solve three first-order equations directly in equation (A.6). We may use Shephard's Lemma to derive the demand equations for inputs from general quadratic cost function. In addition, this derived factor-demand equation, with many parameters to

be estimated, requires non-linear estimation procedures. However, the more parameters there are the larger becomes the danger that the selected initial values lead to estimates which have converged to a local rather than a global minimum.

The quadratic functional form (or the quadratic mean of order β) used in our model is, using Blackorby, Parimont and Russell's (1977) terminology, non-additively separable in the partition. It is a quadratic mean of order β function of CES aggregator function with elasticity of substitution equal to $2/(2-\beta)$. This form makes the simplifying assumption that the reaction term between m_d and m_f , α_{df} is equal to $\alpha_{dd}^{1/2} \alpha_{ff}^{1/2}$. This simplification is necessary to obtain a tractable model which has a simple form solution. But from an empirical research worker's point of view it is much more easily adoptable and still maintains its essential characteristics of quadratic function.

In addition, this assumption assures tractability which is taken up in chapter 3.2 and 3.4, and chapter on the exchange-rate determination. The economic meaning of this assumption is that the marginal productivity of using extra unit of money input is same. In other words, the cross effects of using another money input is same. We rewrite the above equation as follows:

$$(m_s/T)^\beta = (\alpha_{dd}^{1/2} m_d^{\beta/2} + \alpha_{ff}^{1/2} m_f^{\beta/2})^2$$

$$\text{Then, } m_f = \{ [1/(\alpha_{ff}^{1/2})] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} \}^{2/\beta}.$$

We can rewrite (A.6) as follows:

$$(A.7) \quad C = i_d m_d + (i_f + \delta - x) m_f,$$

$$= i_d m_d + (i_f + \delta - x) \{ [1/(\alpha_{ff}^{1/2})] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} \}^{2/\beta}.$$

Set $\partial C / \partial m_d = 0$, or

$$i_d = (i_f + \delta - x) \left\{ \left[1/(\alpha_{ff})^{1/2} \right] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} \right\}^{(2/\beta)-1} \\ \left[(\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{(\beta/2)-1} \right]$$

We can express m_d in terms of holdings costs and other exogenous variables. With substitution and simplification we can solve the conditional money demand equation as follows:

$$(A.8) \quad m_d = \alpha_{dd}^{-1/\beta} \left\{ 1 + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \right\}^{-2/\beta} m_s T^{-1},$$

This is equation (3.5) in chapter 3.

Following the same procedures as above, we can express the case of financial dualism in developing countries by using the following basic model. We assume that individuals and firms can only obtain funds either from domestic organized or unorganized money markets. They minimize the cost of obtaining a given level of monetary services provided either in official or unorganized money markets.

$$(A.9) \quad \text{Minimize: } C = i_d m_d + i_u m_u,$$

$$\text{Subject to: } m_s = T(t) \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta}, \quad i, j = d, u.$$

where d is organized money market, u is unorganized market, M_u is money borrowed from the unorganized market, and i_u is the interest rate on the unorganized market. The optimal money demand for the domestic organized market is derived by solving equation (A.9). That is,

$$(A.10) \quad m_d = \alpha_{dd}^{-1/\beta} \left\{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \right\}^{-2/\beta} m_s T^{-1},$$

This is the equation for financial dualism in Appendix B.

All studies on currency substitution assumed that the degrees of substitution can be measured by Hick-Allen partial elasticities of substitution. Although some questions can be raised on such an assumption, our study also uses this measure. The concept of the Hicks-Allen elasticity of substitution (σ) has been applied in the literature on currency substitution. When $\sigma_{ij} < 1$, currency i and j

are said to be complements, whereas if $\sigma_{ij} > 1$, then the two currencies are said to be substitutes. The elasticity of substitution in our quadratic function is $\sigma = 2/(2-\beta)$. If the isoquant is to be convex to the origin, $\sigma > 0$, the range of values for β is $-\infty < \beta < 2$.

Most theoretical and empirical formulations of production functions in the literature implicitly assume that separability conditions do prevail. Blackorby, Primont and Russell (1977) examine the implications of imposing separability on the flexible functional forms. The quadratic functional form (or the quadratic mean of order β) used in our model is, using Blackorby, Parimont and Russell's (1977) terminology, non-additively separable in the partition. It is a quadratic mean of order β function of CES aggregator function with elasticity of substitution equal to $2/(2-\beta)$.^[4]

Next, we analyze currency substitution with financial dualism and consider the effects on the domestic demand for money. We assume that individuals and firms can borrow their working capital not only from domestic markets (both organized and unorganized) but also from foreign sources. To this end, we expand the framework of the previous section to examine a domestic money demand function for developing countries allowing for combining financial dualism and foreign exchange considerations. The model can be rewritten as follows:

$$(A.11) \text{ Minimize: } C = i_d m_d + i_u m_u + (i_f + \delta - x) m_f,$$

$$\text{Subject to: } m_s = T(t) \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta},$$

where $i, j = d, u, \text{ and } f$.

Again, to simplify expression, we assume:

$$\alpha_{df} = (\alpha_{dd} \alpha_{ff})^{1/2}, \alpha_{du} = (\alpha_{dd} \alpha_{uu})^{1/2}, \text{ and } \alpha_{uf} = (\alpha_{uu} \alpha_{ff})^{1/2}.$$

To solve the above optimal problem, we can set the following equation:

$$m_f = \{ [1/(\alpha_{ff})^{1/2}] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} - (\alpha_{uu}/\alpha_{ff})^{1/2} m_u^{\beta/2} \}^{2/\beta}.$$

We can express

$$\begin{aligned} C &= i_d m_d + i_u m_u + (i_f + \delta - x) m_f, \\ &= i_d m_d + i_u m_u + (i_f + \delta - x) \{ [1/(\alpha_{ff})^{1/2}] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} - \\ &\quad (\alpha_{uu}/\alpha_{ff})^{1/2} m_u^{\beta/2} \}^{2/\beta}. \end{aligned}$$

Again, set $\partial C / \partial m_d = 0$, $\partial C / \partial m_u = 0$.

We have

$$\begin{aligned} i_d &= (i_f + \delta - x) \{ [1/(\alpha_{ff})^{1/2}] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} \\ &\quad - (\alpha_{uu}/\alpha_{ff})^{1/2} m_u^{\beta/2} \}^{(2/\beta)-1} [(\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{(\beta/2)-1}]. \end{aligned}$$

$$\begin{aligned} i_u &= (i_f + \delta - x) \{ [1/(\alpha_{ff})^{1/2}] (m_s/T)^{\beta/2} - (\alpha_{dd}/\alpha_{ff})^{1/2} m_d^{\beta/2} \\ &\quad - (\alpha_{uu}/\alpha_{ff})^{1/2} m_u^{\beta/2} \}^{(2/\beta)-1} [(\alpha_{uu}/\alpha_{ff})^{1/2} m_u^{(\beta/2)-1}]. \end{aligned}$$

To solve them together, we get

$$\begin{aligned} (A.12) \quad m_d &= \alpha_{dd}^{-1/\beta} \{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \\ &\quad + [i_d/(i_f + \delta - x)]^{\beta/(2-\beta)} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} \}^{-2/\beta} y^{1/u} T^{-1}, \end{aligned}$$

This is equation (3.7) in chapter 3.3

Again, we can follow same procedure to express m_u in terms of m_d , m_f , m_s , T , and other exogenous variables. Then, substitute into the cost function, and set

$$\partial C / \partial m_d = 0 \quad \text{and} \quad \partial C / \partial m_f = 0.$$

Taking the ratio of the above two equations, we have

$$(A.13) \quad (m_d/m_f) = \{ (\alpha_{ff}/\alpha_{dd})^{1/2} [i_d/(i_f + \delta - x)] \}^{2/(\beta-2)},$$

This is equation (3.9) in chapter 3.3.

