Essays on the Determination of Equilibrium Real Exchange Rate for Taiwan, 1981-1993

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ESSAYS ON THE DETERMINATION OF EQUILIBRIUM REAL EXCHANGE RATE FOR TAIWAN, 1981-93

by

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ABSTRACT

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Taiwan is one of four smaller Asian economies. Before 1960, Taiwan pursued industrialization policies by limiting imports of manufactured goods, gradually adopting an open and outward-oriented economic policy, believing it would expend exports and yield gained ground.

With this increasingly open and outward-oriented economic policy as the background, we will study the real exchange rate (RER) misalignment in Taiwan over the period 1981-93. The RER plays a critical role in maintaining external competitiveness. Hence, from the policy point of view, this rate should not be allowed to deviate much from its equilibrium level. Since the equilibrium real exchange rate (ERER) is unobservable, it is very important that the concept be based on sound economic reasoning and its measurement should be done as correctly as possible.

It is generally agreed that misalignment in the RER has a negative effect on the economic performance of a country. This dissertation is divided into two essays. The first essay deals with the estimation of ERER by using the Edwards and the Elbadawi approaches and the measurement of the RER misalignment from two different approaches. The second essay investigates the empirical importance of the distinction between the permanent and temporary components of the determinants of the ERER. By using the same reduced form equation from the first essay and reestimating the ERER by employing the techniques of a modern time-series analysis, which is introduced by Steven Beveridge and Charles Nelson, an empirical analysis is presented of the RER behavior.

(137 pages)

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Many thanks to Dr. Christopher Fawson for his endless support as a good friend; to Dr. Herbert Fullerton for his unfailing recognition of my capability; to Dr. Christopher Barrett for guiding me in my studies and regarding me as his friend; and to Dr. Donald Snyder and Dr. Philip Swensen for their full trust in my work. I will always remember the generous friendships Dr. Terry Glover and Dr. Dwight Israelsen shared with me. A special thanks to my friend, Ruby Vázquez, for her technical assistance in preparing this dissertation, and for Christine, Suzette, and Lorelei's lovely friendships.

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Mei-Ling Chen

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In the first essay, the factors affecting the real exchange rate (RER) behavior of Taiwan are analyzed empirically over the period 1981-93. A study of exchange rate misalignment is very important because of its implications for the growth of the economy. In the floating exchange rate regime, this issue has been more important. Most industrialized countries have floating exchange rates while most of the developing countries peg the external value of the domestic currencies to a single other currency or some basket of currencies. Controlled currencies do not readily adjust to market signals (demand, supply, inflation, etc.). Failure to adjust to market demand and supply creates a situation whereby the observed RER of a country is not at par with the equilibrium real exchange rate (ERER). Dornbusch (1982) and Williamson (1985) discussed the consequences of RER misalignment for the economy. Harberger (1986) and Dervis and Petri (1987) analyzed the role of RERs in the economic performance of developing countries. In developing countries, the exchange rate is generally overvalued—a result of restrictive trade policies and inconsistent monetary-fiscal policies. In Taiwan's case, the exchange rate was usually undervalued, until April 1989, when the central bank set up the highest and lowest bounds for the exchange rate. When the different considerations are weighted on the issue of undervaluation, there are plausible reasons for maintaining an exchange rate in a position that keeps a country supercompetitive.

There is a widespread view that misalignment of the RER of a country affects the growth of the economy in an adverse way. This view presupposes the existence of the ERER. Generally two approaches for determining the ERER are used. The simplest and most popular approach is based on the purchasing power parity (PPP) theory. The relative price level of the home country and its trading partner determines the equilibrium exchange rate. Relative inflation rates determine the rate of change of the nominal exchange rate over time. Relative to a base year, when the observed exchange rate diverges from the PPP-determined exchange rate, this divergence is interpreted as the RER being out of its equilibrium value. An alternative approach, which is now popular in the literature (Edwards 1989), defines the RER as the relative price of tradable to nontradable goods. This definition points to the real aspect of the rate of exchange between the goods of two countries. This definition of the RER focuses on the units of domestic goods (i.e., nontradables) that must be given up to acquire one unit of internationally traded goods. The RER thus defined is theoretically more appealing since it is an indicator of incentives guiding resource allocation between the tradable and the nontradable sectors. For example, if the domestic price of the traded goods increases, resources will move from the nontradable sector to the tradable sector. That is, more export goods and import goods would be produced. As a result, the trade balance will improve. After we define the RER as the price of tradables in terms of nontradables, the next step is to give a precise meaning to the ERER. The ERER is that rate which, for given sustainable (equilibrium) values of other relevant variables, such as taxes, terms of trade, and technology, results in the simultaneous attainment of internal and external equilibria. Internal equilibrium implies that the nontradable goods market is cleared, whereas external equilibrium implies that the current account imbalance is offset by corresponding movements in the capital account. Hence, RER misalignment means that the observed RER is different from the "equilibrium" RER. It should be noted that an observed change in an index of RER is the result of a change in the ERER arising from different types of external and domestic real shocks and also due to such distortionary policies of the government as capital control, exchange control, etc. One objective of this work is to estimate the extent of misalignment. Hence we need to be careful in estimating the ERER, which is unobservable. One contribution of this dissertation is the estimation of the ERER by using the techniques of modern time-series analysis. From a policy point of view, the more accurate are the estimated values of the ERER, the more appropriate will be the policies designed to correct misalignment. The estimated exchange rate will be taken as a reference point from which the degree of misalignment can be gauged. If the RER is overvalued, i.e., if the relative price of tradables in terms of nontradables is less than the equilibrium value, the country is less competitive externally. Policies should be designed to increase the competitiveness by correcting overvaluation. In Taiwan's case, the exchange rate was usually undervalued until April 1989 when the central bank set up the highest and lowest bounds for the exchange rate. Let us briefly summarize the problem associated with the undervaluation of the domestic currency. The following discussion is based on Dornbusch (1986).

First, trade and current account surpluses come at the expense of a domestic absorption of resources. A country that builds up current account surpluses will be acquiring external assets. This increase in net assets might take the form of building up reserves, paying off debts, or allowing indigenous residents to buy financial and real assets abroad. Reserves act as shock absorbers and are thus well worth having. Nevertheless, investment at home should be preferred to debt repayment. The reason is that it is difficult to borrow when trouble comes, and thus it is better not to repay debt prematurely when things are going well. Hence it is wise to invest at home. It is certainly not reasonable for residents to buy foreign treasury bills in preference to investing resources in their own countries so as to raise productivity and the standard of living. The use of an undervaluated exchange rate to earn the foreign exchange with which to finance capital exports is the opposite of good development strategy.

Second, it is true that countries with an undervalued RER produce a better growth record than countries with an overvalued RER. But to have strong growth on a sustainable basis is what is essential for sustained investment. High level of investment requires high domestic saving. Some investment can be externally financed, and doing so entails current account deficits, but the major part must come from domestic saving. To have high investment at home, firms must have confidence in a sustained profitability of production, both for home market and for export and import substitution. If the currency is undervalued, this acts as a disincentive and resources are transferred abroad rather than invested at home.

Third, the RER has a counterpart in the real wage. When the RER is such as to make a country particularly competitive, then it is also the case that real wages are low and the profitability of traded goods is high. A RER policy is also an income distribution policy. If the RER is kept undervalued, income can be redistributed toward capital in the traded goods sector and away from labor.

In summary, it is important that the ERER be computed and the degree of misalignment be measured so that policies can be designed to correct it. To accomplish this objective, we need to define the ERER and then measure the degree of misalignment by taking the deviation of the actual RER from the estimated RER.

The main objective of the second essay is to estimate the ERER by using the reduced form equation of the RER. So the theoretical part is almost the same as the model used in the first essay. We restate the definition of the ERER given by Edwards (1989).

Edwards (1989) defines the ERER as the "relative price of tradables to nontradables that, for given sustainable (equilibrium) values of other relevant variables—such as international prices, the government consumptions on nontradables, and technology—results in the simultaneous attainment of internal and external equilibrium" (p. 16). The term internal equilibrium is used to describe market clearing in goods. External equilibrium requires the trade balance to be zero over the current and future periods. The condition of current account balances implies that in the long run, the capital flow is sustainable. ERER is therefore a function of external terms of trade, government consumption of nontradables, the extent of controls over capital flows, the severity of trade restrictions and exchange control, technological progress, and the ratio of investment to GDP—the RER "fundamentals."

Many economists suggest that it is important to distinguish between the permanent and the transitory components in a series. The reason is that permanent movements in a series can induce people to react in a direction that is different from the direction induced by a temporary change. For example, a transitory price decline induces consumers to purchase more at the current time period rather than in the future. If the price reduction is permanent, then people will not demand as much as they would under a temporary price reduction. If we ignore the difference between permanent and transitory components, we will not get correct results. We decompose changes in RER into permanent and transitory components. Our interest in the cyclical movements in the exchange rate is based on the belief that, for policy purposes, the amplitude, duration, and shape of the cyclical part are at least as important as the underlying long-run trend. An accurate characterization of exchange rate behavior is essential for designing countercyclical stabilization policies in developing countries. If the trend is a variable one, the regression technique using a trend stationary process (TSP) is not the appropriate one. That is, in the case of the stochastic trend, the Beveridge-Nelson (1981) (hereafter B-N) technique is used to decompose the observed changes into the permanent and transitory ones. Because of stochastic nonstationarity, we use the B-N type of decomposition to generate the "sustainable components" of the fundamentals.

I. Statement of Problem

A. First Essay

According to the relative PPP theory, the change in the nominal exchange rate between two currencies over time is determined by the change in the two countries' relative price level.

The theoretical implication is that the RER does not change if the equilibrium condition holds. In reality, it is impossible for the equilibrium to remain constant over time; empirically, the equilibrium conditions do not remain constant. That is why we adopt the

Edwards model in which the RER is defined as the relative price of tradables over nontradables.

The underlying real factors affecting the relative price cause a change in the ERER. The empirical part of Edwards's (1989) work is unsatisfactory in the sense that Edwards did not look into the stationarity problem of the time-series data. The present work addresses that issue and extends the analysis by using the cointegration technique used by Elbadawi (1994).

B. Second Essay

The ERERs are determined by the permanent components of fundamentals, and these permanent components are nothing but sustainable values. So to estimate the ERER, we need to estimate those permanent components that are unobservable. To accomplish this, we use the B-N methodology to decompose the fundamental variables into permanent and transitory components.

The ERER is that value of the RER that is consistent with sustainable (or permanent) values of the fundamentals. This suggests the existence of a long-run relationship between the ERER and the permanent components of fundamentals. Or, in other words, there exists a cointegration relationship between the permanent components of fundamentals and the ERER.

For both essays, the baseline model is developed within the framework of a structural equation. The basic objective is to focus on the determinants of the relative price of tradables in terms of nontradables in the reduced form. Because of the small country assumption, the nominal price of tradables is exogenous. So the determination of the ERER becomes a determination of the price of the nontradables.

II. Objectives

A. First Essay

The main purposes of this essay are to: (1) analyze empirically the fundamental factors affecting the RER behavior in Taiwan, and (2) measure the ERER and then calculate the degree of misalignment of the RER. To be more specific, the objectives are to:

1. Explain the concept of the RER and its measurement,
2. Develop the concept of the ERER, discuss the influence of fundamental variables on the ERER, and analyze the effect of "nominal devaluation" on the ERER,
3. Identify the equilibrium relationships by estimating the short-run dynamics using an error correction model, and
4. Compare the ERER that is derived from the cointegration equation with the ERER based on the model of RER determination.

B. Second Essay

The main purpose of this essay is to estimate the ERER using the reduced form equation of the RER. Specific objectives are outlined as follows:

1. A cointegration technique is used to identify the long-run equilibrium relationship,
2. An estimate is made of the permanent part of the fundamentals by using the B-N decomposition method,

3. The estimated permanent part is used as the sustainable value of the fundamentals to estimate the ERER, and

4. The parameters needed for computing the ERER in the error-correction model (ECM) framework is estimated.

III. Procedure

This dissertation uses some alternative approaches to estimating the ERER. In the first essay, according to Edwards (1989), "the real exchange rate misalignment is defined as sustained deviations of the actual real exchange rate from its long-run equilibrium level" (p. 16). Misalignment is associated with both overvaluation and undervaluation.

To understand the concept of exchange rate misalignment, one must begin with the definition of the RER. The RER (e) is defined as the ratio of the domestic price of tradable goods (P_T) to the domestic price of nontradable goods (P_N): $e = P_T/P_N$. This definition summarizes incentives that guide resource allocation across the tradable and the nontradable sectors.

A more traditional and popular definition of the RER is based on the PPP approach. According to the relative PPP theory, the change in the nominal exchange rate between two currencies over any time period is determined by the change in the two countries' relative price level. The implication is that the RER does not change if the equilibrium condition holds. But, in reality, it is impossible that the equilibrium conditions hold in any time period. That is why we adopted the Edwards model as the framework of our analysis.

Edwards (1989) developed a structural model with three goods—exports, imports, and nontradables. This is an optimizing intertemporal model where households maximize the present value of utility from the consumption of three goods. Firms, in turn, maximize profit from the production of the three goods. Using the duality theory, the demand function and the supply function of the nontradable goods are derived subject to the constraint that the present value of current account balances has to be zero. Edwards assumes that decision-making agents have access to the international capital markets where borrowing and lending can be done at the given world interest rate.

On the basis of the structural equations, the reduced form of the model is derived and used to express the ERER in terms of exogenous variables that are considered the fundamentals, such as international terms of trade, government expenditure on nontradables, extent of capital controls, severity of trade restriction and exchange control (i.e., import tariffs), the ratio of investment to GDP, and technological progress.

We use a dynamic equation for the RER to estimate the parameters of the equation derived from the model. This equilibrium is attained after all adjustments take place. The partial adjustment analysis says that the actual change is only a fraction of the desired change. Edwards (1989) incorporates certain factors to interpret the different forces to influence the ERER.

To derive the coefficients necessary to estimate the ERER, we substitute the reduced form equation and partial adjustment equation and solve for ERER. The degree of misalignment is calculated as [(RER – ERER)/ERER]*100 percent.

The alternative methodology of estimating the ERER is derived from Elbadawi (1994). The difference between Edwards (1989) and Elbadawi is that Edwards applies the partial adjustment method to calculate the unobserved ERER, whereas Elbadawi uses the cointegration analysis and an error correction framework to estimate the ERER. Elbadawi follows Edwards, defining ERER as the ratio of price of tradables to the price of nontradables—this reflects a slight difference in the included fundamental variables. In this section, we follow Edwards's (1989) framework but employ Elbadawi's (1994) cointegration analysis methodology to calculate the ERER and interpret which one is more robust in capturing RER movements.

We compute the indexes for the ERER using the coefficients derived from the long-run estimating equation and multiply the sustainable values of the fundamentals. By following the Elbadawi methodology, the sustainable component of fundamental variables was proxied by 4-quarter moving averages. The 4-quarter period was used since it reflects the median of the number of the quarters needed to eliminate an exogenous shock.

In the second essay, economic theory tells us that the RER moves over time in an economy in equilibrium. We follow Edwards (1989) in defining the ERER as the relative prices of tradables to nontradables given sustainable (permanent) values of other relevant variables. Based on this definition, a structural model is developed and a reduced form equilibrium relationship is derived. The ERER paths are based on the "permanent" historical time-series components of the fundamentals. The model is applied to the case of Taiwan to test for and estimate long-run cointegration specifications to identify the equilibrium relationship. This theory is done on a theoretical level. Then a cointegration framework is used to estimate the parameters. Sustainable values are identified with the permanent component of the variables. The concept of "sustainability" on the part of the fundamentals is thus implemented.

The above methodology used for obtaining the ERER is based on the idea that the ERER is the value of RER that satisfies for sustainable (or permanent) values of the fundamentals. The sustainable part of the fundamentals is nothing but the permanent components of the fundamentals that are attainable by using the B-N technique. From the theoretical point of view, it is valid that the cointegration relationship exists. Then the existence of a cointegration relationship corresponds to the error correction specification. Another method of estimating the ERER is derived from the basic Edwards (1989) approach. First, replace the moving average technique with the decomposition methodology. The difference between the Edwards approach and our methodology is that Edwards applies the moving average technique to construct time series for the "sustainable" values of the ERER fundamentals, and our methodology uses permanent components of fundamentals to be the sustainable values of fundamentals. According to the definition of ERER and the theoretical consideration, permanent components of fundamentals are nothing but sustainable values.

After we estimate the unobserved ERER, this becomes an important reference point for policy makers to determine the extent of misalignment and intervene in the foreign exchange market to correct it. We know the observed RER is not only affected by fundamental variables but also by the inconsistent macroeconomic policies or any short-run shocks. If the government takes the observed RER as a reference point and then sets up a policy to correct it, this action may lead to the wrong results. That is why the ERER is so important from the policy point of view. If the government has some knowledge of the ERER level, the RER should not be allowed to deviate much from its equilibrium. In this case, the economy can be prevented from serious misalignment.

ESSAY ONE: ESTIMATING LONG-RUN EQUILIBRIUM RER

I. Introduction

The long-term, steady growth of a small island economy, such as Taiwan's, depends heavily on its foreign trade performance. Since the 1960s, its economy has experienced vigorous growth, based chiefly on the rapid and steady expansion of its international trade. Taiwan is one of four smaller Asian economies, often known as four "tigers." The other three are Hong Kong, South Korea, and Singapore. Real GDP (gross domestic producr) in these four economies has grown at a very high rate since the mid-1960s. The average growth rate has been 6 to 8 percent,[1] compared with 2-3 percent in the United States and western Europe.

Before 1960, Taiwan did not follow an outward-looking trade policy. The first ten years of the Nationalist administration were marked by rampant inflation, large government budget deficits, low foreign exchange reserves, and a large influx of refugees. The government adopted an inward-looking trade policy, that is, an import-substituting industrialization policy. A number of economists raised questions concerning the government's early economic approach. They argued that a more liberal policy would expand exports and yield quicker results for the economy. This gained ground and an outward-looking trade policy was gradually adopted.

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[1]The average growth rates of Taiwan in the 1960s, 1970s, and 1980s are 5.6 percent, 7.5 percent, and 5 percent, respectively.

A. An Overall Review: Phases of Trade Liberalization in Taiwan

Trade liberalization in Taiwan first took place in 1958 with a 250 percent nominal devaluation of the NT (New Taiwan) dollar and the removal of quantitative restrictions on permissible imports, which at the time constituted about 50 percent of all importable items. The devaluation of the exchange rate, together with the system of export incentives, including import duty rebates for exporters, were the main elements in what became known as the " export promotion strategy". The essence of the strategy was to give an incentive to the export sector that was at par with the incentive given to the production of import-competing goods. Bhagwati (1988) terms this policy as "trade-neutral or bias-free strategy." This did not imply free trade, since within the average effective exchange rate for export and import-competing sectors there were very substantial variations between different industries. The second phase of trade liberalization occurred in the 1970s as policy makers came to realize that foreign exchange was no longer the binding constraint on growth. After three years of trade surplus, which reached 6.2 percent of GDP in 1973, the Ministry of Economic Affairs drastically cut the number of controlled and prohibited imports in 1974 and reduced their number from 42 percent to only 2 percent of all importable items (Tu and Wang 1988). Although almost all imports became "permissible," licensing continued for the ostensible purpose of protecting the national security and maintaining health and safety standards. However, these licensing procedures were employed for purely protectionist purposes, especially for the benefit of public enterprises (Tu and Wang 1988).

The third phase of import liberalization began in the late 1970s and was accelerated in the 1980s, again in response to growing trade surpluses, especially with the United States.

Since 1974, Taiwan has reduced the average tariff rate by about 84 percent. The average tax on imports, measured as a ratio of tariff revenue over the value of imports, has fallen from 18 percent in 1968 to only 6 percent in 1988. In 1984, the Ministry of Economic Affairs declared its intention of bringing Taiwan's tariff schedule in line with those of the OECD countries within six years.

In recent years, Taiwan also lowered numerous nontariff barriers, including the lifting of bans on importation of some agricultural products, relaxing import procedures for steel products, and eliminating local content requirements. However, the thorniest of all nontariff trade issues was intellectual property rights, of which Taiwan earned a reputation of being of one of the world's most flagrant violators. This brief historical review of trade policies of Taiwan will provide the background for the study of RER (real exchange rate) misalignment over the period 1981-93. Restrictive trade policies result in the deviation of the observed RER from some concept of the equilibrium exchange rate. It is generally agreed that a misalignment in the RER has a negative effect on the economic performance of a country.

In this essay, we analyze empirically the factors affecting the RER behavior of Taiwan over the period 1981-93. A study of exchange rate misalignment is very important because of its implications for the growth rate of the economy. In the floating exchange rate regime, this issue has been more important. Most industrialized countries have floating exchange rates, while most developing countries peg the external value of the domestic currencies to a single other currency or some basket of currencies. Controlled currencies do not readily adjust to market signals (demand, supply, inflation, etc.). Failure to adjust to market demand and supply creates a situation whereby the observed RER of a country is not at par with the ERER. Dornbusch (1982) and Williamson (1985) discussed the consequences of RER misalignment for the economy. Harberger (1986) and Dervis and Petri (1987) analyzed the role of RERs on the economic performance of developing countries. In developing countries, the exchange rate is generally overvalued—a result of restrictive trade policies and inconsistent monetary/fiscal policies. In Taiwan's case, the exchange rate was usually undervalued until April 1989 when the central bank set up the highest and lowest bounds for the exchange rate. When the different considerations are weighted on the issue of undervaluation, there are plausible reasons for maintaining an exchange rate in a position that keeps a country supercompetitive.

There is a widespread view that misalignment of the RER of a country affects the growth of the economy in an adverse way. This view presupposes the existence of the ERER. Generally, two approaches for determining the ERER are used. The simplest and most popular approach is based on the purchasing power parity (PPP) theory. The relative price level of the home country and its trading partner determines the equilibrium exchange rate. Relative inflation rates determine the rate of change of the nominal exchange rate over time. Relative to a base year, when the observed exchange rate diverges from the PPP-determined exchange rate, this divergence is interpreted as the RER being out of its equilibrium value. An alternative approach defines the RER as the relative price of tradable to nontradable goods. This definition points to the real aspect of the rate of exchange between goods of two countries. This definition of the RER focuses on the units of domestic goods (i.e., nontradables) that must be given up in order to acquire one unit of internationally traded goods. The RER thus defined is theoretically more appealing since it is an indicator of incentives guiding resource allocation between the tradable and the nontradable sectors. For example, if the domestic price of the traded goods increases, resources will move from the nontradable sector to the tradable sector. That is, more export goods and import goods would be produced. As a result, the trade balance will improve. In this context, the ERER is defined as the relative price of tradables to nontradables, which, for given sustainable (equilibrium) values of other relevant variables, such as taxes, terms of trade, and technology, results in the simultaneous attainment of internal and external equilibria. Internal equilibrium implies that the nontradable goods market is cleared, whereas external equilibrium implies that the current account imbalances are offset by corresponding movements in the capital account. Hence, RER misalignment means that the observed RER is different from the ERER. It should be noted that an observed change in an index of the RER is the result of a change in the ERER arising from different types of external and domestic real shocks and also due to such distortionary policies of the government as capital control, exchange control, etc. One objective of this work is to estimate the extent of misalignment. Hence we need to be careful in estimating the ERER that is unobservable. One contribution of this dissertation is the estimation of the equilibrium RER by using the techniques of modern time-series analysis. From the policy point of view, the more accurate are the estimated values of the ERER, the more appropriate will be the policies designed to correct misalignment. The estimated exchange rate will be taken as a reference point from which the degree of misalignment can be gauged. If the RER is overvalued, i.e., if the relative price of tradables in terms of nontradables is less than the equilibrium value, the country is less competitive externally. Policies should be designed to increase the competitiveness by correcting overvaluation. Let us summarize the problem associated with the undervaluation of the domestic currency. This brief discussion is based on Dornbusch (1986).

First, trade and current account surpluses occur at the expense of a domestic absorption of resources. A country that builds up current account surpluses will be acquiring external assets. This increase in net assets might take the form of building up reserves, paying off debts, or allowing indigenous residents to buy financial and real assets abroad. Reserves act as shock absorbers and are thus well worth having. Nevertheless, investment at home should be preferred to debt repayment. The reason is that it is difficult to borrow when trouble comes, and thus it is better not to repay debt prematurely when things are going well. Hence it is wise to invest at home. It is certainly not reasonable for residents to buy foreign treasury bills in preference to investing resources in their own countries so as to raise productivity and the standard of living. The use of an undervaluated exchange rate to earn the foreign exchange with which to finance capital exports is the opposite of good development strategy.

Second, it is true that countries with an undervalued RER produce a better growth record than do countries with an overvalued RER. But to have strong growth on a sustainable basis is what is essential for sustained investment. A high level of investment requires high domestic saving. Some investment can be externally financed, and doing so entails current account deficits, but the major part must come from domestic saving. In order to have high investment at home, firms must have confidence in a sustained profitability of production, both for the home market and for export and import substitution. If the currency is undervalued, this acts as a disincentive and resources are transferred abroad rather than invested at home.

Third, the RER has a counterpart in the real wage. When the RER is such as to make a country particularly competitive, then it is true that real wages are low and the profitability of traded goods is high. A RER policy is also an income distribution policy. If the RER is kept undervalued, income can be redistributed toward capital in the traded goods sector and away from labor.

In summary, it is important that the ERER be computed and the degree of misalignment be measured so that policies can be designed to correct it. In order to accomplish this objective, we need to define the ERER more specifically and then measure the degree of misalignment by taking the deviation of the actual RER from the estimated RER.

B. Determination of the ERER: A Brief Review

As previously mentioned, one estimate of the equilibrium exchange rate is based on the criterion of purchasing power parity (PPP), which is one of the most important and hotly debated equilibrium conditions in international macroeconomics. There are two versions of PPP. One is the absolute version and the other is the relative version. According to the absolute version, the ERER is determined by taking into account the price levels of the two countries so that the ERER will equate the purchasing power of the two currencies. This is based on the "law of one price." According to the relative version of PPP, the ERER changes to offset the differential rates of inflation; therefore, if PPP holds, the RER remains constant. However, ERERs can change over time as a result of changes in productivity, the terms of trade, tariffs, and the level and composition of government expenditure on traded and nontraded goods. These are some of the fundamentals used by Edwards (1989) and Elbadawi (1994) in their works. If such economic fundamentals as terms of trade, tariff rates, and technology change, the ERER will not remain constant. As fundamentals change over time, the equilibrium also changes over time. Since PPP implies that the RER remains constant, it does not provide a correct measure of the ERER. A second measure of RER misalignment, which is used in this study, is based on a formal model of an ERER determination developed by Edwards (1989). According to Edwards, "the real exchange rate misalignment is defined as sustained deviations of the actual real exchange rate from its long-run equilibrium level" (p. 16). If the actual RER is below the ERER value, there is a RER overvaluation. If the actual RER is above the ERER value, we say that there is an undervaluation. Misalignment is associated with both overvaluation and undervaluation. Another measure of the ERER is provided by Ibrahim Elbadawi (1994), who uses the approach pioneered by Edwards (1989). He uses cointegration techniques to identify the equilibrium relationship and an error correction framework to estimate the adjustment process. In this study, the common approach of both studies will be followed. We start from a structural model and solve for a reduced form equilibrium relationship.

In the Elbadawi methodology, if the cointegration relationship in the reduced form specification is valid, then that equation not only can be interpreted as a long-run equilibrium but is also consistent with a dynamic error correction specification (Engle and Granger 1987). Generally a simultaneous equation model is presented in a static way with the assumption that markets get cleared. Their dynamic specifications were not flexible enough to allow them to adequately represent an economy that is more frequently out of equilibrium than it is in equilibrium. This lack of attention to the dynamic aspect was a natural outcome of the fact that economic theory has some ability to identify a long-run relationship between economic variables. In light of this it seems reasonable to structure econometric models to incorporate information from economic theory about long-run equilibrium forces. At the same time, an allowance is made for a very flexible lag structure, permitting the data to play a strong role in the specification of the model's dynamic structure. One of the unique features of this approach is an error correction term that reflects the current error in achieving long-run equilibrium. This type of model has consequently come to be known as an error-correction model, or ECM.

We adopt an ECM to estimate jointly the short-run behavior and its long-run value and find the speed at which individual variables attain equilibrium. If the cointegration relationship is valid, then a dynamic error correction specification can be formulated (Engle and Granger 1987).

Stein (1992) built the NATREX (natural real exchange rate) model and used it to see to what extent it can explain the behavior of the RER of the U.S. dollar since the mid-1970s. Stein defined the NATREX as the RER that would prevail if speculative and cyclical factors were removed. NATREX is a moving equilibrium rate, responding both to exogenous real disturbances and to the gradual endogenous changes in capital shocks and foreign debt induced by real disturbances. Williamson (1994) criticized the result yielded by models that take interest rate as a part of the fundamentals. Since most of the high interest rates in the early 1980s resulted from the loose fiscal policy, this translates into an appreciation of the NATREX. There are some debates between NATREX and FEER (fundamental equilibrium exchange rate) (Williamson 1994) that NATREX treats interest rate as a fundamental. But FEER treats interest rate as a policy instrument that the authorities can use to prevent the exchange rate from deviating too far from its FEER.

In spite of diverse methods to estimate the ERER, the central point is that the nominal exchange rate is the relative price of two national monies but the RER must be the relative price of two national outputs. Concentrating on this central aspect, Edwards (1989) and Elbadawi (1994) use the Chicago definition of the RER as the price of tradables in terms of nontradables. This is the reason why we choose Edwards's and Elbadawi's methodologies in this study.

II. Model-Base Approach Provided by Edwards—Partial Adjustment

According to Edwards (1989), "the real exchange rate misalignment is defined as sustained deviations of the actual real exchange rate from its long-run equilibrium level" (p. 16). If the actual RER is below the ERER value, there is a RER overvaluation. If the actual RER is above the ERER value, we say that there is an undervaluation. Misalignment is associated with both overvaluation and undervaluation.

To understand the concept of exchange rate misalignment, one must begin with the definition of the RER. The RER (e) is defined as the ratio of the domestic price of tradable goods (P_T) to the domestic price of nontradable goods (P_N): $e = P_T/P_N$. This definition summarizes incentives that guide resource allocation across the tradable and the nontradable sectors. An increase in e will make the production of tradables relatively more profitable, and resources move from the nontradables sector to the tradables sector.

A more traditional and popular definition of the RER is based on the PPP approach.

$$e_{ppp} = E\frac{p*}{p} \tag{1}$$

where e_{ppp} denotes the empirical measure of the RER, E is the bilateral nominal exchange rate expressed as the price of one unit of the foreign currency in terms of the domestic currency, and P and $P*$ refer to the domestic price index and the foreign price index, respectively. Since it is difficult to get data on the tradables and nontradables relative price, the PPP RER (e_{ppp}) is used to construct time series of RER indexes.

According to the relative PPP theory, the change in the nominal exchange rate between two currencies over any time period is determined by the change in the two countries' relative price level. This is written in the following manner:[2]

$$\tilde{E} = \tilde{p} - \tilde{p}* \tag{2}$$

where the tilde is the percentage change of the variable. According to equations (1) and (2), $\tilde{e}_{ppp} = 0$ is in equilibrium.

The implication is that the RER does not change if the equilibrium condition holds. But, in reality, it is impossible that the equilibrium conditions hold in any time period.

A. RER Measurement

According to the PPP theory, the movement of the nominal exchange rate E, defined

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[2]Equation (2) is based on the law of one price, which states that price is equalized through trade, i.e., P = E.P*. Assuming that causality goes from p and P* to E, we can write E = P/P*, where E is the endogenous variable.

as the number of units of domestic currency per unit of foreign currency, depends on the movement of the domestic price level P and the foreign price level P*. The first building block is the determination of the nominal exchange rate on the basis of the PPP theory. Assuming that the law of one price holds, P = E • P*. Therefore, the PPP RER (e_{ppp}) is written in the following way: $e_{ppp} = E\frac{P^*}{P}$. Let us compare the PPP definition of the RER with the tradables/nontradables relative price definition. That is, a comparison is made between e_{ppp} and $e = \frac{P_T}{P_N}$, where P_T is the price of tradable goods and P_N is the price of nontradable goods.

Let P and P^* be the weighted geometric means of the price of tradables and nontradables of the domestic and foreign country, respectively. The corresponding weights are α and (1-α) for the home country and β and (1-β) for the foreign country. We can write $P = P_N^{\alpha} \bullet P_T^{1-\alpha}$, where P is the weighted geometric mean of P_N and P_T. The weight α indicates the relative share of nontradable goods in the GNP (gross national product) and (1-α) is the share of tradable goods.

For the foreign country, $P^* = P_N^{*\beta} . P_T^{*1-\beta}$, where β and (1-β) are the corresponding weights. If we make the small country assumption, then the country is a price taker in the world market and P_T^* is exogenous to the home country. The small country assumption and the law of one price, along with the absence of transportation cost and no taxes on trade, will mean that $P_T = E . P_T^*$. To simplify the presentation, set E equal to 1. The RER e is defined as $e = \frac{P_T}{P_N}$ and $e_{ppp} = E \bullet \frac{P^*}{P}$. Substitute $P_N^{*\beta} \bullet P_T^{*1-\beta}$ for P^* and $P_N^{\alpha} . P_T^{1-\alpha}$ for P in equation (1).

$$e_{PPP} = E \bullet \frac{P_N^{*\beta} P_T^{*1-\beta}}{P_N^{\alpha} P_T^{1-\alpha}}$$

$$e_{PPP} = E \bullet \frac{(\frac{P_N^*}{P_T^*})^{\beta} \bullet P_T^*}{(\frac{P_N}{P_T})^{\alpha} \bullet P_T}$$

$$e_{PPP} = \frac{(\frac{P_N^*}{P_T^*})^{\beta}}{e^{-\alpha}} \bullet E \bullet (\frac{P_T^*}{P_T})$$

$$e^{-\alpha} \bullet e_{PPP} = (\frac{P_N^*}{P_T^*})^{\beta}, \text{ since } E \bullet P_T^* = P_T. \tag{3}$$

Let the "hat" operator (Λ) represent percentage change. Equation (3) can be written in terms of changes as

$$-\alpha\hat{e} + \hat{e}_{PPP} = \beta(\hat{P}_N^* - \hat{P}_T^*)$$

$$\hat{e} = \frac{1}{\alpha}\hat{e}_{PPP} + \beta(\hat{P}_T^* - \hat{P}_N^*) \tag{4}$$

Equation (4) shows that generally $\hat{e} \neq \hat{e}_{PPP}$, i.e., changes in RERs, according to the two definitions, are not the same. However, growth of a country's income is associated with increased productivity in traded goods. As a result, the relative price of traded goods falls. Growth also may cause a rise in the relative price of nontraded goods and services if they are superior goods in the consumer's demand function as identified by Bergstrand (1991).

Therefore, the second term, $\beta(\hat{P}_T^* - \hat{P}_N^*)$, of the right-hand side of equation (4) will be a negative quantity that will reduce $\frac{1}{\alpha}\hat{e}_{PPP}$. Note that $\frac{1}{\alpha}\hat{e}_{PPP} > \hat{e}_{PPP}$, since $0 < \alpha < 1$.

The above discussion implies that changes in the theoretical definition of the RER as the relative price of tradables are quite close to available empirical measures of changes in the RER measured by adjusting the nominal exchange rate by the appropriate price indices.

B. The Equilibrium RER

1. Basic Model of the ERER

The model presented here is a variant of the Edwards model, which is an optimizing real model of a small open economy with three goods—exports, imports, and nontradables. Exports and imports are tradables. Since the RER is defined as the relative price of tradables to nontradables, i.e., $RER = \frac{P_T}{P_N}$, attention is focused on the determination of $\frac{P_T}{P_N}$.

The small-country assumption implies that P_T is exogenously determined. So the determination of the RER is the same as the determination of P_N, which is determined by the interaction of the demand function and the supply function of N, the nontradables. In this three-goods real model, the world price of exportables is taken as the numeraire.

We now use the preference-based approach to the consumer demand. The consumer's problem is framed as one of utility-maximization subject to the constraints embodied in the Walrasian budget set. The representative consumer is assumed to maximize

$$U = U(C_N, C_M, C_X) \tag{5}$$

subject to $C_X + P_M C_M + P_N C_N =$ wealth. We assume that the consumer has a rational, continuous, and locally nonsatiated preference relation, and we take $U(\cdot)$ to be a continuous utility function. It is also assumed that the elements in the consumption set $C = \{C_N, C_M, C_X\}$ are all nonnegative.

It should be noted that C_N, C_M, and C_X are consumption of the nontradable (N) goods, the importable goods (M), and the exportable goods (X), respectively. The Hicksian (or compensated) demand function can be derived from the expenditure function, which bears a close relationship to the consumer's expenditure minimization problem. The expenditure function can be written as a function of prices and utility (Mas-Colell et al. 1995)

$$E = E(P_M, P_N; U) \tag{6}$$

were P_M is the price of the importables, and P_N is the price of nontradables. Both P_M and P_N are measured in terms of the exportable goods, the numeraire.

Let us describe the supply side of the model. The production side is viewed as being composed of a number of production units, i.e., firms. We take a representative firm that transforms inputs into outputs using the available technology. The objective of the firm is to maximize revenue subject to the transformation function, which depends on V, the vector of factors of production other than capital K, and the existing technology. The revenue function can be written in the following form:

$$R = R(P_M, P_N, V, K) \tag{7}$$

To derive the demand function of the representative consumer and the supply function of the representative firm, duality theory is used. By taking the partial derivative of the expenditure function E in equation (6), with respect to the prices, we get the Hicksian-compensated demand functions. Thus the partial derivative of E with respect to P_M gives the demand function for the importable goods, that is,

$$E_{P_M} = D_M(P_M, P_N, wealth). \tag{8}$$

The demand function for the nontradables is given by

$$E_{P_N} = D_N(P_M, P_N, wealth). \tag{9}$$

The supply function of the representative firm is derived by taking the partial derivative of the revenue function with respect to the output prices. Thus the supply function of the importable good is derived as

$$\frac{\partial R}{\partial P_M} = R_{P_M} = Q_M(P_M, P_N, V, K) \tag{10}$$

Similarly, the supply function of the nontradable goods is written as

$$\frac{\partial R}{\partial P_N} = R_{P_N} = Q_N(P_M, P_N, V, K). \tag{11}$$

2. Aggregation

So far we have derived the demand function of a representative consumer and the supply function of a representative firm. The relevant question here is how can we get the market demand function, a sum of the demands arising from all of the economy's consumers? The same question is relevant for the supply function.

First, we take the aggregate demand side. The demand function of a representative consumer can be expressed as a function of prices and the individual wealth level. Under what conditions can the individual demand functions be aggregated to get the market demand as a function of prices and aggregate wealth? Suppose there are n consumers with $D_{Ni}(P_M, P_N, W_i)$ demand functions, I = 1, 2, . . . , n. In general, given prices (P_M, P_N) and wealth levels $(W_1, W_2, \ldots, W_n)$ for the n consumers, aggregate demand can be written as

$$D_N (P_M, P_N, W_1, W_2, \ldots, W_n) = \sum_{i=1}^{n} D_{Ni} (P_M, P_N, W_i) \tag{12}$$

Equation (12) says that aggregate demand depends on prices and the specific wealth levels of various consumers. Can aggregate demand be written in the simpler form $D_N (P_M, P_N, \Sigma W_i)$ where aggregate demand depends only on aggregate wealth ΣW_i? Aggregate demand can be written as a function of aggregate wealth if there exists an indirect utility function of the Gorman form for all consumers. Under less restrictive assumptions we might be able to express the aggregate demand function as a function of aggregate wealth for any distribution of wealth across countries (Mas-Colell et al. 1995, p 108). We address this issue of aggregation because the data are available only in an aggregate form. In contrast with the theory of aggregate demand, aggregation theory is relatively simple in the case of supply because of the absence of a budget constraint. As prices change, there are only substitution effects along the production frontier (Mas-Colell et al. 1995).

3. The Model

We start with an identity for the private sector. Thus we write

$$R = E + I + T \tag{13}$$

where R is the value of output which depends on V, a vector of factors of production excluding capital, the prices of exportables, importables, and nontradables which are 1, P_M, and P_N. R also depends on the stock of capital K. Thus $R = R(1, P_M, P_N, V, K)$, where E is the private expenditure on the goods X, M, and N. E depends on the prices of these goods and wealth. We use the term wealth instead of income to indicate that over time the discounted present value of income is the relevant one. However, the model is not presented within the intertemporal framework. So $E = E(1, P_M, P_N, W)$. I is investment and T is lump sum tax; thus, equation (13) is written as

$$R\,(1, P_M, P_N, V, K) = E\,(1, P_M, P_N, W) + I + T \tag{14}$$

Another source of demand is the government expenditure, which is $G_X + P_M{}^*G_M + P_NG_N$. G_X, G_M, and G_N are quantities of goods X, M, and N, respectively. To write the government budget constraint, we need the sources of the government revenue. One resource is the lump sum tax T and the other source is the revenue from import taxes. This will depend on the import duty τ and the quantity imported, which is the difference between the domestic demand for the importable goods and the domestic supply for the importable goods. From equation (8) we get E_p, the domestic demand, and from equation (10) we get the domestic supply of the importable. So the government budget constraint is written as

$$G_X + P_M{}^*G_M + P_NG_N = \tau\,(E_p - R_p) + T$$

$$G_X + P_M{}^*G_M + P_NG_N = \tau\,[D_M\,(P_M, P_N, wealth) - Q_M\,(P_M, P_N, V)] + T \tag{15}$$

To determine the price of nontradables, we need to focus on the demand for nontradables and supply of nontradables. For equation (9), we get the private demand for nontradables as

$$E_q = D_N\,(P_M, P_N, wealth) \tag{16}$$

From equation (11) we get the supply of nontradables as

$$R_q = Q_N\,(P_M, P_N, V, K) \tag{17}$$

The government sector demand for nontradables is designated as G_N. It is possible to develop an optimizing model of the government behavior. That is, the government is maximizing utility subject to the budget constraint. Or we can take the government expenditure on nontradables as exogenous. In either case, the equilibrium condition in the nontradables sector dictates that

$$Q_N\,(P_M,\ P_N,\ V,\ K) = D_N\,(P_M,\ P_N,\ wealth) + G_N \tag{18}$$

Equation (18) gives the equilibrium conditions for the nontradables market. That is, the quantity supplies of the nontradables, i.e., Q_N should be equal to the sum of the quantity demanded by the private sector (D_N) and by the government. The solution of equation (18) gives the reduced form of the RER equation. In this reduced form, the endogenous variable RER is expressed in terms of all exogenous variables in the system of structural equation. In the system described above, the exogenous variables are the following:

P_M^* = world relative price of imports,

τ = import tariff

$P = P^* + \tau$

$V = \{V_1,\ V_2,\ \ldots,\ V_n\}$ where Vi is the input for $I = 1, 2, \ldots, n$

T = lumpsum tax

$G_X,\ G_M,\ G_N$ = quantities of X, M, and N consumed by the government

K = stock of capital

Since the $RER = \dfrac{P_T}{P_N} = \dfrac{EP_T^*}{P_N}$, we need to mention how P_T^* is measured. P_T^* is the weighted average of the international prices (dollar-denominated) P_X^* and P_M^*, which are exportable price and importable price, respectively. That is,

$$P_T^* = P_X^{*\alpha} \bullet P_M^{*1-\alpha}\ ;\ P_X^* = 1. \tag{19}$$

We can write in a general way the equilibrium relative prices of nontradables or the ERER as a function of the sustainable levels of all these exogenous variables. Solving for RER implies that there is an instantaneous equilibrium in the nontraded goods market for given levels of exogenous variables. Thus

$$RER = f(P^*, \tau, V, T, G_X, G_M, G_N, K) \tag{20}$$

To analyze empirically the effects of these variables on the RER, we linearize the function in equation (20). All variables are measured in log form. We replace P_M^*, the relative price of importables with the terms of trade. Thus the ERER equation, according to equation (20), is the important "fundamentals" determining the behavior of ERER, which are the following:

(i) external terms of trade is implied by P_M^*. Since P_M^* is the world relative price of imports, $\frac{1}{P_M^*}$ is the relative price of exports, i.e., terms of trade (TOT),

(ii) government consumption of nontradables (GCGDP),

(iii) exchange and trade controls (EXCHCONTROLS) captured by τ,

(iv) technological progress, both embodied and disembodied. Technological progress may be embodied in V, the vector of factors of production, and

(v) capital accumulation (INVGDP), i.e., change in the stock of capital K,

Although we have not included capital controls as one of the determinants of the RER, we can generalize the model by including these variables. Consider a country that controls inflow of capital by imposing a high rate of taxation on foreign borrowing. The country decides to liberalize its capital account by reducing the extent to which foreign borrowing is taxed. The liberalization of the capital account means the reduction of distortion in this economy and will generate positive welfare effects. This will result in an increase in demand for nontradables and consequently an increase in the price of nontradables. This causes an equilibrium RER appreciation. As a result of liberalization of capital control, there will be an inflow of capital or higher net RER appreciation. Incorporating these ideas, the ERER (e_t^*) is written in logarithmic form in the following manner:

$$\log(e_t^*) = \beta o + \beta_1 \log(\text{TOT})_t + \beta_2 \log(\text{GCGDP})_t + \beta_3 \log(\text{CAPCONTROLS})_t$$
$$+ \beta_4 \log(\text{EXCHCONTROLS})_t + \beta_5 \log(\text{TECHPRO})_t + \beta_6 \log(\text{INVGDP})_t + U_t, \quad (21)$$

The meanings of the notations are given below:

e^*:	ERER,
TOT:	external terms of trade, defined as the ratio of price of exports over the price of imports, i.e., (P_x/P_m),
GCGDP:	government consumption of nontradables,
CAPCONTROLS:	measure of the extent of controls over capital flows,
EXCHCONTROLS:	index of the severity of trade restrictions and exchange control,
TECHPRO:	measure of technological progress,
INVGDP:	ratio of investment to GDP,
u:	error term.