However, we should point out that once we depart from the two-dimensional world, any extension of the above quadratic function confronts some intrinsic difficulties. Its generalization to a case of three or more inputs imposes limitations on patterns of substitution. McFadden (1963) and Uzawa (1962) have shown, essentially, that elasticities of substitution among all inputs must be the same in generalized CES function. Fuss and McFadden (1978), and Mundlak (1978) have pointed out that once we depart from the two-inputs case, any extensions of the C.E.S. function have to confront some difficulties.

Since the quadratic function in our model is a quasi-concave homothetic production function which is weakly separable with respect to the partition at a point if and only if the Allen elasticities of substitution among pairs of inputs are equal. We virtually avoid the problem of measuring elasticities between a variety of pairs of different monetary assets simultaneously in the n-input world. This form is limited for the problem at hand because elasticity of substitution is identical for any pair of monetary inputs included in the production function. Based on the multiple inputs CES function, Moroney and Wilbratte (1976) provide the empirical findings that they are unable to reject the hypothesis that all elasticities are equal. Boyes and Kavanaugh (1979), and Sinai and Stokes (1981), they examine three-factor (capital, labor, and real money balance) CES production by assuming all partial elasticities are equal. In this thesis we only examine the overall elasticity of substitution in the quadratic production function.

Footnotes---Appendix A

1. Diewert (1971, 1974) rigorously defined the concept of this definition. A function is a flexible functional form if it can attain an arbitrary level and first-and second-order derivatives at a predetermined single point. Flexible functional forms also frequently have been equated with second-order approximations. Here, flexibility means the ability of the algebraic functional form to approximate arbitrary but theoretically consistent behavior through an appropriate choice of the parameters. The concept of flexibility was first introduced by Diewert (1973,1974).

2. Blackorby, Primont and Russell (1977) have shown that the quadratic mean of order β approaches the homogeneous translog as $\beta \rightarrow 0$. This function can be used to test structural restrictions in the same manner as the translog is used.

3. Suppose the production function $y = f(x) = f(x_1, x_2, \dots, x_n)$ is twice differentiable and strictly quasi-concave, with n inputs denoted $N=1, \dots, n$, and is partitioned into r mutually exclusive and exhaustive subjects $(N_1, \dots, N_r)$, a partition called R . The $f(x)$ is weakly separable with respect to partition R when the marginal rate of substitution between any two inputs x_i and x_j from any subset N_s , $s=1, \dots, r$, is independent of the quantities outside N_s . The weak separability condition is stated as

$$f_{i_1 k} f_{i_1 j k} - f_{i_1 j k} f_{i_1 k} = 0, \text{ or } C_{j_1 k} C_{i_1 k} - C_{i_1 k} C_{j_1 k} = 0.$$

Separability implies that the MRTS between any pair of these inputs is not affected by holdings of other inputs outside this group. Separability shows that each determinant of the function is independent, each pair of utility strong separable whether they are drawn from the same group. The results from the ratio of holding currencies showed that the degree of substitutability between any two assets depends upon the assumptions made about separability. See Berndt and Christensen (1973) and Fuss and McFadden (1978) for the derivation of these concepts.

4. Blackorby, Primont and Russell (1977) develop a theorem characterize the class of symmetric structures that can be modeled by the quadratic mean of order β . This theorem says the aggregator functions for the additively separable sectors are themselves quadratic means of order β and the aggregator functions for the non-additively separable sectors are CES functions with elasticities of substitution equal to $2/(2-\beta)$.

Appendix B:

An Analysis of Financial Dualism in Developing Countries:

— The Case of South Korea and Taiwan —

I. Introduction

It is well known that the financial system in developing countries has a dual structure which consists of the official banking system or the "organized" money markets, and the unorganized money markets. The financial institution is in fact composed of two sectors. One sector commonly thought of as comprising financial institutions consists of the commercial banks, saving banks, and other modern financial intermediates. They promote activities of the markets, which we call the official money markets. The other broad financial sector is unlicensed, unregulated, and consists of informal or unorganized money markets. As such, unorganized money markets are an indispensable part of the financial system in developing countries.

Financial repression, which characterizes an economy with financial dualism, is found in the distorted mechanism which allocates the total credit rather than mobilizing it. The essential characteristic of financial repression is the existence of severe distortion and disequilibria in the financial system. The official banking system is usually controlled by the government for its seignorage through the regulation of deposit rates, which leads to negative real returns to saving. Besides, highly subsidized borrowing rates are provided to favored groups in the country, distorting credit allocation and forcing unfavored borrowers to borrow at a high marginal rate from the formal banking sector or the unorganized market. According to most accounts,

the volume of loans transacted in unorganized money markets are at least as great, and perhaps several fold greater, than that transacted in official money markets.^[1]

In most developing countries interest rates are determined administratively, typically through legally imposed ceilings or floors on lending and deposit rates, and lead to a negative real return to saving through the banking system and thus discourages savings. A reason commonly cited for the authorities to control interest rates is that in most developing countries these markets suffer from severe imperfections.

The nature and interplay of these two components of the overall financial system is an important feature both of the historical process of financial development and of the way resources are raised and distributed and monetary policies implemented. These relationships are especially important in countries where the regulated financial sector is repressed by advertent or inadvertent government policy. Without considering the interaction of these subsystems we can not understand the working of the whole financial system in developing countries. This is why the reconsideration of unorganized money markets has crucial importance in modeling the demand for money in developing countries. In addition, the domestic unregulated financial sector can often generate reasonable data on market-clearing interest rates.^[2] In some economies (most notably Korea and Taiwan) the central bank regularly collects unorganized markets interest rate data as a gauge of monetary and financial conditions.

It is believed that financial repression accounts for much of the interest rate differential between the organized and unorganized money

markets.^[3] The unorganized (curb) money markets mobilize funds from informal lenders and channel them to business firms, where they are mainly used to support working capital. The aggregate size of the unorganized money market in both Korea and Taiwan was estimated to be large and significant. Lying outside regulated channels, activities in the curb market take a wide assortment of forms and employ a large variety of instruments, including suppliers' credit, leasing or installment credit companies, and businesses that surreptitiously accept deposits from staff and outsiders.

McKinnon (1973) and Shaw (1973) among others studied the relation between financial development and economic growth. They disparaged the role of unorganized money markets because of their inefficient intermediation, while focusing on that of the official banking system.^[4] Chang (1986) pointed out two possible reasons for researchers to ignore the role of unorganized money markets: first, unorganized money markets could be absorbed into the banking system during the process of financial development; second, it is difficult to incorporate them into a model because of the unobservable size of the unorganized money market.

In this appendix, we plan to investigate how our previous model can be used to analyze financial dualism and to show the policy implications for financial liberalization in developing countries. We examine how this financial dualism affects the empirical results of the demand of money, and show the differences from previous studies. In this section, we attempt to construct a simple model of the financial markets in developing countries by applying the model from last section.

II Theoretical Model

We assume that individuals and firms, who are not allowed to borrow from foreign sources, can only obtain funds either from domestic organized or unorganized money markets. This is different from the traditional view of unorganized money markets, (Wai 1957) and McKinnon (1973),^[5] that regard the nature of the funds in unorganized markets as more "consumptive" than "productive". Similar to Van Wijnbergen (1983), we assume that the activity of unorganized money markets are productive in the sense that they are to meet the needs of business firms to finance their working capital.^[6] Individual agents minimize the cost of obtaining a given level of monetary services provided either in official or unorganized money markets. We can express the case of financial dualism in developing countries by using the following basic model:

$$(B.1) \text{ Minimize: } C = i_d m_d + i_u m_u,$$

$$\text{Subject to: } m_s = T(t) \left(\sum_i \sum_j \alpha_{ij} m_i^{\beta/2} m_j^{\beta/2} \right)^{1/\beta}, \quad i, j = d, u.$$

where d is the organized money market (official banking system), u is the unorganized market, m_u is money borrowed from the unorganized market, and i_u is the interest rate on unorganized market funds. According to Cole and Park (1983), borrowings in the organized money markets and unorganized markets are substitutes in borrowers' portfolios, in the sense that the borrowers would be indifferent about the sources of borrowing insofar as the costs of borrowers are equal. The degree of substitutability depends on the "fragment" or "separateness" of the two markets in the dualism system, and the

accessibility of the official banking system to the borrowers. On the other hand, the complementary relationship between these two markets essentially hinge upon the way in which firms finance their expenditures. The firm must decide on the division of financing between these two markets, which will depend upon the structure of the firms' portfolios about maturity, liquidity, and the relative costs. Those firms use the official money markets to finance their fixed capital and meet the working capital requirement through unorganized money markets. The nature of such complementarity implies that an increase in the supply of the official banking credit does not necessarily lead to a decrease in the demand for unorganized money markets funds. In fact, it could lead to a rise in demand.

Following the same procedure as in Chapter 3.2 (or see Appendix A), the optimal money demand for the domestic organized market is derived by solving equation (B.1). That is,

$$(B.2) \quad m_d = \alpha_{dd}^{-1/\beta} \{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \}^{-2/\beta} m_s T^{-1},$$

$$M_d = M_d(i_d, i_u, y, T, P_d), \quad \text{where } m_u = (M_u/P_d).$$

The comparative statics associated with equation (B.2) are

$$\partial m_d / \partial i_d = G(-2/2-\beta) i_u^{-1} < 0,$$

$$\partial m_d / \partial i_u = G(-2/2-\beta) (-i_d) i_u^{-2} > 0,$$

$$\partial m_d / \partial y = m_d (uy)^{-1} > 0,$$

$$\partial m_d / \partial T = -T^{-1} m_d < 0,$$

$$\text{where } G = \alpha_{dd}^{-1/\beta} \{ 1 + [i_d/i_u]^{\beta/(2-\beta)} (\alpha_{uu}/\alpha_{dd})^{1/(2-\beta)} \}^{-(2+\beta)/\beta} \\ y^{1/u} T^{-1} (\alpha_{ff}/\alpha_{dd})^{1/(2-\beta)} [(i_d)/(i_u)]^{(\beta/2-\beta)-1}.$$

An increase in the domestic unorganized market interest rate will induce higher money demand in the formal banking system. The higher interest rates of unorganized markets increase the opportunity cost of borrowing such funds. To support a given level of transactions, individuals or firms will substitute borrowing from the organized money market, which leads to an increase in domestic demand for money in the formal banking system. This conclusion is in contrast to Chang's (1986) work. In his model, he assumes that the portfolio choice of households, with a given amount of wealth, is determined by interest rates in unorganized money markets and official money markets, and real income. The demand for money is assumed negatively related to interest rate in unorganized money market. Finally, as a result of increasing technological change, economic agents have apparently decreased their money demands in unorganized markets, given income and interest rates.

There is an interesting question may be asked in the analysis. Why is the interest rate reform (i.e., an increase in the interest rates in the official banking system) in many developing countries today less likely to reduce the size of unorganized money markets than the McKinnon-Shaw hypothesis suggests? The question is whether or not the interest rate reform is likely to reduce the size of the exorbitant unorganized money-market during the process of economic growth. A

standard policy recommendation to emanate a financially repressed economy is to liberalize financial markets by raising the institutionally fixed interest rates.^[7] Recently, some researchers have argued that this policy prescription is less appealing to policymakers in developing countries. Both Van Wijnbergen (1983) and Buffie (1984) note that, in many developing economies there exists an unorganized money market which typically provides more efficient intermediation than the formal banking sector. If the money balances in the unorganized money markets and official banking system are relatively close substitutes, then increasing deposit interest rates will attract funds primarily from the unorganized money market and the total supply of credit may actually decline in the short run.

Our model shows that financial deregulation in a formal banking system will raise the opportunity costs of borrowing in organized markets, in order that a given level of monetary service is satisfied, so economic agents will borrow more money in unorganized money markets.^[8] Our results show that it will induce lower interest rates in unorganized markets to encourage borrowing. However, it is necessary to note that our analysis of financial dualism in developing countries only focuses on the demand side of the credit market.^[9]

Similar to Buffie's (1984) results, our model shows that there is no guarantee that interest rate policy alone will do the job of diminishing the size of unorganized money markets. This model shows that the official banking system has developed in many repressed economies, but in most countries there are flourishing unorganized money markets. Our results are consistent with Cole and Park's (1983) study which find that not only have unorganized money-markets expanded

over the years, despite government efforts as suppression, but the unregulated money-markets have broadened their services to meet the financial needs of borrowers.

III Empirical Evidence

This section presents some quantitative evidence on the elasticities of substitution in unorganized money markets for Korea and Taiwan using quarterly data from 1965.I to 1986.III. Our main objective is to see if these empirical facts are indeed compatible with the implications of our theoretical model. We follow the econometric specification described in section 3.4. The estimated equation can be expressed as follows:

$$(B.3) \quad m_d = \{ 1 + [i_d / (i_u)]^{\beta / (2-\beta)} (C)^{1 / (2-\beta)} \}^{-2\tau / \beta} \\ y^{r/\phi} T^{-\tau} (m_{d,t-1})^{(1-\tau)} + v_{2t},$$

Table B.1-B.8 provides the empirical results for Taiwan and Korea during four different period. In Table B.9 we compare the elasticity of substitution in unorganized money market between these two countries. The equation (B.3) is estimated by the nonlinear least square. Estimated equation is reported together with the asymptotic t-value of each parameter estimate and the standard summary statistics, such as adjusted coefficient of determination, Durbin-Watson statistic, and F test. In the following section, we explain the empirical results of financial dualism for Taiwan and Korea separately.

The case of Taiwan

The estimation results for Taiwan, displayed in Table B.1-B.4, indicate that all estimated parameters are always of the expected sign

and have acceptable values, as suggested by our model; for example, the substitution parameter, $\beta \leq 2$, the speed of adjustments $0 \leq \tau \leq 1$, income elasticity μ , and the distribution parameters $\alpha_{uu}/\alpha_{dd} > 0$. Most of the estimated parameters are significant, based on t-value, and the overall fit seems reasonable. According to Table B.1, during the periods of 1965.I-1986.III, the speed of adjustment, τ , of DD and M1 is statistically significant which implies that the "partial adjustment toward stock equilibrium" specification is appropriate. The estimate of the speed of adjustment ranges from 0.52 to 0.57. The estimates of inverse income elasticity, μ , are highly significant in all monetary aggregates. Income elasticities range from 1.96 to 2.67, which is slight higher than estimates obtained by other investigators.^[10] Table B.1 reports estimated substitution parameter β for different monetary aggregates. We find that, except DD, parameter β in CC, M1, and M2 is statistically insignificant and has a low t-value exceeding unity. Elasticities of substitution, shown in Table B.9, range from 1.02 for M1 to 1.50 for CC, a relatively narrow range of variation. This results show weak evidence (in terms of low elasticity of substitution) financial dualism in Taiwan.

Table B.2-B.4 show the estimation results for three different subperiods. Table B.2 reports that, during 1965.I-1973.IV, the estimated substitution parameter β for different monetary aggregates are statistically significant. Both the speed of adjustment and the inverse income elasticity are statistically significant. The overall fit seem reasonable in this period. In Table B.9 we find that the elasticities range from 1.17 for CC to 2.88 to M2, and the financial dualism do exist in Taiwan during this period. Similar results can be

found in Table B.3 for period 1974.I-1979.IV. Table B.3 shows that the substitution parameter, speed of adjustment, and inverse income elasticity all are statistically significant in terms of high t-value. Interestingly, we find that, during 1974.I-1979.IV, the coefficient for CC is 0.79, and for DD and M1 are nearly to unity. These results imply that three-fourth of the CC adjustment takes place in a quarter, and full adjustment for DD and M1 by the end of the current quarter. Elasticities of substitution range from 1.09 for CC to 12.4 for M2.

Table B.4 provides the estimated results for Taiwan during 1980.I-1986.III. Both the estimated speed of adjustment, τ , and inverse income elasticities, μ , are highly statistically significant in terms of t-value. Except M2, quick adjustment to equilibrium takes place in a quarter, and the estimated of μ imply an income elasticity ranging from 1.53 for CC to 2.08 for M2. In addition, we find that the estimated substitution parameter β in both CC and M2 is statistically significant, elasticities of substitution are 5.12 and 7.78 respectively (shown in Table B.9). In general, the results show strong evidence (in terms of high elasticity) of financial dualism in Taiwan.