The equation (20) or its empirical counterpart, equation (21), says that the long-run ERER is a function of real variables. In the long run, ERER movements depend on real variables only. But the actual RER will generally deviate from the long-run equilibrium value. Short-run deviations may be due to short-run frictions and adjustment costs. There can be persistent deviation causing major and sustained differences between actual and ERERs. These sustained differentials can be called RER misalignment. Let us illustrate the point by taking one example of fiscal policies inconsistent with some chosen exchange rate regimes. Suppose that a country is on a fixed exchange rate system. The government runs a budget deficit that is financed by money creation. If the domestic creation of money or credit creation is greater than the rate of growth of money demand, the price of nontradables will grow faster than international price of tradables, i.e., there will be a RER appreciation. Suppose fundamental real variables do not change. Then this real appreciation of the currency will mean that there is a RER misalignment caused by the expansive domestic credit policy. We give this example taking the case of a fixed exchange rate economy. Under a managed floating rate system there can be inconsistent monetary and fiscal policies. To correct the RER misalignment, nominal devaluations can be used, but that will be effective only if it is accompanied by appropriate macroeconomic policies. To measure the RER misalignment, we must know the dynamics of RER behavior. The nature of this behavior depends on the nature of changes in the fundamental variables. Effects of temporary changes in fundamentals will be different from effects of permanent changes on the RER behavior.

4. Measurement of RER Dynamics

Before we proceed in deriving methods for estimating the unobservable ERER, we must mention some difficulties concerning the availability of data. Subscript t denotes time period t. Theoretically, each of these variables affects the ERER. One of the serious obstacles is the data availability. In fact, only time-series data in the external terms of trade (TOT) are readily available. In estimating the RER equation, reliable proxies for other fundamentals have to be found. TOT data were obtained from the *Monthly Statistics of Exports and Imports Taiwan Area, the Republic of China* (Ministry of Finance). There are no data on government consumption on nontradables. For this reason, the GCGDP variable is proxied by the ratio of total government consumption over GDP. Because nontradables cannot be totally replaced by GDP, the results obtained should be interpreted carefully. In the case of capital controls, it was not possible to find time-series data for an appropriate proxy. For this reason, the CAPCONTROLS variable is proxied by the lagged ratio of net capital flows to GDP. It is assumed that changes in the extent of capital controls will also affect the flow of capital moving in and out of the country. In principle, an increase of capital controls will reduce capital flows, and a decrease of capital controls will raise capital flows. Then it is expected that an increase in capital inflows will appreciate the ERER and vice versa. To estimate the EXCHCONTROLS variable, Edwards (1989) used two proxy variables. The implicit import tariff is computed as the ratio of tariff revenues to imports. But this proxy ignores the role of nontariff barriers. For this reason, a more comprehensive proxy that captures the extent of exchange controls in a broad sense is the difference between the black market rate and the official exchange rate. Parallel or black market exchange rates, used in calculations of EXCHCONTROLS, were obtained from various issues of the *World Currency Yearbook* (Cowitt). The rate of growth of GDP is used as a proxy for technological progress (TECHPRO). The investment ratio INVGDP variable is proxied by the ratio of gross fixed capital formation over GDP. We use the gross fixed capital formation to replace gross investment. The rate of growth of domestic credit (DCRE) was derived from the *Financial Statistics Taiwan District, the Republic of China*, in line 32 in various issues. NOMDEV stands for the nominal devaluation and is captured in the rate of growth of the nominal exchange rate. Most of the data sets except TOT, DCRE, and parallel market exchange rates were obtained from the *DRI/McGraw-Hill Encyclopedia of World Economics*.

5. Effects of Changes in Fundamentals on the Long-Run ERER

Terms-of-Trade Change. Here we investigate the way in which terms of trade changes affect the ERER. In order to analyze the effect of a permanent change in international terms of trade on the ERER, Edwards (1989) made some simplifying assumptions that include the absence of government consumption, investment, and taxes on foreign borrowing. However, under these circumstances, a permanent deterioration of international terms of trade will create a negative income effect and a positive substitution effect. The income effect is negative when the permanent deterioration of terms of trade reduces the real income of consumers and compels them to reduce their consumption of nontradables. Consequently, the demand for nontradables falls. In order to restore the equilibrium, the relative price of nontradables has to decline. That is, the ERER depreciates. At the same time, the permanent deterioration of the terms of trade will also create a positive substitution effect because of an increase in the relative price of importables. Consequently, people will reduce their consumption of importables and there will be substitution in favor of nontradables. If the income effect outweighs the substitution effect, this will cause a depreciation of the ERER. If the substitution effect dominates the income effect, this will result in an appreciation of the ERER.

Change in Government Consumption. A change in government consumption will have an impact on the equilibrium path of the RER. The intuition is that an increase in the government consumption of nontradables in period 1 is financed by an increase in public debt. As a result, the effects will take place through two channels. First, the increased demand for nontradables will result in a higher relative price of those goods. That is, the ERER appreciates. Second, the higher level of government borrowing in period 1 will result in a hike in taxes in period 2. This will reduce available income, which will cause a reduction of demand for nontradables in periods 1 and 2. This will cause a depreciation of the ERER. Whether the ERER in period 1 will appreciate or depreciate will depend on the relative strengths of the income effect and the substitution effect. If the income effect dominates the substitution effect, then the ERER depreciates in period 1. If the substitution effect dominates the income effect, there will be an appreciation in the RER in period 1.

Capital Flows. A liberalization of the capital account by way of reducing the tax on foreign borrowing will result in an increase in the net capital inflow and the ERER will appreciate. This impact takes place through two channels. First, the reduction of the tax on foreign borrowing makes future consumption relatively expensive. Since the reduction of tax in period 1 is going to be a burden in period 2, people substitute intertemporally, consuming more in the current period. This results in an increase of the relative price of nontradables and causes appreciation of the ERER. Second, the income effect results from the increasing liberalization of the capital account. Since the liberalization creates a positive welfare effect, the public will increase consumption in both periods. This results in an increase of the domestic price in both periods, and, consequently, the RER appreciates.

Exchange Controls. The spread between the black market and the official exchange rates requires the imposition of exchange controls. In most developing countries, exports decline and imports rise in response to artificial support of the actual value of the home currency. As a result the ERER depreciates.

In Taiwan's case, the government tries to raise the exchange rate (currency depreciation) in order to maintain the international trade competitiveness. In 1986, the Taiwan government started to relax the exchange controls because of U.S. pressure for liberalization (Figure 1). The RER has dropped dramatically since the third quarter of 1985. Therefore, we anticipate a positive sign for EXCHCONTROLS.

Technological Progress. Technological progress is an important determinant of the equilibrium path of the RER. Ricardo (1821/1971) was the first economist to observe that there is a negative relationship between the economic growth and the relative price of tradables to nontradables. The productivity improvement or technological progress is higher in the higher growth countries than the countries having a lower growth rate. He also mentioned that productivity improvement is higher in the tradable goods than the nontradable goods sector. However, in the context of Edwards' (1989) intertemporal two-period model,

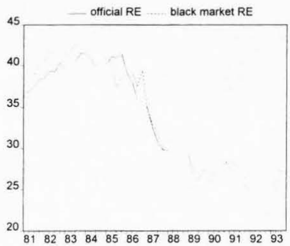

FIG. 1.—The difference between the official RER and the black market RER

a technological progress will create a positive income effect, which translates itself into a high demand for nontradable goods and eventually results in a lower ERER, which is an appreciation. But it also has an effect on the supply side because of technological progress. If technological progress creates an overproduction of nontradable goods, then the relative price of nontradables falls. This results in the depreciation of the ERER.

Ratio of Investment to GDP. The way in which investment affects the ERER depends on the composition of investment expenditure between tradables and nontradables. Wood (1987) argued that fixed investment is likely to generate appreciation because such activity generally involves a high expenditure ratio of nontraded to traded goods. Edwards (1989) has shown that the effect of investment depends on factor intensities characterizing the tradable and nontradable goods sectors. If the investment tends to use more tradable goods, this will result in increasing the relative price of tradable goods. This makes ERER depreciate. If the investment tends to use more nontradable goods, this results in the appreciation of the ERER.

6. Estimation of the ERER

Equation (21) is based on the theoretical derivation of the ERER, which is unobservable. How can we estimate the parameters in equation (21) on the basis of time-series data? The observed RER depends not only on fundamental—the real variables—but also on any inconsistent macroeconomic policies. For example, given a certain nominal exchange rate, if the rate of growth of money stock is greater than the rate of money demand, this will affect the observed movement of the RER. Since this is one usual source of macroeconomic inconsistency, we incorporated this into a partial adjustment model to obtain the parameters in equation (21).

The ERER in (21) is unobservable. This equilibrium is attained after all adjustments take place. There may be lags in the adjustment of actual RER toward the ERER. We can incorporate this adjustment lag in the following manner. Since $\log e_t^*$ is the ERER and $\log e_t$ is the actual RER, $\log e_t^* - \log e_t$ is the difference between the final change and the actual change. The partial adjustment[3] analysis says that the actual change $\log e_t - \log e_{t-1}$ is only a fraction of the desired change, that is, $\log e_t - \log e_{t-1} = \theta(\log e_t^* - \log e_{t-1})$, where $0 < \theta < 1$. Since macroeconomic policies and changes in the nominal exchange rate by the monetary authority affect the actual change, Edwards (1989) incorporated these factors and used the following equation for the dynamics of RER behavior:

$$\text{Log}e_t - \log e_{t-1} = \theta[\log(e_t^*) - \log(e_{t-1})] - \lambda(Z_t - Z_t^*) + \phi[\log(E_t) - \log(E_{t-1})], \quad (22)$$

where Z is a macroeconomic policy index, Z^* is the sustainable level of Z, and E is the nominal exchange rate. Equation (22) specifies that periodic changes in the RER are affected by three forces. First, there will be an autonomous tendency for the actual exchange rate to correct existing misalignment. This force is represented by the partial adjustment term $\theta[\log(e_t^*) - \log(e_{t-1})]$. This self-adjustment process tends to take place, under pegged nominal rates, through changes in the price of nontradable goods. If the value of θ is one, it means that disequilibrium will be eliminated in one period. The closer the value of θ is to unity,

[3]A simple model incorporating adjustment lags is the partial adjustment model. The partial adjustment model says that the actual change is only a fraction of the desired change. This model was popular in the 1950s and 1960s but was criticized as being ad hoc. The desired change is independent by some optimization rule and then the adjustment equation is tagged onto it. However, the costs of adjustment and the costs of being in disequilibrium should be incorporated into the optimization rule.

the faster the RER adjusts towards its long-run equilibrium rate. The second factor affecting the RER dynamics represents the effects of macroeconomic policies (Z_t - Z_t*). This term states that if the macroeconomic policies are unsustainable in the medium to longer run and are inconsistent with a pegged rate, there will be pressures toward a real appreciation, that is , if (Z_t - Z_t*) > 0, with other things remaining constant, Δloge < 0. If the macroeconomic disequilibrium and λ are large enough, these forces can easily dominate the self-correcting term. It suggests that unsustainable macroeconomic policies lead to overvaluation of the RER in most developing countries. The last term of equation (22) captures the effects of nominal exchange rate devaluations on the RER. If the RER was overvalued prior to the corrective action, nominal devaluation will generate short-run depreciation of the new RER upon impact.

To derive the coefficients necessary to estimate the ERER, we substitute equations (21) and (22) and solve for log (*et*) and have the following equation:

$$
\begin{aligned}
log(e_t) &= TREND + \gamma 1 log(TOT)_t + \gamma 2 log(GCGDP)_t + \gamma 3 log(CAPCONTROLS)_t \\
&+ \gamma_4 log(EXCHCONTROLS)_t + \gamma_5 log(TECHPRO)_t + \gamma_6 log(INVGDP)_t \\
&+ (1-\theta)\, log(e_{t-1}) + \lambda_1(DCRE)_t + \lambda_2(DEH)_t - \phi(NOMDEV)_t + \mu_t , \qquad (23.1)
\end{aligned}
$$

where DCRE and DEH are the macroeconomic policy components of (Z_t - Z_t*) in equation (22). The DCRE variable is defined as the rate of growth of domestic credit, while DEH is the ratio of fiscal deficit to lagged high power money. The variable NOMDEV stands for nominal devaluation as a proxy for [$log(E_t)$ - $log(E_{t-1})$] in equation (22). Since a nominal devaluation is hypothesized to lead to RER depreciation, we anticipate a positive coefficient for NOMDEV. The γ's are combinations of the β's and θ.

Equation (23.1) was estimated using quarterly data from 1981-93. Most variables were taken in their natural logarithmic terms; however, variables such as TECHPRO, EXCHCONTROLS, and CAPCONTRLS were not, because they can assume negative values. Regression results are reported in table 1.

7. Stationary Test

The regression results look good, and most are sign-consistent with our theoretical expectations. But as Granger and Newbold (1974) suggested, a good rule of thumb of evaluating whether the estimated regression suffers from spurious regression is $R^2 > d$. With our R^2 being extremely high, the D-W value is 2.07 in order to make sure we do not suffer

TABLE 1

REGRESSION RESULTS FOR THE RER EQUATION (23.1)
Dependent variable: logRE

Variables	Coefficient	t-Value
logTOT	-0.044025*	-2.032637
logGCGDP	-0.088646*	-1.883115
CAPCONTROLS	0.015857	0.212373
EXCHCONTROLS	-0.000262	-0.123692
TECHPRO	0.004896	0.048114
logINV	0.014660	0.682933
logRE (-1)	1.028496*	45.828320
DCRE	0.193853*	2.226519
DEH	0.017860	0.392457
NOMDEV	0.979330*	9.531388

*significant at 5% level.
R^2 is 0.996; D-W statistic is 2.122639.

any spurious regress, where one nonstationary time series is regressed on another nonstationary time series. Thus we have to have stationary checking. The definition of stationary is that if the time series is a stationary series, the mean, variance, and autocorrelations can be approximated by sufficiently long-time averages based on a single set of realization. Formally, a stochastic (random) process having a finite mean and variance is co-variance stationary for all t and $t+s$. To explain this statement, let Y_t be a stochastic time series with these properties: mean is $E(Y_t) = E(Y_{t+s}) = u$, variance is $VAR(Y_t) = E[(Y_t - u)^2] = E[(Y_{t+s} - u)^2] = \sigma_y^2$, and covariance is $E[(Y_t - u)(Y_{t+s} - u)] = E[(Y_{t+j} - u)(Y_{t+j+s} - u)] = r_s$, where u, σ_y^2, r_s are constants. Suppose we shift the original of Y from Y_t to Y_{t+s}. If Y_t is stationary, the mean, variance, and covariance of Y_{t+s} must be the same as those of $\boldsymbol{Y_t}$. That is, a stationary time series, its mean, variance, and covariance remain the same no matter at what time we measure them.

We applied the unit root test for testing the stationarity on both dependent and independent variables.[4] The results are shown in table 2. From these results, it is obvious that we have regressed from one nonstationary time series to another nonstationary time series. In this case, the standard t and f testing procedures are not valid. Thus, equation (23.1) is a spurious regression. Since most variables are stationary in their first difference, is it appropriate that we regress the first difference of the dependent variable (ΔlogRE) on the first difference of the fundamental variables? By using Gujarati's (1995) point of view, the

---

[4]The unit root test is based on the Dickey-Fuller test for testing the null hypothesis $\alpha = 1$ in the equation: $Y_t = \alpha y_{t-1} + U_t$, where U_t is the stochastic error term that follows the classical assumptions, i.e., zero mean, constant variance, and not autocorrelated. Such an error term is known as a white noise error term. If the coefficient of y_{t-1} is equal to one, we have the unit root problem, i.e., nonstationary situation.

TABLE 2

AUGMENTED DICKEY-FULLER UNIT ROOT TEST

Variables	ADF Test Statistic in Level	ADF Test Statistic in First Difference
LogRE**	-0.298402 (-2.9202)[a]	-3.372505 (-2.9215)
logTOT*	-7.806051 (-2.9178)	
logGCGDP*	-2.978003 (-2.9178)	
CAPCONTROLS**	-1.781877 (-2.9202)	-6.218140 (-2.9215)
EXCHCONTROLS*	-3.138757 (-2.9202)	
TECHPRO*	-5.768317 (-2.9215)	
logINV**	-1.520671 (-2.9178)	-6.721073 (-2.9178)
logRE (-1)**	-0.451670 (-2.9215)	-3.210268 (-2.9228)
DCRE**	-2.111721 (-2.9215)	-6.059921 (-2.9228)
DEH**	-2.832557 (-2.9178)	-6.591934 (-2.9178)
NOMDEV*	-3.007866 (-2.9190)	

*stationary at level; **stationary at first difference.

[a]Numbers in parentheses are MacKinnon critical values for rejection of hypothesis of a unit root.

advantage of doing this is solving the nonstationary problem immediately but we lose a valuable long-run relationship between dependent and independent variables.

Most economic analyses emphasize on its level interpretation rather than the first difference form. Another way to solve the nonstationary problem is that the regression results should be reliable if there exists a long-run relationship between dependent and independent variables. It is likely that each variable follows a random walk, although this seems to be harmonious. If dependent and independent variables are cointegrated, then the regression results in equation (23.1) may not be spurious and the standard t and f testing procedures are valid.

8. Cointegration Test

The concept of cointegration refers to the idea of common stochastic trends. Cointegration means that despite being individually nonstationary, a linear combination of two or more time series can be stationary, that is if there is a long-run or equilibrium relationship between them. Stock and Watson (1988) observed that cointegrated variables share common stochastic trends. For ease of exposition, we assume the vector X_t contains only two variables, so that $X_t = (Y_t, Z_t)$. Ignoring cyclical and seasonal terms, we can decompose each variable into a random walk plus an irregular component

$$Y_t = U_{yt} + \epsilon_{yt} \tag{23.2}$$

$$Z_t = U_{zt} + \epsilon_{zt} \tag{23.3}$$

where U_{yt} and U_{zt} are the random walk processes representing the trend in variables Y and Z in period t, respectively. ϵ_{yt} and ϵ_{zt} are the stationary components of variables Y and Z in period t. If Y_t and Z_t are cointegrated of order (1,1), there must be nonzero values of β_1 and β_2 for which the linear combination $\beta_1 Y_t + \beta_2 Z_t$ is stationary, that is

$$\beta_1 Y_t + \beta_2 Z_t = \beta_1(U_{yt} + \epsilon_{yt}) + \beta_2(U_{zt} + \epsilon_{zt}) = (\beta_1 U_{yt} + \beta_2 U_{zt}) + (\beta_1 \epsilon_{yt} + \beta_2 \epsilon_{zt}) \tag{23.4}$$

In order for the linear combination of $\beta_1 Y_t + \beta_2 Z_t$ to be stationary, the first term of equation (23.4) $(\beta_1 U_{yt} + \beta_2 U_{zt})$ must equal zero. Since the second term in equation (23.4) is stationary, the necessary and sufficient condition for Y_t and Z_t to be cointegrated of order (1,1) is $(\beta_1 U_{yt} + \beta_2 U_{zt}) = 0$. This condition holds for all t if and only if

$$U_{yt} = -\beta_2 U_{zt} / \beta_1 \tag{23.5}$$

For the nonzero values of β_1 and β_2, the only way to ensure equality is that the stochastic trends need to be identical up to a scalar. Thus, the two stochastic processes Y_t and Z_t must have the same stochastic trend if they are cointegrated of order (1,1).

A number of methods for testing the cointegration have been proposed. The two most popular and simplest methods are the (augmented) Dickey-Fuller (ADF) test on residuals estimated from the cointegration regression, i.e., equation (23.1), and the other is the cointegrating regression Durbin-Watson (CRWD) test. The null hypothesis of testing the existence of cointegration under the ADF test is that $(\beta_1 U_{yt} + \beta_2 U_{zt}) = 0$. By using the ADF test, if the absolute value of the estimated *t* exceeds any of the 1 percent, 5 percent, and 10 percent critical t values, then we can conclude that despite the dependent and independent variables being individually nonstationary, they are cointegrated. The null hypothesis under the CRWD test is that d = 0. In this study, we adopted the ADF test for testing whether the variables are cointegrated between dependent and independent variables.

By testing the estimated residual, the cointegration equation using the ADF test was obtained. The ADF test statistic is -6.146423, which exceeds the 1 percent critical value, -3.5682. We concluded that the trend in one variable can be expressed as a linear combination of the trends in the other variable(s). As long as the dependent and independent variables are cointegrated, then the regression results in (23.1) are not a spurious regression and the usual *t* and *f* tests are valid.

Before we analyze the econometric results, a brief discussion on the interpretation of presumed signs of the coefficients is in order. Equation (23.1) is a reduced-form specification of the determinants of the RER. It is, therefore, not always possible to be unequivocally certain about the anticipated signs of the independent variables because uncertainty exists whether supply outweighs demand effects, income outweighs substitution effects, or transitory effects outweigh permanent effects. What is important, however, is that the variables denoting economic fundamentals must be included so that an account is made of the impact that contributions have on the ERER.

The TOT variable was negative, which is consistent with the theoretical analysis that a rise in the TOT leads to an equilibrium exchange rate appreciation. According to the income-based argument, any improvement in the external TOT raises real income, which, in turn, raises the demand for nontradables. In order to restore equilibrium, the relative price of nontradables has to increase. Consequently, the ERER appreciates, unless substitution and intertemporal effects outweigh income effects.

We anticipate a negative relationship between government consumption GCGDP and the appreciation of the ERER because most government expenditures, in contrast to household expenditures, are made of nontradables. Consequently, the price of nontradables increases and the foreign exchange price of domestic currency decreases. Thus, we obtain a negative sign for the coefficient that is significant and consistent with the theoretical expectations.

An exogenous inflow of capital appreciates the ERER. Capital inflows allow expenditures to exceed income, thus generating a demand for nontradables. The relative price of nontradables rises to restore equilibrium. We have a positive sign of the coefficient CAPCONTROLS contrary to theoretical expectations.

We anticipated and obtained a negative sign for EXCHCONTROLS. The empirical results are consistent with the presumed sign of EXCHCONTROLS.

We found the coefficient for TECHPRO to be positive and statistically insignificant. It was argued by Balassa (1964) that productivity gains occur more rapidly in the traded goods sector than in the nontraded goods sector. Consequently, economic growth is associated with increases in the relative price of nontradables, that is, the ERER appreciates. Empirically, we get the contrary results. In Taiwan's case, the supply side effects outweigh the demand side effects. Because the technological progress creates a more rapid growth in the nontradables sector than in the tradables sector, this results in a higher relative price of tradables and hence the RER depreciates.

The way in which INVGDP affects the ERER depends on the allocation of investment expenditures between tradables and nontradables. We obtained a positive sign for INVGDP that was statistically not significant. This shows that Taiwan's investment tends to use more tradable goods and results in a higher RER. That is, the RER depreciates.

The sign of the coefficient of the lagged value of the RER is positive and significant. This result is consistent with the theoretical analysis. The coefficient of lagged RER is quite high in the regression. The high value of the coefficient (1.0285) implies a low value of adjustment coefficient θ(-0.0285) because $\theta = 1 - 1.0285$. A low value for θ means that the actual RER converges very slowly towards the long-run equilibrium level.

We anticipate a negative sign between the excess supply of domestic credit and the RER. The way in which the DCRE affects the ERER is that the excess supply of domestic credit comes from the expansionary fiscal policy. This results in both a higher output level and a higher interest rate. Consequently, this will generate a higher domestic price that makes the RER appreciate. In the regressions measures of macroeconomic policy—the fiscal deficit ratio DEH and the rate of growth of domestic credit DCRE—both positively affect the RER. The negative sign indicates that as these policies became increasingly expansive in these countries with higher deficits or increased excess supply of credit, the RER appreciated. Naturally, starting from the RER equilibrium, if other things remain constant, including the fundamentals, this appreciation will reflect an increasing disequilibrium or overvalued RER. In our results, DCRE and DEH were found to be both positive and DCRE is statistically significant, contrary to the theoretical expectations.

The devaluation variable NOMDEV was positive and significant. The coefficient value of 0.97933 indicates that, with all other things constant, a nominal devaluation was transferred in an almost one-to-one real devaluation in the first year. The size of the coefficient is large, and this provides strong evidence in support of the view that nominal devaluation can indeed be a powerful tool for reestablishing RER equilibrium in Taiwan's case.

9. The Numerical Results of the Estimated ERER

To get a quantitative measure of the ERER over time, use is made of the estimated coefficients for the real economic fundamentals in equation (23.1), while assuming that the monetary sector is in equilibrium (DEH = 0, DCRE = 0). The long-run coefficients of equation (21) are calculated as $\beta_i = \gamma_i/\theta$. The coefficient θ was obtained from the estimates of equation (23.1) where the lagged RER coefficient $(1-\theta)$ was 1.0285, thus, $\theta = -0.0285$. Using β_i, we calculated the equilibrium exchange rate with a 5-quarter calculated moving average of the RER fundamentals.[5]

The ERER is computed by using the following equation:

[5] We adopted the moving average procedure because it corresponded more closely with the theoretical concept of the equilibrium exchange rate.

$$\log(e_t^*) = 1.544953678 \log(\mathrm{TOT})_m + 3.110822572 \log(\mathrm{GCGDP})_m - 0.556464065 \log(\mathrm{CAPCONTROLS})_m + 0.009194272 \log(\mathrm{EXCHCONTROLS})_m - 0.171813587 \log(\mathrm{TECHPRO})_m - 0.514458169 \log(\mathrm{INVGDP})_m \quad (24)$$

where subscript "m" stands for the fundamentals that have been transformed in the moving average process. The movements between the observed RER and the ERER are shown in figure 2, where ERER is the calculated ERER and RER is the actual RER. The actual RER and the equilibrium rate are shown in appendix A. Misalignment is then calculated as [(RER - ERER)/ERER]*100 percent, which is shown in figure 3. A misalignment value larger (smaller) than unity represents an overvalued (undervalued) RER.

III. Model/Base Approach Provided by Elbadawi—Cointegration Analysis

An alternative methodology of estimating the ERER is derived from Elbadawi (1994). The difference between Edwards (1989) and Elbadawi is that Edwards applies the partial adjustment method to calculate the unobserved ERER, whereas Elbadawi uses the

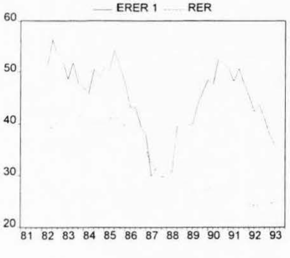

FIG. 2.—The movement between RER and ERER 1

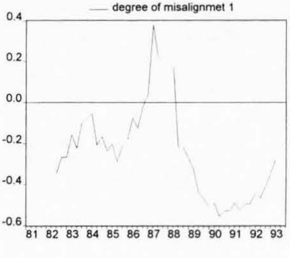

FIG. 3.—The degree of misalignment 1

cointegration analysis and an error correction framework to estimate the ERER. Elbadawi follows Edwards by defining ERER as the ratio of the price of tradables to the price of nontradables. In this section we follow the basic model framework but employ the Elbadawi cointegration analysis methodology to calculate the ERER and then interpret which one is more robust in capturing RER movements.

As presented in the introduction, the ERER solution does not account for the dynamic behavior of the actual RER around its equilibrium. This section provides an extension of the above model along this direction. The ERER therefore moves in response to exogenous and policy-induced shifts in its fundamentals. In addition, the observed RER is influenced in the short to medium run by macroeconomic and exchange rate policies that are not part of the fundamentals. RER misalignment can occur when those policies are inconsistent with the fundamentals. In a system of pegged nominal exchange rates, expansionary fiscal and monetary policies can be a cause of persistent real deviation.

A. Estimation of the ERER

Using the same reduced-form equation from Edwards (1989), the ERER is the value of the RER that satisfies the sustainable values of the right-hand-side variables.

$$\log(e_t) = \beta_1 \log(\mathrm{TOT})t + \beta_2 \log(\mathrm{GCGDP})_t + \beta_3 \log(\mathrm{CAPCONTROLS})_t + \beta_4 \log(\mathrm{EXCHCONTROLS})_t + \beta_5 \log(\mathrm{TECHPRO})_t + \beta_6 \log(\mathrm{INVGDP})_t \qquad (25)$$

By defining the parameter vector $\beta_i = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6)$ and the vector of fundamentals (F):

$$F = [\log(\mathrm{TOT}), \log(\mathrm{GCGDP}), \log(\mathrm{CAPCONTROLS}), \log(\mathrm{EXCHCONTROLS}), \log(\mathrm{TECHPRO}), \log(\mathrm{INV})] \qquad (26)$$

we get the following expression of ERER ($\hat{e}_t$*) for given sustainable values of the fundamentals vector ($\hat{F}_t$),

$$\log(\hat{e}_t{*}) = \sum_{i=0}^{\infty} \beta_i' \hat{F}_t. \tag{27}$$

It can be shown that if the set of fundamental variables is stationary in the first difference, i.e., I(1), then the following cointegration relationship exists (Kaminsky 1987):

$$\log(\hat{e}_t{*}) = \lambda\beta' \hat{F}_t + \eta_t \tag{28}$$

where β_t is the cointegration vector and η_t is the stationary disturbance term.

If the cointegration relationship in equation (28) is valid, then that equation not only can be interpreted as a long-run equilibrium but is also consistent with a dynamic error correction specification. The error correction equation consistent with the cointegration equation is:

$$\Delta \mathrm{loge}_t = b_o(\lambda\beta' F_t - \mathrm{loge}_t) + b_1' \Delta \log F_t + b_2\Delta(\mathrm{NOMDEV}) + b_3\Delta(\mathrm{DCRE}) + \epsilon_t. \tag{29}$$

The error correction term [$\lambda\beta' F_t$ - loge_t] in equation (29) clearly incorporates the RER dynamics. Assume that we start from an initial condition of real undervaluation (i.e., $\lambda\beta' F_t$ - loge_t is positive). The self-correcting mechanism that calls for future appreciation in the actual RER will be set in motion. This effect is captured by the positive error correction term and its negative coefficient of $\Delta\mathrm{loge}_t$ specification. The speed with which this automatic adjustment operates depends on the parameter b_o, which falls in the interval (0, 1). A value of b_o equal to one signifies prompt adjustment over just one period; smaller values signify slower rates of adjustment.

In addition to the equilibrium long-run impact of fundamentals, which is captured by the cointegration vector β_t, temporary changes in the fundamentals may also have short-run effects that are captured by the vector b_1. The short-run impact of nominal depreciation is given by the coefficient b_2. As pointed out by Edwards (1989), a nominal devaluation will help the adjustment process only if the nominal exchange rate is accompanied by a supporting macroeconomic policy. In other words, in terms of our equation, the error correction term is positive and the rate of growth of domestic credit (DCRE) is not negative.

In this section, equations (25) and (29) are estimated for Taiwan, using quarterly data from 1981-93. For purposes of encountering dynamic behavior, the interpretation of equation (25), describing the long-run RER equilibrium, has to be justified. In order for the error correction of equation (29) to be considered adequate for the data-generating process of the observed RER, the individual variables that enter into the equation must be cointegrated. Table 2 provides the formal unit root tests for the individual variables of equation (25). As can be seen from this table, variables such as logTOT, logGCGDP, EXCHCONTROLS, and TECHPRO are stationary at their level, but logRE and CAPCONTROLS are stationary at the first difference. This means that part of the fundamental variables are shown to have unit roots. The remaining condition used to satisfy the above interpretations is cointegration. In Taiwan's case, strong support is provided for cointegration, thus permitting an equilibrium interpretation of the estimates of table 3 as well as providing a justification of the error correction specification estimates of table 4.

B. The Long-Run Cointegration Equilibrium

Starting with the long-run regressions of table 3, we tested the estimated residual that was obtained from the cointegration equation using the ADF test. The ADF test statistic,

TABLE 3

COINTEGRATION REGRESSION
Dependent variable: logRE

Variables	Coefficient	t-Value
TREND	-0.010047*	-9.180551
logTOT	0.644094*	8.436110
logGCGDP	0.268213	1.280355
CAPCONTROLS	0.533161*	1.681111
EXCHCONTROLS	-0.013882	-1.421498
TECHPRO	1.293792*	3.187981
logINV	-0.273435*	-3.896077

$R^2 = 0.9067$; adjusted $R^2 = 0.8939$.
*significant at the 10% level.

TABLE 4

ERROR CORRECTION REGRESSION
Dependent variable: ΔlogRE

Variables	Coefficient	t-Value
$\log\tilde{RER}(-1)-logRER(-1)$	0.156896*	2.640812
ΔlogTOT	-0.111276	-0.778861
ΔlogGCGDP	0.013260	0.161541
ΔCAPCONTROLS	0.262185*	1.735279
ΔEXCHCONTROLS	-0.004114	-1.265842
ΔTECHPRO	0.059417	0.486840
ΔlogINV	-0.008536	-0.309590
ΔDCRE	0.121678	1.046802
ΔNOMDEV	0.426697*	2.408353
DUMMY (1985:3)	-0.012822*	-3.252609

R^2 is 0.421586; adjusted R^2 is 0.291443; D-W statistic is 1.014047.

-2.5983, is significant from the 10 percent critical value -2.741522. We can conclude that the dependent and independent variables are cointegrated. Also, the individual estimates highly corroborate the prediction of the theoretical model. The TOT was negative and significant, which is consistent with the theoretical analysis that a rise in the TOT leads to an ERER appreciation. According to the income-based argument, improvement in the external TOT raises real income, which, in turn, raises the demand for nontradables. In order to restore equilibrium, the relative price of nontradables has to increase. Consequently, the ERER appreciates, unless substitution and intertemporal effects outweigh the income effects. This result shows that the substitution effect tends to dominate the income effect. The findings shown in table 4 are opposite to the findings shown in table 1. Using the Edwards approach, we included the macro factor into the regression equation; thus the missing macro variables may lead to different results.

The ratio of government consumption to GDP is positive and significant for the case of Taiwan. The implication of this result is that government tends to devote more of its expenditure to nontraded goods than do the private sectors. Consequently, the price of nontradables increases and the foreign exchange price of domestic currency decreases. This finding is also opposite to Edwards's (1989) result.

An exogenous inflow of capital appreciates the ERER. Capital inflows allow expenditures to exceed income, thus generating demand for nontradables. The relative price of nontradables rises to restore equilibrium. We have a positive sign of the coefficient CAPCONTROLS that is contrary to theoretical expectations but consistent with Edwards's (1989) finding.

The index proxying exchange and trade controls are negative but not significant when there is an indication that a relaxation of the extent of impediments to international trade results in ERER depreciation. Indeed, this is the contention of the policy literature on trade liberalization reforms. These findings are consistent with Edwards's (1989) results and theoretical expectations.

We found the coefficient for TECHPRO to be positive and statistically significant. It was argued by Balassa (1964) that productivity gains occur more rapidly in the traded goods sector than in the nontraded goods sector. Consequently, economic growth is associated with increases in the relative price of nontradables, that is, the ERER appreciates. Empirically, we get the contrary results. By using Edwards's arguments, the reasons for the estimated coefficient may not be consistent with the theoretical expectations. Admittedly, growth is not a very good proxy for technological progress, and the estimated coefficient may be picking up, in part, the effects of growth in the demand for credit on the behavior of RER. In Taiwan's case, the supply side effects outweigh the demand side effects. Because technological progress creates a more rapid growth in the nontradables sector than in the tradables sector, this results in higher prices for tradables and, hence, the RER depreciates.

The way in which INVGDP affects the ERER depends on the allocation of investment expenditures between tradables and nontradables. We obtained negative signs for INVGDP that were statistically significant. This shows that Taiwan's investment tends to use more non-tradable goods and results in a lower RER, that is, the RER appreciates. This result is opposite to Edwards's findings.

C. The Short-Run Error Correction Estimation

The error correction estimation gives the short-run specification of the RER determination. We incorporated the dummy variable into our equation because the third quarter of 1985 reflected a more than 38 percent real overvaluation within the following two years. We included dummy variables in order to show the structure change. The results shown in table 4 support the error correction model, where the coefficients of the error correction term $\lambda\beta' F_t$ - $\log e_t$ are negative, less than one, and significant.

The elasticity is estimated at 0.16 for Taiwan. This coefficient reflects the dynamic self-correcting mechanism of the error correction model. If the fundamentals in the previous period call for a lower RER than that observed [i.e., $\lambda\beta' F_t - \log e_t < 0$], then the coefficient is positive and the RER will appreciate in the following period.

The short-run effects due to expansive macroeconomic policy and nominal exchange rate overvaluation, however, were not found to be as uniformly significant as in the case of th+e automatic adjustment effect. The self-correcting mechanism is captured by the parameter b_o, which falls in the interval (0, 1). A value of b_0 equal to one signifies prompt adjustment over just one period; smaller values signify slower rates of adjustment. In our case, we obtain the number 0.16, which is close to the 0.19 obtained by Edwards (1989) for a group of developing countries using a partial adjustment model.

The effect due to nominal devaluation is statistically significant. The result validates the view that when starting from an initial condition of real undervaluation, other things held constant, a nominal devaluation could accelerate the process of convergence toward the RER equilibrium, to the extent that the domestic credit is positive. This indicates that the increasing rate of growth of domestic credit results in the RER devaluation. This result is contrary to the theoretical expectations but consistent with Edwards's (1989) findings.

In the short run, the RER is also influenced by the transitory movements of the fundamentals (terms of trade, capital inflows, government consumption, exchange controls, technological progress, and investment ratio). Both terms of trade and exchange control have expected signs but are only marginally statistically significant. In the case of exchange control, it shows the short-run effect is consistent with the corresponding long-run influence, indicating that, on both the long run and the short run, more openness (a relaxation of the extent of impediments to international trade) leads to real depreciation. In the case of terms of trade, the negative influence of the short-run effect is consistent with our expectations but only statistically insignificant, and the positive long-run effect is contrary to theoretical expectations but statistically significant. This indicates that the long-run effect dominates the short-run effect. The improvement of terms of trade will reduce the international competitiveness; moreover, it decreases the export volume and results in RER depreciation.

The short-run influence of government consumption is insignificant at the conventional level and positive, indicating that government consumption tends towards tradable goods. This result is contrary to theoretical expectations and also contrary to Edwards's (1989) findings. But in the case of government consumption, the long-run effect is consistent with the short-run effect, indicating that government consumption tends towards tradable goods in the case of Taiwan with Elbadawi's approach.

Both CAPCONTROLS and TECHPRO, the short-run and long-run effects, are consistent. But the sign of CAPCONTROLS is contrary to theoretical expectations. It is interesting in both Edwards's model and in Elbadawi's model that this variable shows the wrong sign. The reason for the CAPCONTROLS variable is because the tradable and nontradable goods have different income elasticity. The increasing capital inflow leads to a higher price level for domestic goods and consequently increases tradable goods. Tradable goods are superior to domestic goods in most countries. In other words, the elasticity for tradables is higher than for nontradables. This results in a depreciation in real exchange. The negative sign of EXCHCONTROLS is consistent with theoretical expectations and both the Edwards and Elbadawi approaches show the same sign. This indicates that the increasing severity of exchange control resulting in RER devaluation was strongly proven in our study.

In the case of TECHPRO, where the rate productivity improvements are not uniform across sectors, gains in productivity are higher in the tradable goods sector than in the nontradable goods sector. This means that resources move toward the tradables sector from the nontradables sector. On the demand side, any type of productivity shock will have a positive income effect, resulting in a positive demand pressure on tradable goods. The reason for the positive sign of TECHPRO is that it is possible under some conditions that the supply effects of technological progress more than offset the demand effects, generating an equilibrium real depreciation. We get the same results from both approaches.

To the ratio of investment of GDP variable, the short-run and long-run effects are consistent but contrary to the Edwards results where both have a negative effect on RER. That is, the increasing investment level leads to RER appreciation. This shows that investment leans towards nontradable goods. A dummy variable representing the major declines of the exchange rate in Taiwan in 1985 was found to have had a significant and negative influence in the short run.

The error correction coefficients can be manipulated, in the context of the error correction specification, to derive the corresponding adjustment speed in terms of the number of quarters needed to eliminate 50 percent of the effects of an exogenous shock by 3.975 quarters for Taiwan (see table 5). To clear 99.9 percent of the shock, the corresponding period is 39.32 quarters.

D. The Estimated ERER Index

We compute the indexes for the ERER by using the coefficients derived from the long-run estimates of table 3 and multiplying the sustainable values of the fundamentals. Following Elbadawi's methodology, the sustainable component of fundamental variables were proxied by 4-quarter moving averages. The 4-quarter period is used since it reflects the

TABLE 5

SPEED OF AUTOMATIC ADJUSTMENT TO AN EXOGENOUS SHOCK

Country	Coefficient of the Error Correction Term[a]	Quarters to Eliminate Effects of Exogenous Shock[b]	
		50%	99.9%
Taiwan	$\lvert 0.16 \rvert$	3.975	39.319

[a]It is the coefficient of $\log\tilde{RER}(-1)-\log RER(-1)$ in the error correction regression of table 4.

[b]The number of the years to clear 100 percent of an exogenous shock through automatic adjustment alone can be computed from the formula $(1-\lambda)=(1-\gamma)^{T}$, where γ is the estimated coefficient of the error correction term and T is the required number of years.

median of the number of the quarters needed to eliminate an exogenous shock, which is shown in table 5. The estimated ERER is then computed by the following equation:

$$\log(e_t^*) = -0.008715\ (TREND) + 0.6449159\ log(TOT)_f + 0.936953\ log(GCGDP)_f$$
$$+ 0.690098\ log(CAPCONTROLS)_f - 0.008935\ log(EXCHCONTROLS)_f$$
$$+ 1.359950\ log\ (TECHPRO)_f - 0.524627\ log(INVGDP)_f \qquad (30)$$

where the subscript "f" is the sustainable components of the fundamental variables. The derived ERER series is shown in figure 4. Figure 5 shows the corresponding RER misalignment, which is computed as [(RER - ERER)/ERER]*100 percent. The actual RER and ERER are shown in appendix B.

The derived indexes from Elbadawi's approach agree with those of Edwards in that the ERER shows some variability. It follows that at least part of the observed RER variability is related to equilibrium behavior, and that an analysis of RER misalignment based on historical comparisons of the observed RER level (i.e., the PPP approach) may lead to an erroneous conclusion.

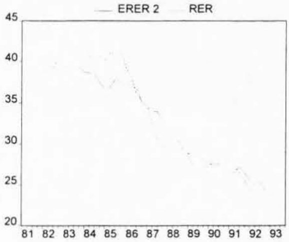

FIG. 4.—The movement between RER and ERER 2

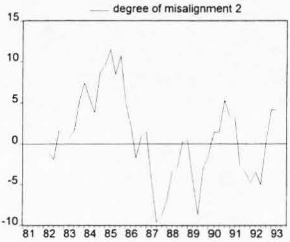

FIG. 5.—The degree of misalignment 2

Figure 5 indicates that the more open the trade policy is, the less the degree of misalignment because the fluctuations gather around the horizonal line gradually. The RER starts to drop dramatically after the third quarter of 1985 and keeps falling until the end of 1997. The pressure comes from the international trade partners as they force the Taiwan currency to appreciate. It is very clear to see before the third quarter of 1985 that the RER represents an upward trend (New Taiwan dollar depreciation), but after that crucial point of time, it is downward sloping. Figure 4 shows us how the appreciation of the Taiwan currency really responds to the long-run equilibrium level. That is why the difference between the RER and the equilibrium rate is getting shorter and shorter.