The estimation results, display in Table B.9, indicate that the estimate of the elasticities of substitution for different periods ranging from 1.09 to 5.12 for CC, from 1.03 to 1.24 for DD, from 1.02 to 1.47 for M1, and from 1.27 to 12.4 for M2. Those values are greater than one, the critical value above which two markets are said to be substitutes. Interestingly, the results also show that even in 1980's unorganized money market still are good substitutes for CC and M2. This results confirm that the unorganized money market still plays an important financial role in Taiwan. There are flourishing unorganized

money market in Taiwan economy, despite government effect to deregulation in official banking system.^[11]

The case of Korea

Compared with the case of Taiwan, the estimated results for Korea during different periods were less successful. It is disappointing to find, as Table B.5-B.7 demonstrates, only one-third of the estimated substitution parameter β had t-value exceeding unity. Parameter β s are either insignificant or display collinearity with other parameters. The high values of the corrected R^2 (Adj R^2) together with the low estimated t-value for the coefficients indicate multicollinearity. However, the estimates of other parameters τ and μ are reasonable in terms of estimated value and t-value. The range of the speed of adjustment τ in different periods are 0.13 to 0.23 (shown in Table B.5), 0.08 to 0.25 (in Table B.6) and 0.10 to 0.34 (in Table B.7), implying that slow adjustment to equilibrium. Income elasticities of different periods range from 1.57 to 2.39 (during 1965.I-1986.III), 1.81 to 1.97 (during 1965.I-1973.IV), and 0.86 to 1.77 (during 1974.I-1979.IV). The estimated elasticity of substitution (in Table B.9) shows that those value range from 1.03 to 1.27 for CC, from 0.78 to 1.55 for DD, from 1.06 to 1.42 for M1, and from 0.75 to 1.15, a relatively narrow rang of variation.

Table B.1 Parameter Estimates for Conditional Money Demand:
Taiwan 1965.I-1986.III

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.666 (1.01)	0.090 (1.17)	0.509* (9.91)	2.953 (0.47)	0.989	2.551	646.9
DD	0.061** (1.74)	0.521* (6.66)	0.380* (48.7)	0.044 (0.79)	0.992	1.695	609.4
M1	0.043 (1.47)	0.570* (8.50)	0.415* (73.1)	0.010 (0.69)	0.995	1.877	540.9
M2	0.431 (1.51)	0.055 (1.37)	0.374 (11.1)	2.611 (0.65)	0.997	1.197	532.5

Note: Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.
** indicates significance at the 10 % level.

Table B.2 Parameter Estimates for Conditional Money Demand:
Taiwan, 1965.I-1973.IV

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.290* (2.25)	0.419* (5.52)	0.379* (20.4)	2.772 (0.67)	0.987	1.827	918.1
DD	0.348* (2.25)	0.605* (6.39)	0.360* (19.1)	5.063 (0.64)	0.974	2.373	435.2
M1	0.368* (2.65)	0.524* (6.46)	0.365* (21.2)	4.434 (0.75)	0.983	2.248	686.1
M2	1.306* (2.69)	0.117 (1.39)	0.287* (4.69)	206.3 (0.97)	0.988	0.988	702.5

Note: Adj R² is adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

**Table B.3 Parameter Estimates for Conditional Money Demand:
Taiwan, 1974.I-1979.IV**

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.167** (1.76)	0.788* (6.06)	0.536* (23.1)	0.059 (0.88)	0.964	1.659	203.8
DD	0.263* (4.40)	1.086* (10.6)	0.471* (34.5)	0.367* (2.27)	0.975	1.111	304.7
M1	0.303* (3.78)	1.008* (10.1)	0.494* (35.7)	0.233* (2.09)	0.983	1.213	349.8
M2	1.839* (39.4)	0.378* (3.72)	0.529* (323)	3.322* (10.2)	0.987	1.300	375.6

Note: Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.
** indicates significance at the 10 % level.

**Table B.4 Parameter Estimates for Conditional Money Demand:
Taiwan, 1980.I-1986.III**

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	1.609* (3.76)	0.519* (3.79)	0.653* (126.7)	1.426 (0.83)	0.942	1.827	221.4
DD	0.389 (1.22)	0.810* (4.87)	0.485* (9.42)	0.590 (0.99)	0.968	1.359	264.1
M1	0.638 (1.26)	0.791* (5.93)	0.528* (13.7)	0.461 (1.12)	0.979	1.740	405.2
M2	1.743* (5.34)	0.050 (0.66)	0.480* (10.9)	3.758* (2.16)	0.992	1.341	245.6

Note: Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

Table B.5 Parameter Estimates for Conditional Money Demand:
Korea, 1965.1-1986.III

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.066 (1.04)	0.234* (6.94)	0.419* (11.3)	0.181 (0.43)	0.936	1.582	419
DD	0.479 (1.47)	0.133* (5.33)	0.636* (9.60)	1.088 (0.73)	0.970	2.147	914
M1	0.110 (0.89)	0.225* (9.73)	0.589* (17.4)	0.042 (0.39)	0.971	2.166	958
M2	0.107 (1.31)	0.125* (10.9)	0.493* (19.9)	0.103 (0.58)	0.955	2.182	916

Note: Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

Table B.6 Parameter Estimates for Conditional Money Demand:
Korea, 1965.I-1973.IV

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.347 (1.31)	0.247* (6.68)	0.523* (6.79)	3.887 (0.66)	0.943	2.358	194
DD	0.708 (0.82)	0.078* (2.98)	0.552* (2.79)	12.39 (0.63)	0.982	2.349	643
M1	0.536 (1.09)	0.129* (4.47)	0.507* (4.50)	10.33 (0.66)	0.973	2.542	414
M2	0.262 (0.40)	0.108* (4.42)	0.522* (3.87)	0.560 (0.22)	0.989	2.295	563

Note: Adj R² is the adjusted coefficient of determination,
D. W. the is Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

Table B.7 Parameter Estimates for Conditional Money Demand:
Korea, 1974.I-1979.IV

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	0.429 (0.87)	0.341* (3.87)	0.565* (4.27)	3.311 (0.26)	0.792	2.627	30
DD	-0.579 (-0.06)	0.102 (0.96)	1.157 (1.08)	3.992 (0.02)	0.652	2.260	35
M1	0.593 (0.77)	0.167* (1.77)	0.564* (2.03)	4.607 (0.18)	0.712	2.410	29
M2	-0.665 (-0.11)	0.135* (2.32)	0.897* (2.67)	3.596 (0.03)	0.911	1.798	78

Note: Adj R² is the adjusted coefficient of determination,
D. W. is the Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

Table B.8 Parameter Estimates for Conditional Money Demand:
Korea, 1980.I-1986.III

Dependent Variable	Estimated Parameter				Summary Statistics		
	β	λ	μ	C	Adj R ²	D. W.	F-test
CC	-0.263* (-2.75)	0.756* (8.09)	1.141* (6.43)	0.284 (0.82)	0.842	2.827	47
DD	1.846* (14.2)	0.302* (5.26)	0.750* (224.4)	4.385* (4.50)	0.920	2.415	171
M1	1.783* (6.80)	0.387* (7.95)	0.721* (258.8)	3.343 (1.56)	0.906	2.417	152
M2	1.646* (3.76)	0.206* (10.2)	0.651* (142.1)	2.330 (0.94)	0.988	1.479	121

Note: Adj R² is the adjusted coefficient of determination,
D. W. is Durbin-Watson test statistic,
Numbers in parentheses are t-statistics,
* indicates significance at the 5 % level.

**Table B.9 Estimated Elasticities of Substitution
in Unorganized Money Market.**

Country	Taiwan				Korea			
Period	CC	DD	M1	M2	CC	DD	M1	M2
1965.I	1.50	1.03	1.02	1.27	1.03	1.31	1.06	1.06
1986.III								
1965.I	1.17	1.21	1.23	2.88	1.21	1.55	1.37	1.15
1973.IV								
1974.I	1.09	1.15	1.18	12.4	1.27	0.78	1.42	0.75
1979.IV								
1980.I	5.12	1.24	1.47	7.78	0.88	13.0	9.22	5.65
1986.III								

Source: Table B.1-8

Note: elasticity of substitution of the quadratic function is $2/(2-\beta)$

During 1980.I-1986.III, shown in Table B.8, the estimation results are good. The substitution parameter β of all definitions of money is statistically significant and has high t-value. Except CC, elasticities of substitution of (shown in Table B.9) DD, M1, and M2 are 13.0, 9.22, and 5.65, respectively. Those values are greater than one, the critical value above which two markets are said to be substitutes. The elasticity of substitution for CC becomes complements rather than substitutes. These results are inconsistent with Sung and Un's (1986) arguments. They find that, in recent years, the gap between interest rates offered by unorganized money markets and the official banking system has narrowed. This tendency results from the more frequent

adjustment of official interest rates and suggests that the markets are more integrated and have become more complementary to each other recently than in the past. However, our results do show strong evidence for the measurement of the elasticity substitution for unorganized money markets in the case of Korea. The financial dualism does exist in Korea during 1980.I-1986.III.

The estimate of income elasticity in this period ranges from 0.88 to 1.54. A notable fact is that the demand for CC shows lower income elasticities than DD. It is consistent with the usual assumption that the deposit money is more luxurious than currency. As for the speed of adjustment, we find the coefficients of adjustment for different monetary aggregates have statistically significant and increased in recent years. The estimate of the speed of adjustment, range from 0.21 for M2 to 0.76 for CC.

Chang (1986) adopts an alternative approach in investigating Korea's unorganized money market from 1970 to 1981. Chang (1986) estimates the effects of interest rates in both the official and unorganized money markets on the demand for different monetary aggregates. The sign and magnitude of the estimated coefficients will then be examined to analyze the implications of his model. However, the interest rates on alternative moneys are highly correlated and the independent cross-elasticity effects cannot be estimated reliably. Illustrative examples of multicollinearity among interest rates are found in his study. The evidence based on cross-elasticities of demand remains unclear. Compared with Chang's approach, our approach estimates the elasticity of substitution between the official banking system and unorganized money markets in a more direct way.

IV. Conclusion

In this appendix we estimate the extent to which domestic money balances in Korea and Taiwan have been influenced by financial repression considerations. To this end, economic agents are estimated to face a relatively simple optimization problem, the solution of which yields the specification of domestic money holding. This specification is implemented empirically and yields mixed success estimates of elasticities of substitution that range between 0.82 to 1.5 for monetary aggregates in Taiwan, between 0.88 to 1.55 for Korea. These results suggest that financial dualism is important for modeling money demand behavior in Korea and Taiwan, and, as a result, for the designing of monetary policies. Finally, it is important to examine the sensitivity of the empirical results to alternative transaction technologies, dynamic adjustments, and the consideration of the credit supply side. Analyses that focus on these considerations are certain to enhance our understanding of financial dualism in developing countries.

Footnotes---Appendix B

1. Both Shaw (1973) and Park (1973) speculated that the supply of funds in the unorganized money markets is probably some multiple of the funds provided in the official banking system.

2. Park (1973) approximated "the rate of interest" in unorganized money markets as an equilibrium rate determined by market forces. In general, it can be said that unorganized money markets serve those who do not have access to the formal banking system or who cannot meet all their needs from the banking sector, and those who are in a position to arbitrage between the two markets.

3. Financial repression is characterized by a monopolistic or oligopolistic banking system which distributes portfolios according to various rationing criteria, and by loan applicants who have been found relatively unappealing by creditors and have been forced to rely heavily on self-finance or the unorganized curb markets. The activities of the latter are unregulated, if not illegal, and so result in higher interest rates than those prevailing in the official, regulated financial market.

4. According to McKinnon (1973) and Shaw (1973), the official money market gradually takes on and absorbs much of the financial activities of the unorganized money market over the course of economic and financial development. The unorganized money market will be integrated with the formal banking system.

5. Wai (1957) and McKinnon (1973) regarded an essential feature of unorganized money markets as a low degree of integration or as "fragmentedness." They described the unorganized money market as very imperfect and noncompetitive, with limited information or interaction within the unorganized markets or with the organized market. Van Wijnbergen (1983) regarded new types of unorganized money markets as characterized by a highly competitive and efficient market structure closely related to the official banking system. Chang (1986) discussed several features between the traditional and the new type of unorganized markets. That is, the degree of integration of the market, consumptive or productive, and the complementarity or substitutability between the official and the unorganized credit was considered.

6. Wai (1957) regarded the nature of the demand for loanable funds in traditional unorganized money markets as more "consumption" than "productive". McKinnon (1973) ignores the mobilizing of sizable investable funds through unorganized money markets because of inefficient financial intermediation. However, Van Wijnbergen (1983) recognizes the "productiveness" of the unorganized money markets loans and efficient functioning of unorganized money markets as financial intermediation.

7. Increasing interest rates paid on deposits held in the banking sector will have two favorable effects. First, by raising the real return available to wealth holder in the economy, consumption will

decrease and the supply of saving will increase, thus alleviating the shortage of investment resources in the economy. Second, an increase in the rate of return to deposits, relative to returns for other assets, will induce a movement from nonproductive assets into deposits in the banking system. The consequence is an increase in the real size of the financial sector, which will also relieve to pervasive credit shortage. Van Wijnbergen (1983) points out that the result obtained by McKinnon (1973) and Kapur (1976), depends crucially on assumption on asset market structures; they assume that the portfolio shift into time deposit's comes out an "unproductive" assets like gold, cash, commodity stocks etc.

8. Kahkonen (1987) used an optimizing, general equilibrium intertemporal framework to find out whether liberalizations policies can be expected to improve the well-being of a financially repressed economy. He concludes that, in a high-tariff economy, attempts to end financial repression by raising the low interest rate in domestic official money markets may lead to a lower level of welfare. By contrast, if the tariff is sufficiently low, financial deregulations will be beneficial to the economy.

9. We recognize that the analysis of financial dualism in this appendix ignores the fact that the low lending rates in the formal banking sector are associated with credit rationing. When McKinnon (1973) and Shaw (1973) argue for an increase in official interest rates, they are discussing about moving toward a market-clearing rate and thus easing the quantitative credit restrictions. This requires looking at the credit market as a whole. Here, we only focus on the demand side of the credit market, without considering the credit market as a whole.

10. However, in the Fasano-Filho (1985) study, he found that the different income elasticities range from 0.72 to 2.81.

11. Cheng (1986) estimated that unorganized money market finance grew from 20% of total domestic financial assets in 1965 to more than 30% in 1980 - about equal to all financial institutions taken together. He further argues that the interest rate policy of Taiwan has resulted in a diversion of domestic savings from official banking systems to unorganized money markets.

Appendix C:

A Currency Substitution Model of Exchange Rate Determination

In Appendix C, we develop a model of exchange rate determination incorporating currency substitution behavior and investigate the role of new information in the determination of exchange rate movements.

I. A Model of Exchange Rate Determination

The demand function for domestic and foreign money from the previous chapter can be expressed as follows:^[1]

$$(C.1) \quad M_d = M_d(i_d, i_u, i_f, \delta, x, Y, T, P_d);$$

$$(C.2) \quad M_f = M_f(i_d, i_u, i_f, \delta, x, Y, T, P_f).$$

Each money demand function includes a scale variable and variables representing opportunity costs of holding money. These functions provide the basis for the subsequent analysis of exchange rate determination. Three important qualifications should be noted. First, the scale variable (the level of domestic income) of the two-money demand functions is the same and therefore plays no role in determining the demand for domestic currency relative to that for foreign balances. Second, opportunity costs (i_u, i_f, x) relevant to portfolio choice now become an argument in the demand functions for both currencies. Third, the money-demand functions, M_d and M_f , are defined by currency, not by country.