IV. Conclusions

The purpose of this essay was to analyze the RER behavior in Taiwan for the period 1981-93. The theoretical model suggests that the RER movements respond to both real and nominal disturbances. To estimate empirically we used an augmented partial adjustment equation for RER dynamics as developed by Edwards (1989) and a cointegration analysis as developed by Elbadawi (1994). The equations from the first part of this essay were used for the purpose of capturing the important features of the theoretical analysis. The empirical results show that (i) the difference between the actual RER and the ERER, and that (ii) a nominal devaluation is neutral in the long run, but in the short run it shows almost one-to-one real devaluation in the first quarter and provides strong evidence in support of the view that nominal devaluation can be a powerful tool for reestablishing ERER. Empirical results also show that the short-run RER responds to macroeconomic disequilibrium and the long-run RER responds to changes in fundamentals.

The estimating results indicate that the autonomous forces for correcting disequilibrium work very slowly. This explains why policy makers are eager to use nominal devaluations to hasten the process of adjustment and to correct the RER misalignment. In Taiwan's case, the large coefficient of NOMDEV shows that much can be done to speed up the RER realignment. One major finding of this study is that the impact effect of the nominal devaluation on the RER is short-lived and does not last in the long run, and the nominal devaluation can help to speed up the process of adjustment only if consistent macro policies are pursued at the same time.

The second part of this essay follows Edwards (1989) by defining the ERER as "the relative price of tradables to nontradables which for given sustainable values of other relevant variables such as international terms of trade, government consumption, capital flows, exchange control, technological progress, and investment GDP ratio, results in the simultaneous attainment of internal and external equilibrium" (p. 16). Elbadawi argued that, given the above concept of equilibrium, it should allow for flexible dynamic adjustment of the RER toward the ERER, and it should allow for the influence of short- to medium-run macroeconomic and exchange rate policies on the RER.

Elbadawi (1994) developed a model that accounted for the aforementioned features. In the presence of stochastic nonstationarity and cointegration, stochastic nonstationarity suggests a natural methodology for generating the "sustainable" component of the fundamentals, by using a moving average technique based on the median of the number of quarters needed to eliminate an exogenous shock. Estimation of the long-run cointegration equation of ERER and the corresponding dynamic error correction specification corroborated the model and produced fairly consistent results with Edwards's (1989) findings. Using sustainable fundamentals, the estimated long-run equations were used to derive indexes of the ERER. The estimated ERER and the corresponding rates of RER misalignment confirm that the ERER is not a fixed number (Edwards). This also implied that simple PPP modeling of the RER could be a misleading simplification.

Empirical results show that (i) the positive and highly significant error correction term reflects a dynamic self-correcting mechanism; (ii) temporary changes in the fundamentals may also have short-run effects, which is consistent with Edwards's (1989) findings; (iii) the short-run impact of nominal depreciation confirms that nominal devaluation can be a useful tool for reestablishing the RER; and (iv) a nominal devaluation will help the adjustment process only if the nominal exchange rate is accompanied by supporting macroeconomic policy. In other words, the error correction term is positive and the rate of growth of domestic credit (DCRE) is not negative.

The main findings in Elbadawi's (1994) approach is that the more open the trade policy is, the less the degree of misalignment in ERER. Also, the dramatical falling of RER actually responds to the behavior of the long-run equilibrium rate.

Appendix A: Partial Adjustment Approach of Numerical Results

TABLE A1

ACTUAL RER AND ERER (PARTIAL ADJUSTMENT)

Year	Real Exchange Rate		Misalignment
	Actual	Equilibrium	(Percentages)
1981:1	36.68664	–	–
1981:2	36.81985	–	–
1981:3	37.54662	–	–
1981:4	38.30438	–	–
1982:1	38.54543	–	–
1982:2	39.36948	50.94300	-22.71858
1982:3	39.32350	56.33099	-30.19206
1982:4	40.35906	53.33418	-24.32796
1983:1	39.55085	52.11869	-24.11389
1983:2	39.99194	48.60596	-17.72215
1983:3	40.56478	51.85043	-21.76577
1983:4	41.52401	47.84166	-13.20535
1984:1	41.54449	46.91377	-11.44499
1984:2	40.80338	45.81963	-10.94780
1984:3	39.88938	50.55727	-21.10060
1984:4	40.59377	48.99530	-17.14762
1985:1	40.15465	50.86927	-21.06305
1985:2	41.07355	50.37218	-18.45986
1985:3	40.99717	54.29016	-24.48508
1985:4	41.38940	50.91191	-18.70388
1986:1	39.12963	47.70587	-17.97733
1986:2	37.91779	43.26480	-12.35880
1986:3	36.03473	43.11106	-16.41418
1986:4	35.47953	39.72434	-10.68566
1987:1	34.99127	37.76504	-7.344798
1987:2	32.46011	29.94819	8.387550
1987:3	30.71254	31.57943	-2.745110
1987:4	29.80271	30.85066	-3.396868
1988:1	29.76690	30.63566	-2.835771
1988:2	29.91883	30.70494	-2.560213
1988:3	29.71759	39.56316	-24.88571

TABLE A1 (Continued)

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1988:4	29.48268	38.71108	-23.83918
1989:1	29.03405	39.78474	-27.02216
1989:2	27.17251	39.92825	-31.94664
1989:3	26.19503	43.85230	-40.26533
1989:4	27.24092	46.18488	-41.01767
1990:1	27.33233	48.38131	-43.50643
1990:2	27.67106	47.59090	-41.85641
1990:3	27.91068	52.40512	-46.74055
1990:4	28.60577	51.76642	-44.74067
1991:1	27.55879	50.54419	-45.47586
1991:2	27.32929	48.20945	-43.31134
1991:3	26.48250	50.61602	-47.67960
1991:4	25.54931	47.73369	-46.47531
1992:1	24.30010	45.34209	-46.40719
1992:2	24.21048	42.38201	-42.87558
1992:3	24.00970	43.65742	-45.00430
1992:4	24.46176	40.90570	-40.19964
1993:1	24.68202	37.88134	-34.84385
1993:2	24.80435	35.93743	-30.97906
1993:3	25.49570	–	–
1993:4	25.21360	–	–

Appendix B: Cointegration Analysis Approach of Numerical Results

TABLE B1

ACTUAL RER AND ERER (COINTEGRATION ANALYSIS)

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1981:1	36.68664	–	–
1981:2	36.81985	–	–
1981:3	37.54662	–	–
1981:4	38.30438	–	–
1982:1	38.54543	–	–
1982:2	39.36948	39.77519	-1.020023
1982:3	39.32350	40.08924	-1.910087
1982:4	40.35906	39.71453	1.622910
1983:1	39.55085	39.10863	1.130745
1983:2	39.99194	39.68347	0.777340
1983:3	40.56478	39.95038	1.537905
1983:4	41.52401	39.41869	5.340919
1984:1	41.54449	38.68301	7.397244
1984:2	40.80338	38.65095	5.568907
1984:3	39.88938	38.42687	3.805944
1984:4	40.59377	37.35960	8.656851
1985:1	40.15465	36.64433	9.579443
1985:2	41.07355	36.85344	11.45108
1985:3	40.99717	37.82259	8.393354
1985:4	41.38940	37.38978	10.697110
1986:1	39.12963	37.26612	5.000548
1986:2	37.91779	37.09493	2.218246
1986:3	36.03473	36.68316	-1.767640
1986:4	35.47953	35.14286	0.958015
1987:1	34.99127	34.49194	1.447690
1987:2	32.46011	34.04243	-4.648096
1987:3	30.71254	33.98271	-9.623036
1987:4	29.80271	32.69910	-8.857703
1988:1	29.76690	31.96387	-6.873297
1988:2	29.91883	30.95277	-3.340389
1988:3	29.71759	30.59637	-2.872178

TABLE B1 (Continued)

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1988:4	29.48268	29.42319	0.202162
1989:1	29.03405	28.91696	0.404899
1989:2	27.17251	28.46559	-4.542598
1989:3	26.19503	28.70206	-8.734684
1989:4	27.24092	28.10850	-3.086534
1990:1	27.33233	27.74717	-1.495074
1990:2	27.67106	27.27787	1.441419
1990:3	27.91068	27.50884	1.460775
1990:4	28.60577	27.15528	5.341469
1991:1	27.55879	26.66069	3.368637
1991:2	27.32929	26.48371	3.192835
1991:3	26.48250	27.22321	-2.720853
1991:4	25.54931	26.46587	-3.463182
1992:1	24.30010	25.50886	-4.738608
1992:2	24.21048	25.08744	-3.495624
1992:3	24.00970	25.27411	-5.002773
1992:4	24.46176	24.38102	0.331128
1993:1	24.68202	23.69673	4.157934
1993:2	24.80435	23.81697	4.145720
1993:3	25.49570	–	–
1993:4	25.21360	–	–

ESSAY TWO: TRENDS AND CYCLES IN TAIWAN'S EQUILIBRIUM REAL EXCHANGE RATE

I. Introduction

Many economists suggest that it is important to distinguish between permanent and transitory components in a series. The reason is that permanent and transitory movements in a series can induce people to have different or even opposite responses. For example, a transitory price decline induces buyers to purchase more at the current period rather than in the future. If the price reduction is a permanent phenomenon, then people will not demand as much as they would under a temporary price reduction. If we ignore the difference between permanent and transitory components in our analysis, the conclusions might be misleading. The model of RER (real exchange rate) determination suggests that the equilibrium value depends on the fundamentals. We intend to distinguish between permanent and temporary changes in these fundamentals in order to investigate if this distinction is relevant for the determination of RER. Our interest in the cyclical movements in the exchange rate is based on the belief that for policy purposes, the amplitude, duration, and shape of the cyclical part are at least as important as the underlying long-run trend. An accurate characterization of exchange rate cyclical behavior is essential for designing countercyclical stabilization policies in developing countries. If the trend is a variable one, the regression technique using a trend stationary process (TSP) is not the appropriate one. That is, in case of the stochastic trend, the Beveridge-Nelson technique is used to decompose the observed changes into permanent and transitory ones. Because of stochastic nonstationarity, we use the Beveridge-Nelson type of decomposition to generate the "sustainable components" of the fundamentals.

The main purpose of this essay is to estimate the ERER (equilibrium real exchange rate) using the reduced form equation of the RER. We employ the decomposition technique and combine it with the different approaches in order to get the most appropriate ERER.

It is in unanimity that misalignment of the RER of a country affects the growth of the economy in an adverse way. This view presupposes the existence of the ERER. Generally two approaches for determining the ERER are used. The simplest approach is based on the purchasing power parity (PPP) theory. The relative price level of the home country and its trading partner determines the equilibrium exchange rate. Relative inflation rates determine the rate of change of the nominal exchange rate over time. Relative to a base year, when the observed exchange rate diverges from the PPP-determined exchange rate, this divergence is interpreted as the RER being out of its equilibrium value. An alternative approach defines the RER as the relative price of tradable to nontradable goods. This definition points to the real aspect of the rate of exchange between the goods of two countries. This definition of the RER focuses on the units of domestic goods (i.e., nontradables) that must be given up in order to acquire one unit of internationally traded goods. The RER thus defined is theoretically more appealing since it is an indicator of incentives guiding resource allocation between the tradables and the nontradables sectors. If the domestic price of the traded goods increases, resources will move from the nontradables sector to the tradables sector. That is, more export goods and import goods would be produced. As a result, the trade balance will improve. In this context, the ERER, corresponding to the relative price of tradables to nontradables, is that rate that for given sustainable (equilibrium) values of other relevant variables, such as taxes, terms of trade, and technology, results in the simultaneous attainment of internal and external equilibria. As already mentioned, internal equilibrium implies that the nontradable goods market is cleared, whereas external equilibrium implies that the current account imbalances are offset by corresponding movements in the capital account. Hence, RER misalignment means that the observed RER is different from the ERER. It should be noted that an observed change in an index of RER is the result of a change in the ERER arising from different types of external and domestic real shocks and also due to such distortionary policies of the government as capital control, exchange control, etc. One objective of this essay is to estimate the extent of misalignment. Hence, we need to be careful in estimating the ERER, which is unobservable. One contribution of this essay is the estimation of the ERER by using the techniques of modern time-series analysis. From a policy point of view, the more accurate the estimated values of the ERER are, the more appropriate will be the policies designed to correct misalignment. The estimated exchange rate will be taken as a reference point from which the degree of misalignment can be gauged.

In 1981, Beveridge and Nelson (hereafter B-N) developed a general procedure for the decomposition of nonstationary time series into a permanent and a transitory component allowing both components to be stochastic. The permanent component is shown to be a random walk with drift and the transitory or cyclical component is a stationary process with zero mean. Cuddington and Winters (1987) described a computational method for carrying out the B-N decomposition of economic time series into permanent and transitory components.

Cuddington and Urzua (1989a) yielded an interpretation of the extent to which commodity price shocks should be viewed as cyclical in nature, as well as providing a useful characterization of the cycles. We use the idea behind their analysis and apply it to the exchange rate market in order to find out if the deviation of RER from the equilibrium level should be viewed as a permanent or transitory movement.

As Cuddington and Urzua (1989b) observed, the standard time stationary (TS) model tends to overestimate the magnitude of the cyclical component in economic time series and, as a consequence, it underestimates secular, growth, or permanent effects. Furthermore, the conceptual basis for the standard procedure is rather weak, since it is based on a model in which the long-run behavior is completely deterministic. That is, although there is some uncertainty in the short run, all uncertainty disappears in the long run in the sense that nothing alters the asymptotic paths of macroeconomic variables. They not only decomposed the economic time series, but they also illustrated its usefulness for examining the cyclical and permanent movements in real GDP (gross domestic product) in Columbia. Here, we adopt their methodology to illustrate the usefulness of decomposing the ERER in Taiwan.

Edwards (1989) decomposed the fundamental variables into a permanent and a transitory component for investigating whether this distinction was empirically important. He used the same methodology proposed by B-N and reported on the ARIMA (autoregressive integrated moving average) models used to perform this decomposition. His findings indicated that both the TOT and EXCHCONTROLS variables, the distinction between temporary and permanent, were relevant. For both of these variables only changes in the permanent component are significant and they also have the expected sign. Moreover, tests for the equality of the coefficients of permanent and transitory components resulted in the strong rejection of the null hypothesis. In the case of GCGDP, the distinction between permanent and transitory parts appears not to be empirically important and the sign does not correspond to what was expected. The coefficients of the capital inflows variables turned out to be insignificant in all of the equations. We followed the same route, decomposing our fundamental variables into permanent and transitory and investigated the empirical importance of the distinction by testing the equality of coefficients.

Not only does the ERER have a strong economic meaning, but it is also a useful reference for policy makers, because the ERER is unobservable. Hence, it is very important that there is an accurate way to compute the ERER and a sound theoretical basis to support it.

II. Methodology

A. The Decomposition Technique: The ARIMA Process

Theory tells us that the permanent components of fundamentals are nothing but sustainable values. In this essay, we use the B-N methodology to decompose the fundamental variables into permanent and transitory components.

This distinction is empirically important in shaping our thinking about economic phenomena, because the permanent and the transitory components can induce people's behavior to be totally opposite. The decomposition methodology was applied to the problem of measuring and dating business cycles in the economy. But from a practical point of view, a serious shortcoming arises from the fact that turning points are detected only with the benefit of hindsight. In this consideration it might be more useful to try numerical measurement of cyclical movements to provide an on-going record as they are developed.

Several approaches to numerical measurement of the business cycle have been suggested. Feller's (1956) cycle component emerges as a residual from the trend line that has enjoyed popularity with students of the business cycle assumptions. The shortcoming arises from the assumption of a long-run deterministic of time series and therefore perfect prediction. Friedman (1957) decomposed income into permanent and transitory components. He suggested that the permanent component may be represented as a geometric distributed lag on past income observations. Compared to Feller's (1956) method, the virtue of such an approach is its freedom from time-series determinism, and the computation of the components only depends on past observations. In this essay, we adopted B-N's concept for measuring cyclical movements, which is based on the fact that any time-series data exhibit homogeneous nonstationarity; therefore, the data can be decomposed into two components—a stationary series and a pure random walk—by using ARIMA[6] methods (B-N) and allowing both components to be stochastic. The main thrust of their methodology is how to capture the impact effects of stochastic shock into long-run equilibrium. They adopt a random walk plus drift to describe the stochastic components and decompose the ARIMA model into the sum of stochastic and stationary components, i.e., general trend plus irregular

[6]In practice, most time series are nonstationary. The procedure used to convert a nonstationary series into a stationary series is successive differencing. The model is called an autoregressive integrated moving-average (ARIMA) model because the stationary ARMA (autoregressive moving average) model is fitted to the differenced data to be summed or integrated to provide a model for nonstationary data.

model. In this study, we applied B-N's methodology for carrying out the permanent and transitory decomposition of time series.

Here we briefly review B-N's procedure. The first step in the B-N procedure is understanding the nature of stochastic trends. To explain stochastic trends, let us consider the simple random walk plus drift model, which is written as:

$$y_t = y_{t-1} + a_o + \epsilon_t. \tag{31.1}$$

Since $E(\epsilon_t) = 0$, the average (the expectation) change in y_t is the deterministic constant a_o. It is clear to see that the nature of stochastic trends is in contrast to a deterministic trend. The stochastic trend increases on average by a fixed amount. The actual change is average change a_o plus stochastic quantity ϵ_t, which will differ over time. The solution[7] of the random walk plus drift model is:

$$y_t = y_o + a_o\,t + \sum_{i=1}^{t} \epsilon_i, \tag{31.2}$$

which has no irregular term. Hence, we say the random walk with drift model is a pure trend.

The second step in understanding the B-N procedure is to obtain the forecast function. Using the ARIMA (0,1,2) model as our example,

$$y_t = y_{t-1} + a_o + \epsilon_t + \beta_1\,\epsilon_{t-1} + \beta_2\,\epsilon_{t-2} = y_{t-1} + a_o + e_t \quad \therefore e_t = \epsilon_t + \beta_1\,\epsilon_{t-1} + \beta_2\,\epsilon_{t-2} \tag{31.3}$$

Given the initial realization for y_o, the general solution for y_t is:

---

[7] $y_t = y_{t-1} + a_o + \epsilon_t$, $y_{t-1} = y_{t-2} + a_o + \epsilon_{t-1}$ . . . . Substituting y_{t-1} into y_t we have $y_t = y_{t-2} + a_{o2} + \epsilon_t + \epsilon_{t-1}$. By substituting until period t, we have $y_t = y_{t-t} + a_o\,t + \epsilon_t + \epsilon_{t-1} + \epsilon_{t-2} + \ldots + \epsilon_{t-(t-1)} = y_o + a_o t + \sum_{i=1}^{t} \epsilon_i$.

$$y_t = y_o + a_o\,\mathrm{t} + \sum_{i=1}^{t} e_i. \tag{31.4}$$

At current time y_t, we forecast s period ahead. We get

$$y_{t+s} = a_o(t+s) + y_o + \sum_{i=1}^{t+s} e_i = a_o\, s + y_t + \sum_{i=1}^{s} e_{t+i}, \tag{31.5}$$

where y_t is a nonstationary series and they invoked Wold's (1938) theorem where its first differences S_t is stationary.

$$S_t = y_t - y_{t-1} = u + \lambda_o\, e_t + \lambda_1\, e_{t-1} + \lambda_2\, e_{t-2} + \lambda_3\, e_{t-3} + \ldots,\ \lambda_o = 1$$

$$= u + \lambda_o\, e_t + \lambda_1\, Le_t + \lambda_2\, L^2\, e_t + \lambda_3\, L^3\, e_3 + \ldots$$

$$= u + \lambda\,(L)\, e_t, \tag{31.6}$$

where u is the long-run mean of the S series, e_t are uncorrelated random innovations (disturbance), L is the lag operator, and $Ly_t = y_{t-1}$. A polynomial in the lag operator can be written as $\lambda(L) = 1 + \lambda_1\, L + \lambda_2\, L + \ldots$, where λi's are constants.

The statistical formulation of the B-N approach, which is called the "difference stationary" (DS)[8] model, supposes that $\Delta y_t = y_t - y_{t-1}$ is an MA (1) process. That is,

$$y_t - y_{t-1} = e_t + B(L)\, e_t,^{9} \tag{31.7}$$

with

$$A(L)\Delta\, y_t = f + B(L)\, e_t, \tag{31.8}$$

[8]Nelson and Plosser (1982) call the model $y_t = \alpha + \beta_t + \mu_t$ a trend-stationary process (TSP) that the disturbance is nonstationary and variance increases over time, and the model, $y_t - y_{t-1} = \beta + \varepsilon_t$ is a difference-stationary process (DSP), where ε_t is a stationary series with zero mean and variance σ^2. So the first difference of y_t is stationary with mean β.

[9]$y_t = y_{t-1} + e_t + Be_{t-1} = y_{t-2} + (e_{t-1} + Be_{t-2}) + (e_t + Be_{t-1}),\ \because\ y_{t-1} = y_{t-2} + e_{t-1} + Be_{t-2}$

$$= \sum_{i=1}^{\infty} e_i + B\sum_{i=1}^{t-1} e_i = (1+B)\left(\sum_{i=1}^{t} e_i\right) - Be_i.$$ Let $y_0 = e_0 = 0$.

where $A(L)$ and $B(L)$ are lag polynomials of order p and q, respectively, and f is a constant. Inverting $A(L)$, the equation (31.8) can be written in its infinite moving average form

$$\Delta y_t = f / A(L) + B(L) / A(L)\, e_t = M + N(L)\, e_t, \tag{31.9}$$

where $M = f / \sum_{i=0}^{\infty} A_i$ and $N(L) = B(L) / A(L)$. Then recursively substituting lagged Δy_t into equation (31.7) and assuming that $y_0 = 1$ and $e_i = 0$ for $i \leq 0$, we have a final expression from (31.7):

$$y_t = M_t + \mathrm{H} \sum_{i=1}^{t} e_i + D(L)\, e_t \tag{31.10}$$

where $H = \sum_{i=0}^{\infty} N_i$ and $D(L) = -\sum_{j=i+1}^{\infty} N_i$. Thus, equation (31.10) can be written as

$$y_t = y_t^P + y_t^s, \text{ where } y_t^P = M + y_{t-1}^P + He_t \text{ and } y_t^s = D(L)e_t. \tag{31.11}$$

Equation (31.11) provides the B-N decomposition for the general ARIMA (p, 1, q) process. Evidently, y_t^P is a random walk with drift M and y_t^s is stationary and M can be calculated as $\sum_{i=0}^{q} B_i / \sum_{i=0}^{p} A_i$. As in the ARIMA (0, 1, 1) case, the innovations in the trend and the cyclical components are both proportional to e_t, and are perfectly correlated.

In the practical implementation of the technique, we assume that equation (31.6) can be written in rational form:

$$S_t = \mu + \frac{(1 - \theta_1 L - \theta_2 L^2 - \ldots - \theta_q L^q) e_t}{(1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_p L^p)}. \tag{31.12}$$

Then the equation

$$S_t = \phi_1 S_{t-1} + \phi_2 S_{t-2} + \ldots + \phi_p S_{t-p} + \mu (1 - \phi_1 - \ldots - \phi_p) + e_t - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} \tag{31.13}$$

is estimated and yields the estimate parameters θ, ϕ, and μ and the innovations e_t. The above equation is referred to as an ARIMA process of order p and q.

Changing the permanent or trend component of y_t, denoted by $\hat{s}_t$, we have

$$\hat{s}_t - \hat{s}_{t-1} = u + (\sum_0^\infty \lambda_i)e_t, \quad \lambda_0 = 1. \tag{31.14}$$

The permanent component (P) as defined by B-N can be interpreted as the current observed value of y_t plus all forecastable future changes in the series beyond the mean rate of drift, that is,

$$\hat{y}_t = y_t + \lim_{k \to \infty} ([\hat{s}_{t1} + \hat{s}_{t2} + \ldots + \hat{s}_{tk}] - ku) \tag{31.15}$$

and for the transitory component denoted by T,

$$T_t = \lim_{k \to \infty} \{[\hat{S}_t(1) + \hat{S}_t(2) + \ldots + \hat{S}_t(k)] - k\mu\} = \left(\sum_1^\infty \lambda_i\right)\varepsilon_t + \left(\sum_2^\infty \lambda_i\right)\varepsilon_{t-1} + \ldots \tag{31.16}$$

The Cuddington-Winter's method started with the above rational form. Their key observation, which is based on the expression $\left(\sum_0^\infty \lambda_i\right)$ in equation (31.14), is merely the steady-state gain function for a transfer function of the form (31.6). The steady-state gain function, which is determined by setting L = 1, is the rational form (31.12) that equals to

$$\hat{S}_t - \hat{S}_{t-1} = \mu + \frac{(1 - \theta_1 - \theta_2 - \ldots - \theta_q)e_t}{(1 - \phi_1 - \phi_2 - \ldots - \phi_p)} \tag{31.17}$$

The above equation describes the permanent component of the time series as innovations e_t occur. As an illustration, the first step of the B-N technique is to take logarithms of the data, then the first differences to obtain a stationary series. Then the Box-Jenkins (1976)[10] technique is used to identify and estimate the model.

[10]The fundamental idea in the Box-Jenkins technique is the principle of parsimony. An additional coefficient will necessarily increase fit and R^2 but trade off the reducing degree of freedom. Box and Jenkins (1976) argue that parsimonious models produce better forecasts than overparameterized models.

B. Estimating Results of Permanent and Transitory Components

From the Box-Jenkins criterion, the autocorrelation function and partial autocorrelation of the first differences of fundamental variables were examined, such as TOT, GCGDP, (CAPCONTROLS), (EXCHCONTROLS). Variables such as TOT and GCGDP were taken in their natural logarithmic terms, but CAPCONTROLS and EXCHCONTROLS were not because they can assume missing observations.

Now it is advisable to check that the model really does give an adequate description of the data. There are some diagnostic checks available, such as the Box-Pierce Q statistic and the Lagrange multiplier (LM) test, for testing goodness-of-fit. Godfrey (Maddala 1992) studied the finite sample properties of the LM context of overfitting an AR (1) process by higher-order autoregressive models and found that the power of the LM test is higher than that of the Q and Q^* test. In the special case where m (i.e., the number of additional included variables) is large, the LM test and tests such as Q and Q^* may coincide.

The LM statistic is given by $LM = NR^2$, which has a $\chi^2_m \sim$ distribution, where R^2 is the coefficient of determination and N is the number of observations (Maddala 1992). In this study, we used time-series data to analyze the empirical phenomenon only, and that is why we used the Box-Pierce Q statistic as the tool for our diagnostic checking. In this study, quarter data were applied, and based on the number of observations, we picked up the forecasting period of the Q statistic around 4, 5, and 6. The detailed diagnostic checking results are shown in table 6.

TABLE 6

THE ESTIMATED PROCESS OF ARIMA

Variable	Estimated Process	Schwarz Criterion	Q, n
ΔlogRE	ARMA (1, 1)	-7.194585	Q (4) = 11.373
	ARMA (2, 1)	-7.229148	n = 51
	ARMA (0, 2)*	-7.230671	Prob = 0.615
logTOT	ARMA (1, 2)	-8.245351	Q (4) = 1.0524
	ARMA (2, 2)	-8.360245	n = 52
	ARMA (0, 1)*	-8.469831	Prob = 0.789
logGCGDP	ARMA (0, 1)	-5.944195	Q (7) = 8.1309
	ARMA (0, 5)*	-6.162308	n = 52
	ARMA (1, 2)	-6.131641	Prob = 0.017
EXCHCONTROLS	ARMA (0, 1)	0.280028	Q (3) = 0.3473
	ARMA (1, 1)*	0.134777	n = 51
	ARMA (1, 2)	0.194374	Prob = 0.556
ΔCAPCONTROLS	ARMA (0, 1)*	-7.529690	Q (4) = 0.3920
	ARMA (0, 2)	-7.456781	n = 51
	ARMA (1, 1)	-7.435188	Prob = 0.822
TECHPRO	ARMA (0, 1)	-7.043984	Q (7) = 3.647
	ARMA (1, 1)	-6.950744	n = 50
	AR(2) AR(4) MA (2) MA(4)*	-7.249550	prob = 0.302
ΔlogINV	ARMA (1, 3)	-4.126706	Q (4) = 1.7167
	ARMA (1, 2)	-4.188076	n = 52
	AR(1) AR(4) MA(1) MA(4)*	-3.961422	Prob = 0.633

*Indicates the specific model yields the most significant value of Schwarz criterion.

The autocorrelation function and the partial autocorrelation of the first difference of fundamental variables were examined. They were identified and estimated as ARIMA processes. It should be noted that the specified ARIMA does not represent a unique specification but picks up the one that reveals the most significant value from the Schwarz criterion. The permanent components of variables are denoted as "P." Some variables are not taking the first differences because they are already stationary at their level.

The results of the estimated model for each variables are summarized below:

$$\Delta \text{logRE}\,(P)_t = -0.007407 + e_t + 0.367284\, e_{t-1} + 0.257984\, e_{t-2}, \quad \text{S.E.} = 0.025 \qquad (31.18)$$

$$\text{logTOT}(P)_t = 4.605034 + e_t - 0.589619\, e_{t-1}, \quad \text{S.E.} = 0.014 \qquad (31.19)$$

$$\text{logGCGDP}(P)_t = -1.845236 + e_t + 0.56182\, e_{t-1} + 0.366329\, e_{t-2} + 0.3362\, e_{t-3} + 0.894265\, e_{t-4} + 0.532215\, e_{t-5}; \quad \text{S.E.} = 0.033 \qquad (31.20)$$

$$\text{EXCHCONTROLS}(P)_t = 0.801771 + 0.688828\,\text{EXCHCONTROLS}(P)_{t-1} + e_t - 0.230627\, e_{t-1}, \quad \text{S.E.} = 1.087 \qquad (31.21)$$

$$\Delta \text{CAPCONTROLS}(P)_t = -0.001008 + e_t - 0.381433\, e_{t-1}, \quad \text{S.E.} = 0.022 \qquad (31.22)$$

$$\text{TECHPRO}(P)_t = 0.006817 - 0.162355\text{TECHPRO}_{t-2} + 0.910776\text{TECHPRO}_{t-4} + e_t - 0.015112\, e_{t-2} - 0.94559\, e_{t-4}, \quad \text{S.E.} = 0.017 \qquad (31.23)$$

$$\Delta \text{logINV}(P)_t = 0.007798 - 0.118049\,\text{logINV}_{t-1} + 0.8376\,\text{logINV}_{t-4} + e_t - 0.408192\, e_{t-1} - 0.564319\, e_{t-4}, \quad \text{S.E.} = 0.099 \qquad (31.24)$$

Table 6 contains the specified models and the results obtained from the estimation of equation (31.16) that distinguish between permanent (P) and transitory (T) shocks to fundamentals. The long-run increase in fundamental variables predicted from a 1 percent unforeseen increase in fundamental variables in one quarter is shown in table 7.

TABLE 7

LONG-RUN COMPONENT IN THE RER

Variables	Estimated Process	Long-Run Increase in *e*, Fundamentals Predicted from a 1% Unforeseen Increase in *e*, and Fundamentals in One Quarter, i.e., Permanent Components
ΔlogRE	ARMA (0, 2)	1.625268
logTOT	ARMA (0, 1)	-0.410381
logGCGDP	ARMA (0, 5)	3.690829
EXCHCONTROLS	ARMA (1, 1)	1.116931
ΔCAPCONTROLS	ARMA (0, 1)	0.618567
TECHPRO	AR(2) AR(4) MA(2) MA(4)	0.052508
ΔlogINV	AR(1) AR(4) MA(1) MA(4)	0.382030

If the fundamental variable has a pure stochastic trend without any transitory component, then a 1 percent increase in the variable will increase the long-run forecast value of this variable by exactly 1 percent. On the other hand, if the fundamental variable has a pure transitory component without any permanent components, then a 1 percent increase in the variable will increase the long-run forecast value of this variable by exactly 0 percent.

The meaning of the negative sign of the logTOT variable is that a positive shock gives permanent level three above the variables a negative response. Maybe this could be evidence that the interruption of government authorization is never good. The transitory components of each variable denoted as "T" are computed by equations (31.18) to (31.24), which are the difference between the observed realization and its permanent components. Figure 6 shows the transitory component of logRE, i.e., logRE (T). Figure 7 shows the

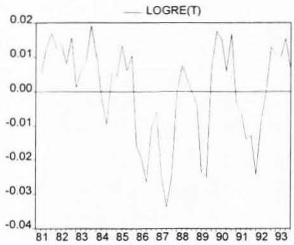

FIG. 6.—The transitory component of LogRE

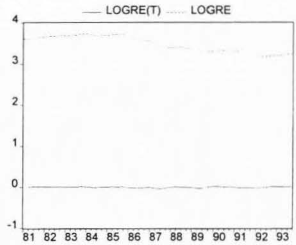

FIG. 7.—The comparison of LogRE and LogRE (T)

difference between the transitory component of logRE and logRE (T). Figure 8 shows the permanent components of logRE, i.e., logRE (P). Figure 9 shows the difference between the permanent components of logRE and logRE (P). We use the line expression to show the extent of goodness-of-fit for the specified ARIMA model to the actual observation of logRE in figure 10.

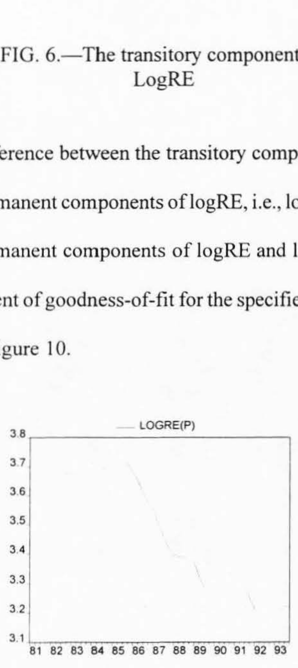

FIG. 8.—The permanent component of LogRE

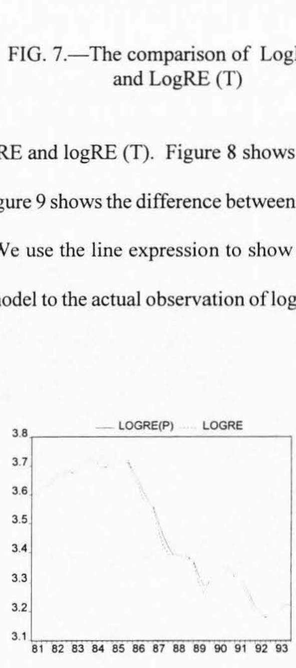

FIG. 9.—The comparison of LogRE LogRE (P)

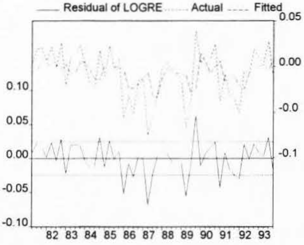

FIG. 10.—The goodness-of-fit of specified ARIMA model of logRE to actual observed data

Using the same computation method, we can decompose the fundamental variables into permanent and transitory components. The transitory components of logTOT(T) are shown in figure 11. Figure 12 represents the difference between transitory components of logTOT and logTOT(T). The permanent components of logTOT(P) are shown in figure 13. Figure 14 represents the difference between permenant components of logTOT and

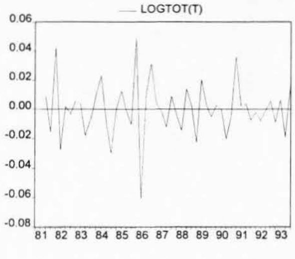

FIG. 11.—The transitory component of LogTOT

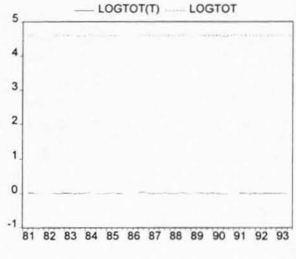

FIG. 12.—The comparison of LogTOT and LogTOT (T)

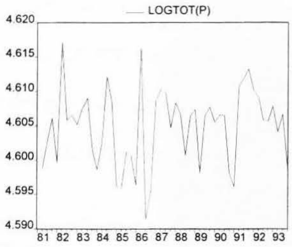

FIG. 13.—The permanent component of LogTOT

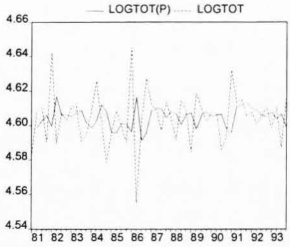

FIG. 14.—The comparison of LogTOT and LogTOT (P)

logTOT(P). We use the line expression to show the extent of goodness-of-fit for the specified ARIMA model to the actual observation of logTPT in figure 15. The estimated permanent and transitory components of the resting variables are shown in appendix E.

To obtain the forecasts of the above variables' levels rather than their changes, one has to have a level at some time *t* (i.e., an initial condition), then integrate the first-difference

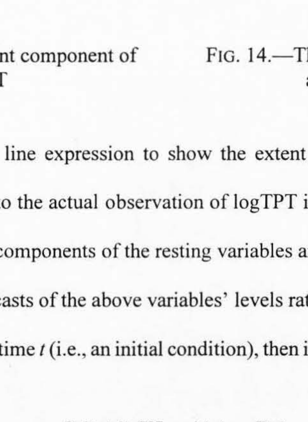

FIG. 15.—The goodness-of-fit of specified ARIMA model of logTOT to actual observed data

series.[11] This can be accomplished using equation (31.15). For example, $TOT(P_t)$ is given by the value of TOT_t plus all forecastable future changes in the series beyond the mean rate of growth at any chosen time t. We found that TOT(P) = exp $\{TOT(P_t)\}$, and the transitory component TOT(T) is the difference of real TOT and TOT(P).

III. The Implication of Decomposition Technique to Elbadawi's Approach

When we talk about the permanent component of an economic time series, we refer to the long-run trend component of it. If the trend is deterministic, the data-generating process is called a trend stationary process. In that case, the estimation of the permanent component is simple. Using the standard regression technique, the deterministic trend is estimated and the stationary part (that is, the cyclical part) is obtained after subtracting the deterministic part from the observed value. But estimation of the permanent or the trend component becomes more difficult when there exist variable trends in the time-series data. This variable trend is also called the stochastic trend, and in recent years the idea of stochastic trend has emerged and enriched the framework of analysis to investigate economic time series. Within this framework we estimate the permanent components of the fundamentals like the terms of trade, the ratio of government consumption to GDP, the exchange control proxy, and the capital flows. We use the B-N decomposition technique, which estimates ARIMA models for this purpose.

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[11] In the case of the decomposition of the CAPCONTROLS variable, which is ARIMA(1,1,1): $\Delta CAPCONTROLS = CAPCONTROLS_t - CAPCONTROLS_{t-1} = \alpha_0 + [\alpha_1(CAPCONTROLS_{t-1} - CAPCONTROLS_{t-2}) + e_t + \beta_1 e_{t-1}] + u_t$, the value of α_0, α_1, and β_1 are already known from the estimated regression (31.15). The value of u_t is assumed to be zero. Therefore, we can obtain the forecasted value of $CAPCONTROLS_t$.

A. Stochastic Trend as a Logical Implication of an Economic Theory

Here we briefly consider whether the stochastic trend can be derived from an economic theory. Let us look at the definition of the ERER (Edwards 1989, p. 16):

> The equilibrium real exchange rate (ERER) is defined as the relative price of tradables to nontradables which, for given sustainable values of other relevant variables such as taxes, international terms of trade, commercial policy, capital and aid flows and technology, results in the simultaneous attainment of internal and external equilibrium.

The sustainable values mentioned above are nothing but the long-run trend components of the relevant economic time series. This long-run trend is the stochastic trend.

B. Long-Run Relationship: Cointegration Approach

We estimated the ERER in terms of the sustainable or permanent components of the relevant explanatory variables. The ERER itself is nonstationary, as are the fundamentals. All these variables, that is, the fundamentals and ERER, have stochastic trends. The concept of stochastic trends has resulted in the development of investigating long-run economic relationships. This is the theory of cointegration. The cointegrating combination provides long-run (equilibrium) relationships among economic variables. This long-run equilibrium relationship is based on economic theory, which suggests explanatory variables for inclusion in the equation (fundamentals in the ERER equation). However, long-run equilibrium relationships among economic variables may not be exactly true in the short run. So a model is developed to incorporate the disequilibrium, i.e., the extent to which the long-run equilibrium is not met. This term is called an error correction term, since it measures the deviation from the long-run equilibrium. This model, known as the error correction model

(ECM), provides the dynamics of the model that estimates the long-run relationship with the short-run dynamics.

In the Elbadawi methodology, if the cointegration relationship in the reduced form specification is valid, then that equation not only can be interpreted as a long-run equilibrium but is also consistent with a dynamic error correction specification (Engle and Granger 1987). The specification is developed in two stages. First, a traditional econometrics equation is specified, with a generous lag structure on all the explanatory variables, including lagged values of the dependent variable. Second, this equation is manipulated to reformulate it in terms that are more easily interpreted, producing a term representing the extent to which the long-run equilibrium is not met. This last term, one of the unique features of this approach, is called an error-correction term, since it reflects the current error in achieving long-run equilibrium. This type of model has consequently come to be known as an ECM.

Generally, a simultaneous equation model is presented in a static way with the assumption that markets get cleared. Their dynamic specifications were not flexible enough to allow them to adequately represent an economy that is more frequently out of equilibrium than it is in equilibrium. This lack of attention to the dynamic aspect was a natural outcome of the fact that economic theory has some ability to identify long-run relationships between economic variables. In light of this, it seems reasonable to structure econometrics models to incorporate information from economic theory about long-run equilibrium forces and, at the same time, to allow for a very flexible lag structure, permitting the data to play a strong role in the specification of the model's dynamic structure. One of the unique features of this approach is an error correction term that reflects the current error in achieving long-run equilibrium. This type of model has consequently come to be known as ECM. We adopt the ECM to jointly estimate the short-run behavior and its long-run value and find the speed at which individual variables attain the equilibrium. The main idea of this implication comes from the theory. Theory tells us that the permanent components of fundamentals are nothing more than sustainable values. Edwards (1989) was trying to use 5-quarter moving averages to estimate the sustainable value of fundamental variables, and Elbadawi (1994) used the moving average technique based on the median period needed to eliminate the exogenous shock. No matter how they did it, they are trying to get the best quasi-estimation of sustainable value. According to the importance of the ERER policy implication, we need to be careful in estimating the equilibrium exchange rate that is unobservable. The permanent (or sustainable) components of the fundamentals are obtained by using the time series decomposition technique. The ERER is the value of RER that satisfies for sustainable (or permanent) values of the fundamentals. It is obvious that there exists the cointegration relationship between permanent components of fundamentals and ERER.

C. Theoretical Framework

Using the same reduced form equation from the basic model, the ERER is the value of the RER that satisfies sustainable values of the right-hand-side variables.

$$\log(e_t) = a_1 \log(\mathrm{TOT})_t + a_2 \log(\mathrm{GCGDP})_t + a_3 \log(\mathrm{CAPCONTROLS})_t$$
$$+ a_4 \log(\mathrm{EXCHCONTROLS})_t + a_5 \log(\mathrm{TECHPRO})_t + a_6 \log(\mathrm{INVGDP})_t \qquad (32)$$

By defining the parameter vector $\delta_t = (a_0, a_1, a_2, a_3, a_4, a_5, a_6)$ and the vector of fundamentals (F):

$$F = [\log(\mathrm{TOT}), \log(\mathrm{GCGDP}), \log(\mathrm{CAPCONTROLS}),$$

$$\log(\mathrm{EXCHCONTROLS}), \log(\mathrm{TECHPRO}), \log(\mathrm{INV})] \tag{33}$$

we get the following expression of ERER ($\hat{e}_t$*) for a given permanent portion of the fundamentals vector $F(P_t)$. The difference between Elbadawi's (1994) approach and this essay is that Elbadawi used the moving average technique to estimate the sustainable values of the fundamentals, but we used the decomposition technique to decompose the fundamentals into permanent (P_t) and transitory (T_t) components and to replace the $\hat{F}_t$ by $F(P_t)$. Since the permanent components of fundamentals are invariable and proportional to the original data, they are different from the transitory components that are expected to vanish as the series moves to its permanent level. A practical approach to introducing the concept of "sustainability" on the part of fundamentals is still needed. We employ this idea into Elbadawi's approach, which is based on a strong theoretical support, and expect to yield a more appropriate estimation of ERER.

$$\log(\hat{e}_t{*}) = \sum_{i=0}^{\infty} a_i' \hat{F}_t. \tag{34}$$

It can be shown that if the set of fundamental variables is stationary in the first difference, i.e., I(1), then the following cointegration relationship exists (Kaminsky 1987):

$$\log(\hat{e}_t{*}) = \delta_i' a_i F_i(p_t) + \eta_t \tag{35}$$

where $\delta_i' a_i F_i(p_t)$ is the cointegration vector and η_t is the stationary disturbance term.