Since there is a monetary service production constraint, when the equilibrium conditions for domestic official and foreign money markets are met, the market equilibrium condition for the unorganized money market can be regarded as redundant.^[2] The money market equilibrium conditions for the other two markets are as follows:

$$(C.3) \quad M_{sd} = M_d$$

$$(C.4) \quad M_{sf} = M_f.$$

where M_{sd} and M_{sf} are the money supply of domestic and foreign currency.

Equation (C.3) reflects the assumption that the small country's currency is not held by foreign residents, since we assume that residents of the country issuing the strong currency (as an international medium of exchange) will have no need to diversify their currency holding for transaction purposes. This asymmetric currency substitution is most prevalent in developing countries. Thus, holdings of domestic currency by the small country's residents are equal to the money supply determined by the monetary authority. At any given moment, the nominal stock of the small country's currency, M_{sd} , is exogenous. This assumption has been adopted in the stock-flow approach, for example, by Calvo and Rodriguez (1977) and Niehans (1977). If monies could be traded freely in the world economy then we would consider the world supply and demand for each money. But the economy in question has capital controls in the sense that regulations are in force that restrict the availability of foreign exchange. The stock of foreign money is assumed to be exogenous and cannot be adjusted instantaneously.^[3]

Taking the ratio of equation (C.3) to equation (C.4), we have the following expression:

$$(C.5) \quad (M_{sd}/M_{sf}) = (m_d/m_f) (P_d/P_f).$$

Recall that m_d/m_f is the ratio of domestic holdings of real domestic and foreign balances. This ratio was shown in chapter 3.3 equation (3.9).^[4] Given the widely recognized failure of purchasing power parity to hold in the short run relevant to exchange rate

determination, we consider the case which allows deviations from purchasing power parity. ξ_t is a composite error term reflecting deviations from purchasing power parity, $\theta(L)\xi_t = v_t$, where L is the lag operator, and v_t is white noise. Equation (C.6) expresses the deviation of purchasing power parity in logarithmic form.^[5]

$$(C.6) \quad \ln e_t = \ln P_{d,t} - \ln P_{f,t} + \xi_t.$$

Substituting equation (3.9) into equation (C.5), then taking logarithms and substituting equation (C.6), we obtain the following expression for the exchange rate:

$$(C.7) \quad \ln e = \ln M_{sd} - \ln M_{sf} - [2/(\beta-2)] \ln[(\alpha_{dd}/\alpha_{ff})^{1/2} [i_d/(i_f + \delta - x)]] + \xi_t.$$

Equation (C.7) is a equation (4.1) in chapter 4. Many studies have been concerned with the case where the exchange rate is indeterminate in the presence of perfect substitution.^[6]

Equation (C.7) suggests that the larger the magnitude of the elasticity of substitution between domestic and foreign currency, the larger will be the effect of holding costs on the exchange rate. If the elasticity of substitution between the two currencies were zero, there would be no substitution between them, and the relative money supplies would determine the exchange rate. Hence, in the absence of any substitutability between two currencies, interest rate differentials and capital controls will have no effect on exchange rate determination.

To simplify our notation, let $\ln e_t = s_t$, $\ln M_{sd,t} = m_t$, $\ln M_{sf} = m_t^f$, and $\ln(\alpha_{dd}/\alpha_{ff})^{1/2} = k$. Recall that the definition of x is the expected rate of depreciation of the domestic currency. Under the assumption that expectations are formed rationally, $x_t = E_t s_{t+1} - s_t$, where $E_t s_{t+1}$ is the expectation of the exchange rate at time $t+1$ conditioned on

information available at time t . The information set at time t is assumed to include knowledge of all current and past variables as well as knowledge of the structure of the economy. Equation (C.7) can be approximated by the following equation:^[7]

$$(C.8) \quad s_t = (m_t - m_t^f) - [2/(\beta-2)]k - [2/(\beta-2)](i_{d,t} - i_{f,t} - \delta_t) \\ + \xi_t - [2/(\beta-2)](E_t s_{t+1} - s_t), \text{ or}$$

$$(C.9) \quad s_t = (\beta-2/\beta-4)(m_t - m_t^f) - [2/(\beta-4)]k - [2/(\beta-4)](i_{d,t} - i_{f,t} - \delta_t) \\ + (\beta-2/\beta-4)\xi_t - [2/(\beta-4)]E_t s_{t+1}.$$

Equation (C.9) shows that the log of today's spot rate depends on today's exogenous variables plus our expectation of the spot rate in the next period. However, from equation (C.9), $E_t s_{t+1}$ depends on $E_t s_{t+2}$, $E_t s_{t+2}$ depends on $E_t s_{t+3}$, and so forth. Equation (C.9), however, could not be directly tested without an additional assumption, since $E_t s_{t+1}$ is an unobservable variable. By applying rational expectations to equation (C.9), we generate an expression that specifies the expected value of exchange rates in any future period. This expression may be repeatedly substituted into equation (C.9) to obtain

$$(C.10) \quad s_t = (1-\gamma) \sum_{j=0}^{\infty} \gamma^j E_t (m_{t+j} - m_{t+j}^f) + \gamma \sum_{j=0}^{\infty} \gamma^j E_t (i_{d,t+j} - i_{f,t+j}) \\ + (1-\gamma) \sum_{j=0}^{\infty} \gamma^j E_t \xi_{t+j} + \gamma \sum_{j=0}^{\infty} \gamma^j k - \gamma \sum_{j=0}^{\infty} \gamma^j E_t \delta_{t+j},$$

where $\gamma = -[2/(\beta-4)]$.

This is equation (4.2) in chapter 4. Since $\beta \leq 2$, $0 \leq \gamma \leq 1$, and the convergence assumption that $\lim_{j \rightarrow \infty} \gamma^j E_t s_{t+1} = 0$ is made here. Equation (C.10) clearly illustrates that the exchange rate is the relative price of two monies. The current spot rate depends on both

current values and the expectation of all important driving variables (exogenous variables), including the relative money supply, interest rate differentials, coefficients of production technology, capital controls, and (infinite) expected future values. Thus, changes in the expected values of these variables can result in abrupt changes in spot exchange rates.

Equation (C.10) predicts that relative money supplies and nominal interest rate differentials are positively related to nominal exchange rates. The exchange rate is an increasing function of the domestic money stock and a decreasing function of the domestic resident's holdings of foreign money. An increase in the domestic interest rate implies a depreciation of the domestic currency; as the opportunity cost of holding that currency increases, demand falls, and it becomes less valuable relative to foreign currency.^[8] The fundamental determinants of the exchange rate are assumed to be the relative supplies of the two currencies and the relative costs of holding currencies.

As mentioned before, although the currency substitution literature can explain the "dollarization" phenomenon, it fails to account for the effect of government actions on the exchange rate. In this model, we consider the case in which the government imposes capital controls and transaction costs on the use of foreign currency. This affects the relative borrowing costs and relative demand for the two currencies and, thus, exchange rate determination. The implication of our analysis is that a liberalization scheme reducing the transaction costs of using the foreign currency will lead to a depreciation of the domestic currency.

In addition, the higher the marginal productivity of domestic money in the production of monetary services, that is, the lower k (higher distribution parameter α_{dd}), the more valuable the domestic currency will be relative to the foreign currency. As the distribution parameter α_{ff} becomes large, as the foreign currency's marginal production of money services increases, the demand for foreign currency by domestic residents can be raised to such an extent that a depreciation of the domestic currency occurs.

Based on the production approach to currency substitution with the assumption of rational expectations, we provide an explanation for the volatile behavior of exchange rates. First, the exchange rate is the relative price of monies, rather than national output, and is determined basically by the demand and supply of money stocks. Second, exchange rates are strongly influenced by the money holder's expectation of future exchange rates. Third, the foreign exchange market is efficient in the sense that all information relevant to future market conditions is discounted into the current exchange rate.

These results are similar to those obtain in the rational expectations monetary models, for example, Bilson (1979), Mussa (1982), Hoffman and Schlagenhauf (1983), and Finn (1986).^[9]

II. Economic News and Exchange Rate Movements

In the previous section we showed that the current spot exchange rate is determined by all the expected future values of the exogenous variables. The current rate reflects what is known or expected about the future. Exchange rates change only in response to unanticipated events (that is, changes in exogenous variables in a future periods).