If the cointegration relationship in equation (35) is valid, then that equation not only can be interpreted as a long-run equilibrium but is also consistent with a dynamic error correction specification. The error correction equation consistent with the cointegration equation is:

$$\Delta \log e_t = b_0\{\delta_i' a_i F_i - \log e_t\} + b_1 \Delta \log F_t + b_2 \Delta(\text{NOMDEV}) + b_3 \Delta(\text{DCRE}) + \epsilon_t \qquad (36)$$

The error correction term $\{\delta_i' a_i F_i - \log e_t\}$ in equation (36) clearly incorporates the RER dynamics.

For the purpose of encountering the dynamic behavior, the interpretation of the cointegration equation (35), as described in the long-run RER equilibrium, has to be justified. The error correction in equation (36), in order to be considered for the short-run dynamics of the observed RER, must have the individual variables that enter into the equation in order to be cointegrated.

By using the Dickey-Fuller statistic test for the unit root, it shows that part of the fundamentals are nonstationary; therefore, the regression results and the *t, f* statistics are unreliable. If and only if there exists a cointegration relationship in equation (35), then the regression results are reliable and the *t, f* statistics are valid. Hence, a test for cointegration is used in this essay. Testing the estimated residual obtained from the cointegration equation is done using the ADF test. The ADF test statistic -2.380109 is significant at the 5 percent critical value -3.5682. We conclude that the trend in one variable can be expressed as a linear combination of the trends in the other variable(s), that is, the dependent and independent variables are cointegrated. The individual estimating results are shown in table 3.

D. The Long-Run Equilibrium

The TOT variable was positive and significant, contrary to theoretical analysis. The ratio of government consumption to GDP is positive but not significant for the case of Taiwan. An exogenous inflow of capital appreciates the ERER. We have a positive sign of the coefficient CAPCONTROLS contrary to theoretical expectations. The index proxying exchange and trade controls are negative and significant where there is an indication that a relaxation of the extent of impediments to international trade resulted in ERER depreciation. The coefficient for TECHPRO is positive and statistically insignificant. Empirically we get the contrary results. The way in which INVGDP affects the ERER depends on the allocation of investment expenditures between tradables and nontradables. We obtained a negative sign for INVGDP that was statistically significant. This shows that Taiwan's investment tends to use more nontradable goods and results in a lower RER. That is, the RER appreciates.

E. The Short-Run Error Correction Estimation

The error correction estimation gives the short-run specification of the RER determination. Table 8 presents the ECM where the coefficients of the error correction term $\delta_t' a_t F_t$ - loge_t are positive, less than one, and significant.

Short-run effects are due to expansive macroeconomic policy and nominal exchange rate overvaluation. The effects, due to nominal devaluation, are statistically significant. The result validates the view that when starting from an initial condition of real undervaluation, with other things held constant, a nominal devaluation could accelerate the process of convergence toward the RER equilibrium, to the extent that domestic credit is positive. This indicates that the increasing rate of growth of domestic credit results in the RER devaluation. This result is contrary to theoretical expectation but consistent with Edwards's (1989) findings.

TABLE 8

ESTIMATION OF SHORT-RUN EQUILIBRIUM MODELS

Variables	Coefficient	t-Value
$\log\tilde{RER}(-1)$ - $\log RER(-1)$	0.140029*	2.085679
ΔlogTOT	-0.162484	-1.001054
ΔlogGCGDP	0.060708	0.635387
ΔCAPCONTROLS	0.242834	1.384969
ΔEXCHCONTROLS	-0.004878	-1.285297
ΔTECHPRO	0.031528	0.232172
ΔlogINV	0.010168	0.331096
ΔDCRE	0.155513	1.151747
ΔNOMDEV	0.420726	2.065531

R^2 is 0.20966; adjusted R^2 is 0.0.055447; D-W statistic is 0.813285.
*Significant at 10% level.

The elasticity is estimated at 0.14 for Taiwan (see table 9). As already mentioned, this coefficient reflects the dynamic self-correcting mechanism of the ECM. If the fundamentals in the previous period call for a lower RER than that observed [i.e., $\delta_i' a_i F_i$ - $loge_t$ <0], then since the coefficient is negative, the RER will appreciate in the following period.

In the short run, the RER is also influenced by the transitory movements of the fundamentals (terms of trade, capital inflows, government consumption, exchange controls, technological progress, and investment ratio). Both the terms of trade and exchange control have expected signs but are only marginally statistically significant. In the case of exchange control, it shows that the short-run effect is consistent with the corresponding long-run

TABLE 9

SPEED OF AUTOMATIC ADJUSTMENT TO A PERMANENT EXOGENOUS SHOCK

Country	Permanent Shock	Coefficient of the Error Correction Term[b] i.e., Transitory Shock	Quarters to Eliminate Effects of Exogenous Shock[c]	
			50%	99.9%
Taiwan	0.86[a]	$\|0.14\|$	4.265	42.5

[a]The permanent shock is derived by 1- $|0.14| = 0.86$.

[b]It is the coefficient of $\log\tilde{RER}(-1) - \log RER(-1)$ in the error correction regression of table 9.

[c]The number of years to clear 100 percent of an exogenous shock through automatic adjustment alone can be computed from the formula $(1-\lambda) = (1-\gamma)^T$, where γ is the estimated coefficient of the error correction term and T is the required number of years.

influence, indicating that more openness (a relaxation of the extent of impediments to international trade) leads to real depreciation. In the case of terms of trade, the negative influence of short-run effect is consistent with our expectation but only statistically insignificant, and the positive long-run effect, which is contrary to theoretical expectation, is statistically significant. This indicates that the long-run effect dominates the short-run effect. The improvement of terms of trade will reduce the international competitiveness; moreover, it will decrease the export volume, resulting in the RER depreciation. The short-run influence of government consumption is insignificant at the conventional level and positive, indicating that government consumption leans towards nontradable goods. This result is contrary to Edwards's (1989) findings. But in the case of government consumption, the long-run effect is contrary to the short-run effect, and the long-run positive effect is dominated by the short-run negative effect, since the former is more significant. This is an indication that government consumption tends towards tradable goods.

Both CAPCONTROLS and TECHPRO, the short-run and long-run effects, are consistent. But the sign of CAPCONTROLS is contrary to theoretical expectation. They are either in the Edwards or the Elbadawi model—all show the wrong sign. The reason for the CAPCONTROLS variable is because the tradable and nontradable goods have different income elasticity. Tradable goods are more superior than domestic goods in most countries. This results in a depreciation in RER. The negative sign of EXCHCONTROLS is consistent with theoretical expectations. The increasing severity of exchange control results in RER devaluation. The reason for a positive sign for TECHPRO is that the supply effects of technological progress more than offset the demand effects, generating an equilibrium real depreciation. For the ratio of investment of the GDP variable, the short-run effect is positive when insignificant and the long-run effect is negative when significant. The short-run effect shows that the investment tends towards tradable goods and the long-run effect shows that the investment tends towards nontradable goods.

F. The Estimated ERER

We compute the indexes for the ERER using the coefficients derived from the long-run estimates of table 8. The estimated ERER is computed by the following equation:

$$\begin{aligned}\log(e_t^*) = &- 0.010047(TREND) + 0.644094log(TOT)_p + 0.268213log(GCGDP)_p \\ &+ 0.533161(CAPCONTROLS)_p - 0.013882(EXCHCONTROLS)_p \\ &+ 1.293792(TECHPRO)_p - 0.273435log(INVGDP)_p \qquad (37)\end{aligned}$$

where the subscript "p" is the permanent components of fundamental variables. The derived

ERER series are shown in appendix C. Figure 16 shows the movements between the actual and equilibrium RERs. Figure 17 shows the corresponding RER misalignment, which is computed as [(RER - ERER)/ERER]*100 percent.

The derived indexes from the Elbadawi (1994) approach agree with those of Edwards (1989) in that the ERER shows some variability. It follows that at least part of the observed RER variability is related to the equilibrium behavior, and that an analysis of RER misalignment, based on historical comparisons of an observed RER level, may lead to an erroneous conclusion.

IV. The Implication of a Decomposition Technique to Edwards's Approach

A. The Reduced Form of Edwards's Model

The RER (e) is defined as the ratio of the domestic price of tradable goods (P_T) to the domestic price of nontradable goods (P_N): $e = P_T / P_N$.

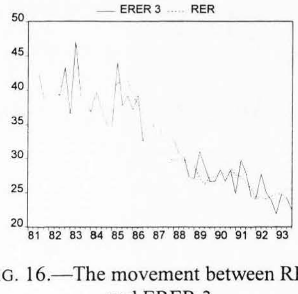

FIG. 16.—The movement between RER and ERER 3

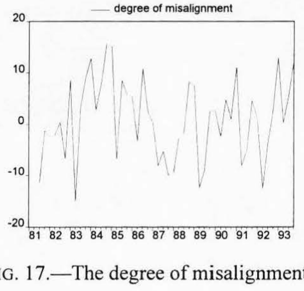

FIG. 17.—The degree of misalignment 3

A more traditional and popular definition of the RER is based on the PPP approach.

$$e_{PPP} = E\frac{P^*}{P}, \tag{38}$$

where e_{PPP} denotes the empirical measure of the RER, E is the bilateral nominal exchange rate expressed as the price of one unit of the foreign currency in terms of the domestic currency, and P and P^* refer to the domestic price index and the foreign price index, respectively.

According to the relative PPP theory, the exchange in the nominal exchange rate between two currencies over any time period is determined by the change in the two countries' relative price level. This is written in the following manner:

$$\tilde{E} = \tilde{p} - \tilde{p}*,^{12} \tag{39}$$

where the tilde is the percentage change of the variable. According to equations (38) and (39), $\tilde{e}_{ppp} = 0$ is in equilibrium.

The implication is that the RER does not change if the equilibrium condition holds. But, in reality, it is impossible that the equilibrium conditions hold in any time period. So the Edwards model is used as the framework.

The ERER equation, in its reduced form, is written in the following manner:

$$\log(e_t^*) = \beta_o + \beta_1 \log(\mathrm{TOT})t + \beta_2 \log(\mathrm{GCGDP})_t$$
$$+ \beta_3 \log(\mathrm{CAPCONTROLS})_t + \beta_4 \log(\mathrm{EXCHCONTROLS})_t$$
$$+ \beta_5 \log(\mathrm{TECHPRO})_t + \beta_6 \log(\mathrm{INVGDP})_t + U_t, \tag{40}$$

The meanings of notations are given below:

---

[12]Equation (39) is based on the law of one price, which states that prices are equalized through trade, i.e., $P = E.P^*$. Assuming that causality goes from p and P^* to E, we can write $E = P/P^*$ where E is the endogenous variable.

e^*: ERER,

TOT: external terms of trade, defined as the ratio of price of exports over the price of imports, i.e., (P_x/P_m).

GCGDP: government consumption of nontradables,

CAPCONTROLS: measure of the extent of controls over capital flows,

EXCHCONTROLS: index of the severity of trade restrictions and exchange control,

TECHPRO: measure of technological progress,

INVGDP: the ratio of investment of GDP,

u: error term.

B. Partial Adjustment Analysis

Since $\log e_t^*$ is the ERER and $\log e_t$ is the actual RER, $\log e_t^* - \log e_t$ is the difference between the final change and the actual change. The partial adjustment analysis says that the actual change, $\log e_t - \log e_{t-1}$, is only a fraction of the desired change, that is, $\log e_t - \log e_{t-1} = \theta (\log e_t^* - \log e_{t-1})$, where $0 < \theta < 1$. Since macroeconomic policies and changes in the nominal exchange rate by the monetary authority affect the actual change, Edwards (1989) incorporated these factors and used the following equation for the dynamics of RER behavior:

$$\log e_t - \log e_{t-1} = \theta\, [\log(e_t^*) - \log(e_{t-1})] - \lambda(Z_t - Z_t^*) + \phi[\log(E_t) - \log(E_{t-1})] \qquad (41)$$

where Z is a macroeconomic policy index, Z^* is the sustainable level of Z, and E is the nominal exchange rate. To derive the coefficients necessary to estimate the ERER, we substitute equations (40) and (41) and solve for $\log(e_t)$ and have the following equation:

$$\log(e_t) = \gamma_1 \log(\text{TOT})_t + \gamma_2 \log(\text{GCGDP})_t + \gamma_3 \log(\text{CAPCONTROLS})_t$$
$$+ \gamma_4 \log(\text{EXCHCONTROLS})_t + \gamma_5 \log(\text{TECHPRO})_t + \gamma_6 \log(\text{INVGDP})_t$$
$$+ (1\text{-}\theta) \log(e_t\text{-}1) + \lambda_1(\text{DCRE})_t + \lambda_2 (\text{DEH})_t - \phi(\text{NOMDEV})_t + \mu_t, \qquad (42)$$

where DCRE is the rate of growth of domestic credit and DEH is the ratio of fiscal deficit to lagged high power money. NOMDEV is the nominal devaluation as a proxy for $[\log(E_t)\text{-}\log(E_t\text{-}1)]$ in equation (41) and the γ's are the combination of the β's and θ.

C. The Short- and Long-Run Impacts to the RER

The analysis presented above did not distinguish between permanent and temporary changes in fundamentals. In order to investigate whether this distinction was empirically important, we decomposed each single fundamental variable into permanent and transitory components by using the B-N methodology and regressed the equation as shown below:

$$log(e_t) = \text{logTOT}(P_t) + \text{logTOT}(T_t) + \text{logGCGDP}(P_t) + \text{logGCGDP}(T_t) +$$
$$\text{CAPCONTROLS}(P_t) + \text{CAPCONTROLS}(T_t) + \text{EXCHCONTROLS}(P_t) +$$
$$\text{EXCHCONTROLS}(T_t) + \text{TECHPRO}(P_t) + \text{TECHPRO}(T_t) + \text{logINV}(P_t) +$$
$$\text{logINV}(T_t) \qquad (43)$$

The estimated results are shown in table 10, which contains two alternative equations that distinguish between permanent (P) and transitory (T) shocks for fundamentals.

These results are quite interesting. First, they show that for the TOT and GCGDP variables, the distinction between permanent and transitory was important. For both of these variables, the changes in the permanent and transitory are significant and they also have expected signs. Except for the lagged ratio of net capital flow to GDP (CAPCONTROLS),

TABLE 10

TEMPORARY AND PERMANENT SHOCKS TO FUNDAMENTALS AND RER DYNAMICS
Dependent variable: logRE

Variables	Coefficient	t-Value
logTOT(P)	-0.055200*	-2.226814
logTOT(T)	-0.263652*	-2.334296
logGCGDP(P)	-0.097729*	-1.859761
logGCGDP(T)	-0.163848*	-2.612208
CAPCONTROLS(P)	0.040878	0.549144
CAPCONTROLS(T)	0.278191	1.470549
EXCHCONTROLS(P)	-0.001334	-0.607707
EXCHCONTROLS(T)	-0.002325	-0.447868
TECHPRO(P)	-0.035360	-0.289124
TECHPRO(T)	-0.158374	-0.909048
logINV(P)	0.004130	0.181079
logINV(T)	0.027238	1.227504
logRE(-1)	1.024953*	44.67646
DCRE	0.193599*	2.143153
DEH	-0.004577	-0.103829
NOMDEV	0.996276*	9.534762

R^2 is 0.997; D-W statistic is 1.76.
*Significant at 5% level.

exchange and trade controls (EXCHCONTROLS), technological progress (TECHPRO), and ratio of investment of GDP (INVGDP), the distinction between permanent and transitory does not appear to be empirically important. But all of them have the expected signs. The coefficient of macroeconomic variables has ambiguous results. The sign of DEH is consistent with theoretical expectations but the sign of DCRE is contrary to our expectations. An important characteristic of the results in table 6 is that the coefficient of the lagged dependent variable is greater than one. This finding is consistent with the results of Edwards

(1989). The high value of the coefficient (1.025) implies a low value of adjustment coefficient θ(-0.025) because θ = 1-1.025. A low value of θ means that the actual RER converges very slowly towards its long-run equilibrium level. The devaluation variable NOMDEV was positive and significant, which is consistent with the theoretical expectations and also very close to the results from Edwards's methodology.

In summary, the results reported in table 6 indicate that, at least for some of the fundamentals—TOT and GCGDP—the distinction between permanent and transitory is an important one.

D. Alternative to Moving Average Technique with Decomposition Methodology

The difference between the Edwards (1989) approach and our methodology is that Edwards applies the moving average technique to construct a time series for the "sustainable" values of the ERER fundamentals, and our methodology uses permanent components of fundamentals to be the sustainable values of fundamentals. According to the definition of ERER and theoretical consideration, permanent components of fundamentals are nothing more than sustainable values. The calculated ERER is computed by using the following equation:

$$log(e_t^*) = \frac{\gamma_1}{\theta} F_1(p_t) + \frac{\gamma_2}{\theta} F_2(p_t) + \frac{\gamma_3}{\theta} F_3(p_t) + \frac{\gamma_4}{\theta} F_4(p_t) + \frac{\gamma_5}{\theta} F_5(p_t) + \frac{\gamma_6}{\theta} F_6(p_t) \tag{44}$$

where $log(e_t^*)$ is the calculated ERER; $F_i(p_t)$'s are the permanent components of fundamental variables.

E. The Estimated ERERs

The estimated ERER is then computed by the following equation:

$$\log(e_t^*) = 1.544953678 \log(\mathrm{TOT})_p + 3.110822572 \log(\mathrm{GCGDP})_p - 0.556464065 \log(\mathrm{CAPCONTROLS})_p + 0.009194272 \log(\mathrm{EXCHCONTROLS})_p - 0.171813587 \log(\mathrm{TECHPRO})_p - 0.514458169 \log(\mathrm{INVGDP})_p, \quad (45)$$

where the subscript "*p*" is the permanent components of the fundamental variables.

The movements between the observed RER and the ERER are shown in figure 18, where ERER is the calculated ERER and RER is the actual RER. The degree of misalignment is shown in figure 19. The ERERs are reported in appendix D.

F. The Comparison of Two Models and Two Techniques

In order to investigate which model performs better, we take the difference between the estimated ERER and the black market rate to show the extent of deviation. The less the

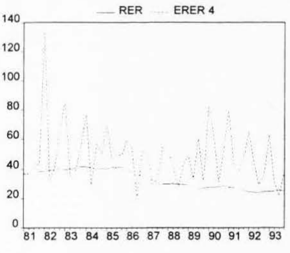

FIG. 18.—The movement between RER and ERER 4

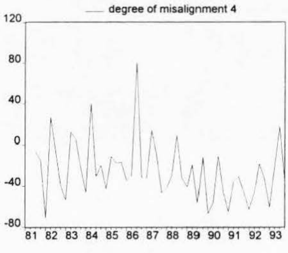

FIG. 19.—The degree of misalignment 4

amount of deviation, the better the model. The idea of using the black market rate as a proxy for the ERER behavior is that the black market rate usually reflects the market forces without government intervention. Figure 20 shows the difference between the black market rate and the estimated ERER from the cointegration approach, and figure 21 indicates the degree of misalignment[13] between them.

Here, we use descriptive statistics to show which approach can perform better in Taiwan's case. The mean absolute error (MAE) between the estimated ERER and Taiwan's black market rate is 18.3272 and 2.415024 for the Edwards and Elbadawi approaches, respectively. The mean absolute percentage error (MAPE) is 57.58651 and 7.127871 for the Edwards and Elbadawi approaches. From the above results, we can say that, in Taiwan's case, the Elbadawi approach can mimic the unobserved ERER better than the Edwards approach because it yields a smaller value.

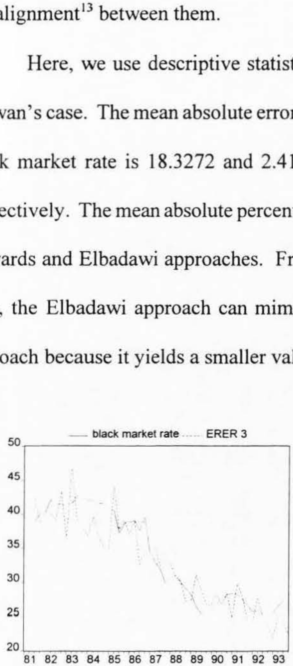

FIG. 20.—The movement between ERER 3 and black market rate

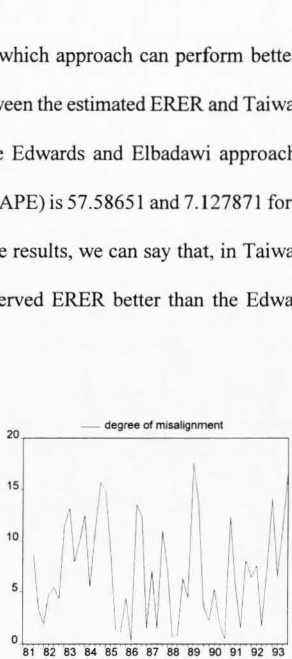

FIG. 21.—The degree of misalignment between ERER 3 and black market rate

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[13]We define the degree of misalignment as $\left[\left(\dfrac{ERER\ -\ black\ market\ rate}{black\ market\ rate}\right) \bullet 100\ percent\right]$.

Figure 22 shows the movement between the black market rate and the estimated ERER in the partial adjustment approach. The degree of misalignment is shown in figure 23. Table 11 reports the descriptive statistics of different approaches and techniques.