Changes in exchange rates largely may reflect revised expectations

resulting from "news" or "surprises,"^[10] which may explain the widespread failure of econometric work in this area. Isard (1987) and Saidi (1983) believe that one reason structural models do not outperform random walk models may be that the former do not take news into account. In particular, both authors argue that the need to separate the role of unanticipated and anticipated movements in the exogenous driving variables is vastly underplayed.^[11] They suggest that structural models need to be properly tested in a "news" or innovations framework.

In this section we derive the "news" version of exchange rate movements, based on the previous model. We provide an analysis of how news affects exchange rate movements.

Solving backward to get an expression for s_{t-1} from equation (C.10), and subtracting this from equation (C.10), gives the rate of change of the exchange rate:

$$(C.11) \quad s_t - s_{t-1} =$$

$$\begin{aligned} & (1-\gamma) \sum_{j=0}^{\infty} \gamma^j [E_t (m_{t+j} - m_{t+j}^f) - E_{t-1} (m_{t+j-1} - m_{t+j-1}^f)] \\ & + \gamma \sum_{j=0}^{\infty} \gamma^j [E_t (i_{d,t+j} - i_{f,t+j}) - E_{t-1} (i_{d,t+j-1} - i_{f,t+j-1})] \\ & - \gamma \sum_{j=0}^{\infty} \gamma^j [E_t \delta_{t+j} - E_{t-1} \delta_{t+j-1}] \\ & + (1-\gamma) \sum_{j=0}^{\infty} \gamma^j [E_t \xi_{t+j} - E_{t-1} \xi_{t+j-1}]. \end{aligned}$$

Now, we can add and subtract $E_{t-1}(m_{t+j-1} - m_{t+j-1}^f)$, $E_{t-1}(i_{d,t+j-1} - i_{f,t+j-1})$, $E_{t-1} \xi_{t+j-1}$, k , and $E_{t-1} \delta_{t+j-1}$. Summing and rearranging yields:

$$(C.12) \quad s_t - s_{t-1} =$$

$$\begin{aligned} & (-\gamma/2) \sum_{j=0}^{\infty} \gamma^j \{ [2-(2/\gamma)] [(E_t - E_{t-1})(m_{t+j} - m_{t+j}^f) + (1-\gamma)E_{t-1}(m_{t+j-1} - m_{t+j-1}^f)] \} \\ & + (\gamma/2) \sum_{j=0}^{\infty} \gamma^j \{ 2[E_t - E_{t-1}] (i_{d,t+j} - i_{f,t+j}) + (1-\gamma) E_{t-1} (i_{d,t+j-1} - i_{f,t+j-1}) \} \\ & - (\gamma/2) \sum_{j=0}^{\infty} \gamma^j \{ [2-(2/\gamma)] [(E_t - E_{t-1}) \xi_{t+j} + (1-\gamma) E_{t-1} \xi_{t+j-1}] \} \\ & + (\gamma/2) \sum_{j=0}^{\infty} \gamma^j \{ (1-\gamma) k \} \\ & - (\gamma/2) \sum_{j=0}^{\infty} \gamma^j \{ 2 [E_t - E_{t-1}] \delta_{t+j} + (1-\gamma) E_{t-1} \delta_{t+j-1} \} \\ & + (\gamma/2) [(1-\phi)(m_{t-1} - m_{t-1}^f) - 2(i_{d,t-1} - i_{f,t-1}) + (1-\phi)q_{t-1} - 2k_{t-1} - 2\delta_{t-1}]. \end{aligned}$$

To get a clear expression of the above equation, we need to make two substitutions. First, referring to equation (C.12), the second expression within each of the first five pairs of square brackets in the above equation may be collected into one term, which may be replaced by $(1-\gamma)E_{t-1}s_t$. Second, in the last term of the above equation (C.12), we may substitute the following relationship, $s_{t-1} = \gamma E_{t-1}s_t$. After combining terms, equation (C.12) can be expressed as follows:

$$(C.13) \quad s_t - s_{t-1} =$$

$$\begin{aligned} & (1-\gamma) \sum_{j=0}^{\infty} \gamma^j [(E_t - E_{t-1}) (m_{t+j} - m_{t+j}^f)] \\ & + \gamma \sum_{j=0}^{\infty} \gamma^j [(E_t - E_{t-1}) (i_{d,t+j} - i_{f,t+j})] \\ & + (1-\gamma) \sum_{j=0}^{\infty} \gamma^j (E_t - E_{t-1}) \xi_{t+j} \end{aligned}$$

$$\begin{aligned}
& j=0 \\
& - \gamma \sum_{j=0}^{\infty} \phi^j (E_t - E_{t-1}) \delta_{t+j} + (1-\gamma) E_{t-1} s_t - s_{t-1} + \gamma E_{t-1} s_t.
\end{aligned}$$

The rate of change of the exchange rate, Δs_t , can be written as:

$$\begin{aligned}
(C.14) \quad \Delta s_t = s_t - s_{t-1} = & \\
& (1-\gamma) \sum_{j=0}^{\infty} \gamma^j [(E_t - E_{t-1}) (m_{t+j} - m_{t+j}^f)] \\
& + \gamma \sum_{j=0}^{\infty} \gamma^j [(E_t - E_{t-1}) (i_{d,t+j} - i_{f,t+j})] \\
& + (1-\gamma) \sum_{j=0}^{\infty} \gamma^j (E_t - E_{t-1}) \xi_{t+j} \\
& - \gamma \sum_{j=0}^{\infty} \gamma^j (E_t - E_{t-1}) \delta_{t+j} \\
& + [E_{t-1} s_t - s_{t-1}].
\end{aligned}$$

Equation (C.14) can be used to formalize the findings of Dornbusch (1980), Frenkel (1981a), Hartly (1983), Edwards (1983), and Isard (1983) regarding the importance of unanticipated shocks. The total change in the exchange rate can be easily decomposed into anticipated and unanticipated components. That is,

$$\begin{aligned}
(C.15) \quad \Delta s_t = s_t - s_{t-1} & \\
= (s_t - E_{t-1} s_t) + (E_{t-1} s_t - s_{t-1}) & \\
= \Delta s_t^u + \Delta s_t^a. &
\end{aligned}$$

This is equation (4.3) in chapter 4. A Δ denotes a first difference in the variable. The first four terms in the left-hand side of equation (C.14) are the discounted sums of unanticipated changes (innovations or news) in the exogenous variables (relative supplies of

domestic and foreign monies held by domestic residents, nominal interest rate differential, and the degree of capital controls) associated with the unanticipated change in the exchange rate, Δs_t^u . The divergence between the expected exogenous variables for period t (as set on $t-1$ period) and the actual exogenous variables in period t , or market forecasting error, can be explained by the fact that the exogenous variables in t reflect new information that was unavailable in period $t-1$. From this perspective, in every period people will use the "news" to revise their forecast about the future spot rate. In other words, unanticipated movements in the exogenous variables should lead to movements in the exchange rate. The final term in the left-hand side of equation (C.14) is the anticipated change in the exchange rate.

The first term in equation (C.15) is the unexpected variation in the exchange rate. It is exclusively a function of new information accruing between time $t-1$ and t . The second term in equation (C.15) can be expressed as $E_{t-1} s_t - s_{t-1} = \Delta s_t^a$, which is the anticipated change in the exchange rate (based on information available at time $t-1$). This component contains past actual and expected future changes in the exogenous variables, all based on information available in time $t-1$.

Notice that equation (C.14) suggests that news about a number of variables affects exchange rate behavior. To the extent that $E_t m_{t+j}$, $E_t m_{t+j}^f$, $E_t i_{d,t+j}$, $E_t i_{f,t+j}$, and $E_t \delta_{t+j}$ are jointly determined, equation (C.14) shows there are multiple channels through which particular news is transmitted to the exchange rate. News has been modeled in a variety of ways. For example, Frenkel (1981a) allows unanticipated changes in the term structure of interest rates to play the role of "news". Dornbusch (1980) represents news by unanticipated current

account balances. Hartley (1983) identifies several types of news including money supplies and national incomes. In our study we show that the exchange rate response to news involves a wide variety of economic variables.

III Conclusions

In this appendix, we have derived the equation for exchange rate determination in a news framework. The exchange rate is affected by an influx of new information at once. We showed that news about several economic variables on which expectations are based leads to unobservable revisions in expectations and observable changes in exchange rates. We found that both unanticipated exogenous variables, and expected future exogenous variables are predicted to influence directly the path of the exchange rate.

In particular, the currency substitution model implies that exchange rate determination is related to anticipated and unanticipated changes in relative holding of domestic and foreign monies in the domestic country, interest rate differentials, and the degree of capital controls. The importance of expectations imply that the stability of exchange rates may require stable expectations. This may have particular relevance for the way in which exchange rate policy and monetary policy are conducted with respect to domestic and external objectives.

Footnotes—Appendix C

1. To simplify our notation, we do not explicitly express the exact form of the demand functions. In Appendix A we derive both demand functions explicitly.

2. Here, we follow Girton and Roper's (1981) assumption about the equilibrium condition. The model of currency substitution developed by them contains two money-demand functions which, together with exogenous money supplies, are used to analyze the money exchange rate. A third non-monetary asset is implicit in the model, but the balance sheet constraint makes the market equilibrium condition for the asset redundant.

3. We assume for simplicity that the nominal stock of foreign money is equal to the demand for foreign currency by domestic residents, rather than that there is a given supply of each money in the world. In the case of very rigid exchange controls, we should consider that only the black market exchange rate adjusts to clear the domestic market for the two moneys. The assumption of exogenous money supplies has been adopted in Girton and Roper (1981), and Canto and Miles (1983). In addition, Sundararajan (1987) studies the private investment function in Korea, and assumes that the value of foreign currency debt is treated as exogenous owing to restrictions on capital flows. Kouri (1976) and Calvo and Rodriguez (1977) extend the analysis of the money supply process by explicitly introducing a function determining the supply of foreign currency coming into the domestic economy through the balance of payments.

4. Stulz (1984) showed that the ratio of holdings of domestic balances to foreign balances does not depend on either the rate of time preference or relative risk aversion.

5. Purchasing power parity does not hold in the short run. A commonly cited source of recent shifts in the long-run terms of trade are the oil price rises of the 1970s. Other possible sources include nontraded goods prices. In Hooper and Morton's (1982) terms, ξ_t is the long-run or "sustainable" real exchange rate. Empirical evidence indicates that ξ_t (real exchange rate) is probably non-stationary. Roll and Solnik (1979) have indicated that the deviations from purchasing power parity follows a random walk. In here, we follow the assumption adopted by Edward (1983) and Hartley (1983) that the deviations from purchasing power parity can be shown to be a random element.

6. There are two possible ways through which perfect substitution can be achieved. One is perfect substitution in supply, emphasized by the monetary approach, which is nothing more than the fixed exchange rate case. The other possibility is that currencies are perfect substitutes in demand, considered in the currency substitution approach.

$$\begin{aligned}
7. \quad & \text{Since } \ln [i_d / i_f + \delta - x] = \ln [(i_d - 1) + 1] / [(i_f + \delta - x - 1) + 1] \\
& = \ln [(i_d - 1) + 1] - \ln [(i_f + \delta - x - 1) + 1] \\
& \approx (i_d - 1) - (i_f + \delta - x - 1) \\
& = i_d - i_f - \delta + x.
\end{aligned}$$

8. The Frenkel (1976)-Bilson (1979a), or flexible-price monetary model, posits that the interest rate differential coefficient restriction is positive. In contrast to the Frenkel-Bilson model, Dornbusch (1976) and Frankel (1979) hypothesize that the coefficient on the interest differential is negative. The principal theoretical difference between the Frenkel-Bilson model and the Dornbusch-Frenkel model is that the latter allows for short-run deviations from purchasing power parity caused by sticky domestic prices. The result of the interest coefficient is similar to Bilson (1979b) but different from Dornbusch (1976) and Frankel (1979).

9. To estimate equation (4.10), it is necessary to obtain an observable expression for the expectational terms it contains. Both Haffman and Schlagenhauf (1983) and Finn (1986) use the method to specify the stochastic processes of the exogenous variables. For this purpose the Box-Jenkins technique was carried out. A prerequisite of this analysis is that the variable be stationary.

10. Frenkel (1981a) has suggested that short-run movements in exchange rates are dominated by the effect of unanticipated movements in the exogenous variables.

11. Meese and Rogoff (1983) show that the empirical exchange rate models of the 1970s provide poor explanations of exchange rate behavior out of sample. Such evidence is not surprising; Mussa (1979) already had pointed out that exchange rate movements are predominantly unexpected or, equivalently, are predominantly a reflection of revisions in expectations in response to news. Finn (1986) shows that full-information maximum-likelihood estimation leads to a somewhat improved forecasting performance relative to a random walk model in the case of the dollar/mark exchange rate.

Appendix D: Data Definitions and Sources

Chapter 3 (Quarterly Data)

Korea:

- (1) CC - currency in circulation (in real terms, billions of Won, end of period)
- (2) DD - demand deposits (in real terms, billions of Won, end of period)
- (3) M1 - CC + DD (in real terms, billions of Won, end of period)
- (4) e - Won per US Dollar (end of period)
- (5) i_d - interest rate on deposits at Deposit Money Banks (3 month)
- (6) i_u - interest rate on unorganized money market
- (7) i_f - US treasury bill rate (3 month)
- (8) y - constant GNP (billions of Won, 1980 - 100)
- (9) P - GNP deflator (1980 - 100)

Source: (1)-(4) are from IMF Financial Statistics (various issues).

(5) - (6) are from Bank of Korea, Monthly Statistical Bulletin, Monthly Economic Statistics (various issues).

(7) is from the CITIBASE data base.

(8)-(9) are from the Bank of Korea, The Quarterly GNP of Korea (various issues).

Taiwan:

- (1) CC - currency in circulation (in real terms, billions of NT\$, end of period)
- (2) DD - demand deposits (in real terms, billions of NT\$, end of period)
- (3) M1 - CC + DD (in real terms, billions of Won, end of period)
- (4) e - NT Dollar per US Dollar (end of period)
- (5) i_d - interest rate on time deposits (3 month)

(6) i_u - interest rate on unsecured loan on unorganized money market of Taipei city.

(7) i_f - US treasury bill rate (3 month)

(8) y - constant GNP (billions of NT\$, 1981 = 100)

(9) P - GNP deflator (1981 = 100)

Source: (1)-(4) are from IMF Financial Statistics (various issues).

(5)-(6) are from The Central Bank of China, Financial Statistics.

Monthly Taiwan District (R.O.C.), (various issues).

(7) is from the CITIBASE data base.

(8)-(9) are from the Directorate-General of Budget, Accounting and

Statistics, Executive Yuan, Quarterly National Income Statistics in Taiwan Area (R.O.C.), (various issues).

Chapter 4 (Monthly Data)

United States:

(1) M_1 - currency plus demand deposits (billions of US dollar, end of period)

Source: (1) is from the CITIBASE data base.

Korea:

(1) E_b - black market exchange rate (Won per US dollar, end of period)

(2) E_o - official exchange rate (Won per US dollar, end of period)

(3) M_1 - CC + DD (billions of Won, end of period)

(4) M_2 - M_1 + Quasi-Money (billions Won, end of period)

Source: (1) is from the World Currency Yearbook 1986.

(2)-(4) are from the Bank of Korea, Monthly Statistical Bulletin

(various issues).

Taiwan:

- (1) E_b = black market exchange rate (NT\$ per US dollar, end of period)
- (2) E_o = official exchange rate (NT\$ per US dollar, end of period)
- (3) $M1 = CC + DD$ (millions of NT\$, end of period)
- (4) $M2 = M1 + \text{Quasi-Money}$ (millions of NT\$, end of period)

Source: (1) is from World Currency Yearbook 1986.

(2)-(4) are from The Central Bank of China, Financial Statistics
Monthly Taiwan District (R.O.C.), (various issues).

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