The moving-average technique yields smaller values for MAE and MAPE in both the partial adjustment approach and the cointegration approach. This result indicates that the

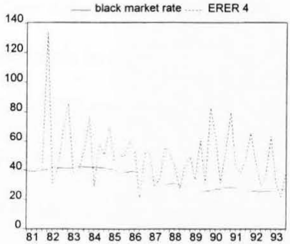

FIG. 22.—The movement between ERER 4 and black market rate

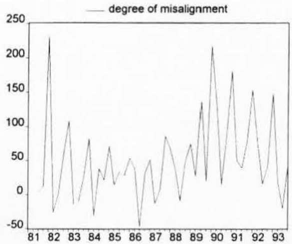

FIG. 23.—The degree of misalignment between ERER 4 and black market rate

TABLE 11

THE SUMMARY OF DESCRIPTIVE STATISTICS ON TWO APPROACHES AND TWO TECHNIQUES

	Edwards's Approach		Elbadawi's Approach	
	MAE	MAPE	MAE	MAPE
Moving average	11.6168	38.73388	1.7418	5.0657
Decomposition	18.3272	57.5865	2.4150	7.1279

moving-average approach is better than the decomposition approach in capturing Taiwan's exchange rate behavior, insofar as the MAE and MAPE are relevant.

V. Conclusions

The first part of this study applied a statistical technique devised by B-N to decompose exchange rate movements into permanent and transitory components. This technique suggests that roughly 86 percent of the average shock to the Taiwan exchange market should be viewed as permanent, while the remaining 14 percent is transitory and dies out within 42.5 quarters (table 9). The coefficient-of-error correction term is so-called "the speed of automatic adjustment to an exogenous shock," and this term captures the short-run dynamic effects. The adjustment coefficient is 0.14 over a period of one quarter, and this result is close to Elbadawi's (1994) annual estimates, which are 0.78 for Chile, 0.71 for Ghana, and 0.67 for India.

We use the B-N decomposition technique to determine the permanent part of the fundamental variables in order to investigate the impact of permanent or sustained components on the ERER. The results reported in table 10 indicate that for at least some of the fundamental variables—TOT and GCGDP—the distinction between the permanent and transitory components is important. We also investigated the effects of temporary and permanent shocks to fundamentals on RER dynamics. Some of the variables (TOT and GCGDP) showed that the distinction between permanent and transitory was important. Both of these variables have a strong impact on the RER from both short-run and long-run shocks. The lagged ratio of net capital flow to GDP, the exchange and trade controls, the technological progress, and the ratio of investment do not have a significant impact on RER, even though they have the expected sign.

We also use descriptive statistics to show which approach can perform better in Taiwan's case. The MAE between the estimated ERER and Taiwan's black market rate is 18.3272 and 2.415024 for the Edwards and Elbadawi approaches, respectively. The MAPE is 57.58651 and 7.127871 for the Edwards and Elbadawi approaches. From the above results we can say that the Elbadawi approach can mimic the unobserved ERER better than the Edwards approach in Taiwan's case, because it yields a smaller value. The permanent components estimated by the B-N model of the decomposition technique were used in both models—Edwards's and Elbadawi's—and the empirical results indicate that the ERER is more stable in the Elbadawi approach. From the results of the descriptive statistics, we can say that the Elbadawi approach can mimic the unobserved ERER better than the Edwards approach, and the moving-average technique can yield a closer estimating result for the black market RER in Taiwan's case.

Appendix C: Numerical Results of the Cointegration Approach, Including the Decomposition Technique

TABLE C1

ACTUAL RERS AND MISALIGNMENT FROM EQUILIBRIUM RATE

Year	Real Exchange Rate		Misalignment (Percentages)
	Actual	Equilibrium	
1981:1	36.68664	–	–
1981:2	36.81985	–	–
1981:3	37.54662	42.36243	-11.36812
1981:4	38.30438	38.75522	-1.163296

TABLE C1 (Continued)

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1982:1	38.54543	39.50871	-2.438153
1982:2	39.36948	40.17546	-2.006150
1982:3	39.32350	39.14268	0.461950
1982:4	40.35906	43.30221	-6.796757
1983:1	39.55085	36.38208	8.709692
1983:2	39.99194	47.06225	-15.02330
1983:3	40.56478	39.25929	3.325312
1983:4	41.52401	38.03996	9.158912
1984:1	41.54449	36.81817	12.83692
1984:2	40.80338	39.70493	2.766534
1984:3	39.88938	36.95466	7.941401
1984:4	40.59377	35.11205	15.61208
1985:1	40.15465	34.87198	15.14876
1985:2	41.07355	44.09052	-6.842669
1985:3	40.99717	37.77367	8.533716
1985:4	41.38940	39.12531	5.786774
1986:1	39.12963	37.13314	5.376578
1986:2	37.91779	39.20643	-3.286816
1986:3	36.03473	32.51844	10.81323
1986:4	35.47953	34.63663	2.433561
1987:1	34.99127	34.85772	0.383133
1987:2	32.46011	35.31407	-8.081664
1987:3	30.71254	32.40547	-5.224198
1987:4	29.80271	33.11609	-10.00535
1988:1	29.76690	32.84665	-9.376151
1988:2	29.91883	30.74959	-2.701690
1988:3	29.71759	30.19201	-1.571359
1988:4	29.48268	27.20428	8.375143
1989:1	29.03405	26.99203	7.565244
1989:2	27.17251	31.03792	-12.45383
1989:3	26.19503	28.80771	-9.069405
1989:4	27.24092	26.58977	2.448864
1990:1	27.33233	26.63663	2.611814
1990:2	27.67106	28.35007	-2.395113
1990:3	27.91068	26.62879	4.813944
1990:4	28.60577	28.31295	1.034256
1991:1	27.55879	24.79440	11.14926
1991:2	27.32929	29.74276	-8.114488
1991:3	26.48250	27.88261	-5.021445
1991:4	25.54931	24.41965	4.626004
1992:1	24.30010	24.01652	1.180782
1992:2	24.21048	27.69487	-12.58137
1992:3	24.00970	24.94559	-3.751721
1992:4	24.46176	23.84525	2.585442
1993:1	24.68202	21.84120	13.00670
1993:2	24.80435	24.73286	0.289072

TABLE C1 (Continued)

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1993:3	25.49570	24.22500	5.245417
1993:4	25.21360	22.45037	12.30817

Appendix D: Partial Adjustment Approach Including the Decomposition Technique

TABLE D1

ACTUAL RERS AND MISALIGNMENT RATE

Year	Real Exchange Rate Actual	Real Exchange Rate Equilibrium	Misalignment (Percentages)
1981:1	36.68664	–	–
1981:2	36.81985	–	–
1981:3	37.54662	40.19815	-6.596158
1981:4	38.30438	45.02288	-14.92241
1982:1	38.54543	133.6270	-71.15445
1982:2	39.36948	31.04915	26.79726
1982:3	39.32350	41.57458	-5.414552
1982:4	40.35906	66.74151	-39.52929
1983:1	39.55085	85.56408	-53.77634
1983:2	39.99194	35.67972	12.08591
1983:3	40.56478	38.73004	4.737253
1983:4	41.52401	53.74916	-22.74483
1984:1	41.54449	76.71348	-45.84460
1984:2	40.80338	29.07951	40.31661
1984:3	39.88938	57.47669	-30.59903
1984:4	40.59377	50.52442	-19.65515
1985:1	40.15465	69.96219	-42.60521
1985:2	41.07355	46.24073	-11.17453
1985:3	40.99717	49.66946	-17.46001
1985:4	41.38940	49.69740	-16.71717
1986:1	39.12963	59.61128	-34.35867
1986:2	37.91779	54.03939	-29.83306
1986:3	36.03473	19.90237	81.05752
1986:4	35.47953	51.81212	-31.52271
1987:1	34.99127	51.94951	-32.64369
1987:2	32.46011	28.54598	13.71165
1987:3	30.71254	34.38669	-10.68480
1987:4	29.80271	55.41625	-46.22027

TABLE D1 (Continued)

Year	Real Exchange Rate		Misalignment
	Actual	Equilibrium	(Percentages)
1988:1	29.76690	51.28239	-41.95493
1988:2	29.91883	42.58245	-29.73905
1988:3	29.71759	27.26176	9.008335
1988:4	29.48268	43.16531	-31.69822
1989:1	29.03405	49.29308	-41.09914
1989:2	27.17251	33.58192	-19.08587
1989:3	26.19503	60.16886	-56.46415
1989:4	27.24092	30.80580	-11.57209
1990:1	27.33233	82.45235	-66.85075
1990:2	27.67106	63.12829	-56.16695
1990:3	27.91068	31.25116	-10.68914
1990:4	28.60577	52.73990	-45.76066
1991:1	27.55879	79.40022	-65.29129
1991:2	27.32929	42.29096	-35.37795
1991:3	26.48250	38.21922	-30.70893
1991:4	25.54931	47.28475	-45.96713
1992:1	24.30010	65.14126	-62.69630
1992:2	24.21048	45.19854	-46.43527
1992:3	24.00970	29.36765	-18.24438
1992:4	24.46176	36.33612	-32.67923
1993:1	24.68202	63.12996	-60.90284
1993:2	24.80435	31.49893	-21.25336
1993:3	25.49570	21.74452	17.25117
1993:4	25.21360	38.19063	-33.97961

Appendix E: Demonstration of Permanent and Transitory Movements of the Fundamental Variables

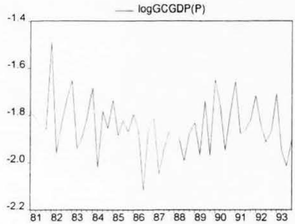

FIG. E1.—The permanent components of logGCGDP

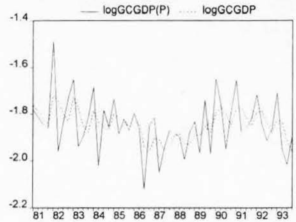

FIG. E2.—The movement between logGCGDP(P) and LogGCGDP

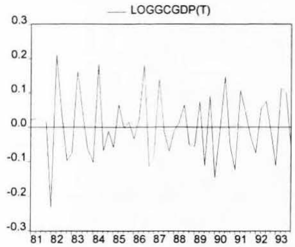

FIG. E3.—The transitory components of logGCGDP(T)

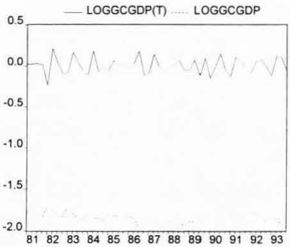

FIG. E4.—The movement between logGCGDP(T) and logGCGDP

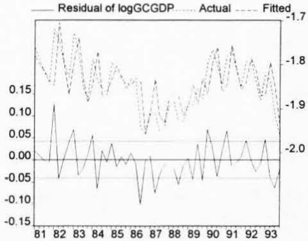

FIG. E5.—The goodness-of-fit of logGCGDP

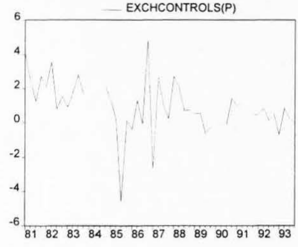

FIG. E6.—The permanent components of EXCHCONTROLS

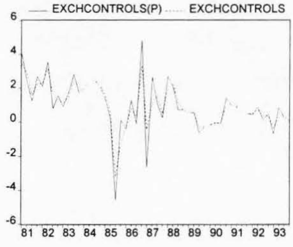

FIG. E7.—The movement between EXCHCONTROLS(P) and EXCHCONTROLS

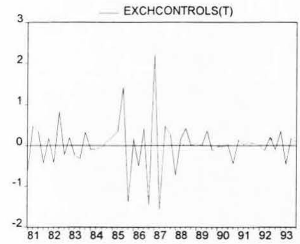

FIG. E8.—The transitory components of EXCHCONTROLS(T)

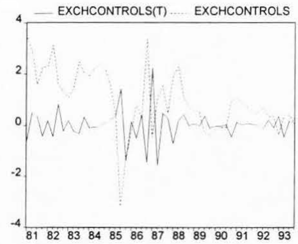

FIG. E9.—The movement between EXCHCONTROLS(T) and EXCHCONTROLS

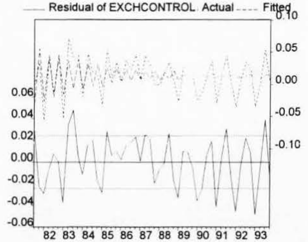

FIG. E10.—The goodness-of-fit of EXCHCONTROLS

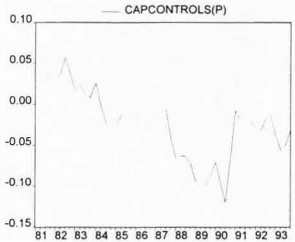

FIG. E11.—The permanent components of CAPCONTROLS

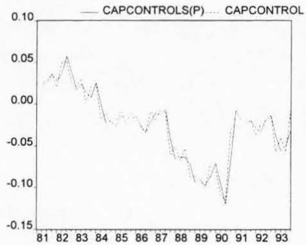

FIG. E12.—The movement between CAPCONTROLS(P) and CAPCONTROLS

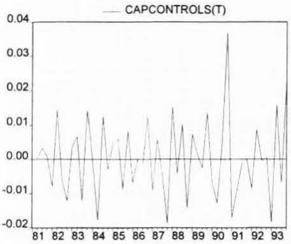

FIG. E13.—The transitory components of CAPCONTROLS

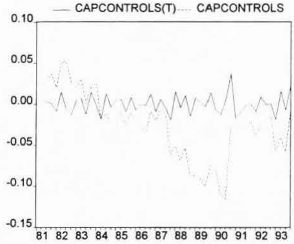

FIG. E14.—The movement between CAPCONTROLS and CAPCONTROL(T)

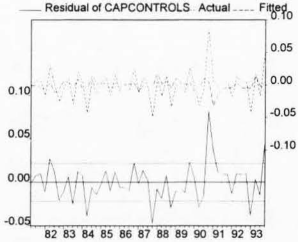

FIG. E15.—The goodness-of-fit of CAPCONTROLS

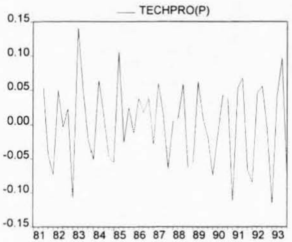

FIG. E16.—The permanent components of TECHPRO

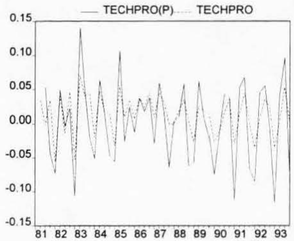

FIG. E17.—The movement between TECHPRO(P) and TECHPRO

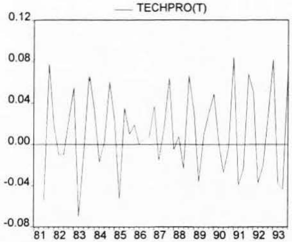

FIG. E18.—The transitory components of TECHPRO

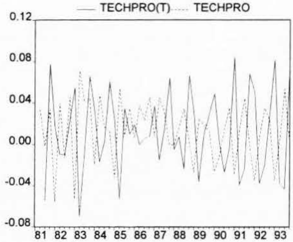

FIG. E19.—The movement between TECHPRO and TECHPRO(T)

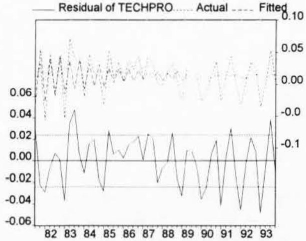

FIG. E20.—The goodness-of-fit of TECHPRO

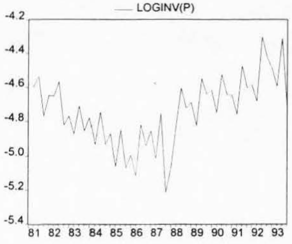

FIG. E21.—The permanent components of logINV

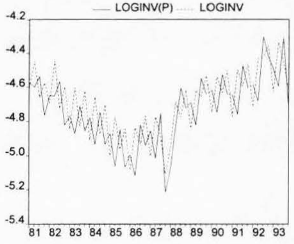

FIG. E22.—The movement between logINV(P) and LogINV

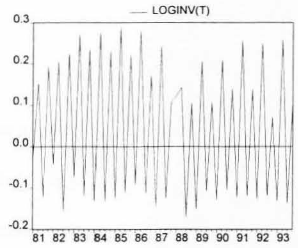

FIG. E23.—The transitory components of logINV

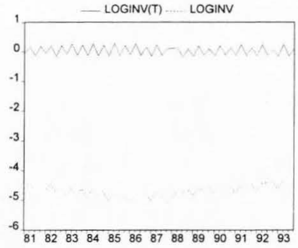

FIG. E24.—The movement between logINV(T) and logINV

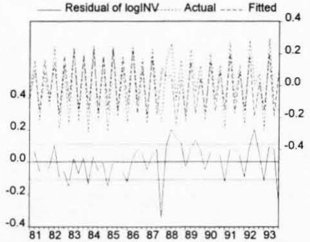

FIG. E25.—The goodness-of-fit of logINV

CONCLUSIONS

This essay attempts to quantify the RER misalignment. The extent of misalignment is measured as the deviation of the ERER from the observed RER. We take the definition of RER adopted by Edwards (1989). According to Edwards, the ERER is "the relative price of tradables to nontradables which, for given sustainable values of other relevant variables such as international terms of trade, government consumption ratio to nontradables, exchange control, capital controls, technique progress, and investment ratio to GDP, results in the simultaneous attainment of internal and external equilibrium" (p. 16).

Edwards's (1989) RER model was used to derive estimates of long-run ERER. Subsequently, measures of exchange rate misalignment were expressed as the ratio of the difference between actual RER and the estimated ERER over the estimated ERER, i.e., [(RER - ERER)/ERER]*100 percent.

This analysis was good as far as it goes, but it did not allow for flexible dynamic adjustment of the RER toward the ERER, and neither did it allow for the influence of short- to medium-run macroeconomic and exchange rate policies on the RER. To address this issue, we followed the Elbadawi (1994) model that accounts for the above features. A desirable property of the model is that, in the presence of stochastic nonstationarity and cointegration, the short-run dynamic adjustment of the long-run ERER path collapses to the simple equation predicted by the basic model. Furthermore, stochastic nonstationarity suggests a natural methodology for generating the sustainable components of the fundamentals by using the moving-average technique.

The estimated long-run cointegration equation of the ERER and the corresponding dynamic error correction specification reinforces the conclusion in Elbadawi. By using proxies for sustainable fundamentals, the estimated long-run equations were used to derive indexes of the ERER.

In the first essay, the empirical results show that the ERER derived from Elbadawi's approach is much closer to the RER than the Edwards approach. The estimated ERER, according to the Edwards model, deviates from the observed values significantly, whereas in the other model, the difference between the two is much less. Several reasons can be suggested for this discrepancy: (i) the Edwards model does not show the short-run dynamic behavior. The ERER is derived from the long-run relation; however, RER is influenced in the short to medium run by macroeconomic and exchange rate policies that are not part of the fundamentals. When this model fails to incorporate the short-run dynamic behavior, it may increase the difference between the RER and ERER; (ii) our observed period may be too short to meet the requirements of the long run for deriving the long-run ERER. Because the ERER is unobservable, we may need a longer time period to investigate the more valid relationship between RER and ERER.

In the second essay, we interpreted the sustainable values of fundamentals as permanent components of fundamentals. Because the ERER is unobservable and it is important for policy purposes, it is very important to estimate the ERER as correctly as possible. Permanent components of fundamentals contrary to the transitory component are the part that will stay in the long run. Edwards and Elbadawi try to use the moving-average technique because it corresponds to the theoretical concept of the ERER. Hence, the alternative to the moving-average process is the decomposition technique, which is more scientific and is expected to produce correct results.

From the empirical results, it seems that our approach yields a higher fluctuation than either Edwards's or Elbadawi's. The reason could be that the permanent component constitutes a large part of the fundamental variables. Hence, it has a strong influence on the ERER. It should be noted that the influence of the transitory component on the ERER is not included in our computation of ERER. This is because the influence of the transitory component is short-lived and could not be a part of the long-run ERER.

The estimated ERER and the corresponding rates of RER misalignment, either from Edwards's or Elbadawi's or the modified Elbadawi, confirm that the ERER is not a fixed, constant number. This finding implies that the simple PPP modeling of the RER could be a misleading simplication.

Since the ERER follows a stochastic trend process, there should be a band with an upper and a lower limit within which the RER should be managed. The recent crises in some Asian countries have been partly the consequence of their maintaining pegged exchange rate regimes for too long. In spite of record growth and strong trade performance, Korea, Thailand, Hong Kong, and Singapore have been facing continual economic upheavals in recent times. The maintenance of the pegged exchange rate system encouraged external borrowing and led to excessive exposure to foreign exchange risk in both the financial and corporate sectors. There was a sharp deterioration in the quality of the banks' portfolios. There was another factor that added to the problem. These countries failed to pursue appropriate macroeconomic policies along with the relevant exchange rate policy when it was increasingly evident that the economy was overheated. The overheating of the economy was manifested in large external deficits. The relevance of this study to the present crises of these countries is that a correct estimation of the ERER will give the government a guideline for the appropriate exchange rate policy. Of course, if there is any political uncertainty and if there is any doubt about the authorities' commitment and ability to implement the necessary adjustments, policies will be less effective. The crisis in the foreign exchange market is the consequence of reluctance of monetary authorities to tighten monetary conditions and to close insolvent financial institutions. Thailand, Indonesia, and Korea have a loss of confidence. In each of these countries, weak financial systems, excessive unhedged foreign borrowing by the domestic private sector, and a lack of coordination among government, business, and banks has led to the crises and their currencies being deeply depreciated. What is the relevance of the present study in containing the crises and restoring confidence? This research extends earlier work in estimating the path of the ERER. Once these rates are determined and a range is selected, there should be an appropriate monetary policy that is firm enough—with interest rates being allowed to rise sufficiently—to resist excessive exchange rate depreciation.

Compared with other countries in Asia, Taiwan's currency remains relatively stable. Taiwan's situation is very similar to that of Singapore, which has a sound and strong economic foundation. But in an interdependent world, the economy of any country is influenced by Asia's financial crisis. Because of Taiwan's huge foreign exchange reserve and trade surplus, its currency has maintained its stability, which, in turn, has helped to lower the government budget deficit and create an efficient banking system. Taiwan's central bank has announced that the current exchange rate is already overcorrected. This indicates that Taiwan's government has some knowledge about the ERER. This illustrates the usefulness of a correct definition and measurement of the ERER for policy purposes.

Additional research is needed to identify the extent to which specific monetary, fiscal, and commercial government policies cause distortions in the RER. Also, the spillover exchange rate effects among all the trading countries need to be included for interpreting the short-run dynamics of the RER behavior.

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