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The relevance of domestic and foreign capacity utilization rates in forecasting future inflation rate has been investigated empirically, using five industrialized countries for which the comparable data are available.

It has been found that capacity utilization rates, both domestic and foreign, have a long run stable relationship with domestic inflation rate and a positive shock in the capacity utilization rate results in a significant, although a little bit delayed, acceleration in the domestic inflation rate. Various econometric techniques have been used and led to consistent empirical findings.

The results in the present study, therefore, dispute the claim that an increase in capacity utilization rate may not necessarily lead to an accelerated inflation down the road.

Capacity Utilization and Inflation: International Evidence

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Capacity Utilization and Inflation: International Evidence

CHAPTER 1

INTRODUCTION

It has been recently stated (Business Week, November 7, 1994) that capacity utilization rate numbers are understated since increased productivity allows manufacturers to obtain increased output without the addition of new capacities. It is also suggested that capacity utilization numbers are based only upon domestic production, a factor which makes little sense in an increasingly global world marketplace. Nonetheless, policy makers and the economists in the private sector (those from the financial sector, in particular) continue to pay particular attention to the capacity utilization numbers. The natural question which should be asked is then: Does the domestic capacity utilization rate remain an important indicator for the measurement of the degree of overheating that may lead to accelerated inflation? Or can we safely discount the importance of the domestic capacity utilization rate as an indicator of looming inflation?

If the effect of the domestic capacity utilization rate has been overstated to the extent that it makes little sense in a global world, then the foreign capacity utilization rate may continue to play an important role in determining the domestic inflation rate. In fact, a recent article issued by the Federal Reserve Bank of St. Louis (International Economic Conditions, July 1994) raised the following question: Will international excess capacity restrain U.S. inflation? If excess capacity abroad can hold down U.S. inflation pressures at least temporarily, despite the high U.S. domestic capacity utilization rate, there would be a positive relationship between the inflation and foreign capacity utilization rates. This article stated that there was actually a slightly negative, rather than a positive relation, between the U.S. inflation and foreign capacity utilization rates. However, the study at the same time failed to acknowledge that the regression was based on contemporaneous relations. As a result, the dynamic adjustment process between the two variables was not reflected in the argument.

Of course there are a potentially large number of important macro variables used for determination of the inflation rate, among them most notably monetary growth rate(Barro, 1993.) The previous discussion has identified two seemingly important determinants of the inflation rate, the domestic and foreign capacity utilization rates, but recent studies have disputed the relevance and importance of these variables. The purpose of the present study is to establish the long-run and short-run relationships among the domestic and foreign capacity utilization rates and the domestic inflation rate. A casual examination of contemporaneous relations among these variables is misleading in the establishment of their "true" relationships, which should rather be examined from a dynamic point of view. That is, an increase in capacity utilization may not have an instantaneous effect upon the inflation rate, but it may well have significant subsequent and delayed effects. Moreover, since the foreign capacity utilization rate may be an important factor in the determination of foreign inflation rates, which in turn may have an effect upon the domestic economy in the global economy, the foreign inflation rate variable should also be included in the study.

The efforts have been made to identify the existence of a stable relationship over time among capacity utilization rate, both domestic and foreign, foreign inflation rate, and the domestic inflation rate. Recently developed econometric time series methods, including Cointegration and error-correction mechanism, have been employed for the purpose and these variables for the five countries under study have been uniformly found to follow a stable long run path.

Further efforts have been made to investigate the dynamic effect of an increase in the domestic and/or foreign capacity utilization on the inflation rate. The Vector Autoregression method has been used to find that an increase in the capacity utilization rate will eventually lead to an accelerated inflation, although the accelerated inflation occurs with some delays.

The rest of the present study is structured as follows. In Chapter 2, econometric methods for the present study are introduced and their relevance is discussed. Augmented Dickey-Fuller unit root test is used to determine whether relevant series contain unit roots and for the preliminary step of the cointegration method. Both the cointegration and error correction methods are used in this study. The basic reason for their use is that cointegration can be used to imply stationary deviations with finite variances from equilibrium, though the series themselves are nonstationary and have infinite variance. The error correction mechanism can be used to view adjustments to long-run paths. Two types of cointegration and error correction methods are used for the present study, one from Engle and Granger (1987) and the second from MacKinnon (1991.) Though the two tests have the same asymptotic efficiency, the tabulated distribution of critical values for the cointegration tests differ.

The final part of Chapter 2 explains the tools that are particularly useful for investigating the short-run fluctuations in the dynamic setting. The Vector Autoregression (VAR) model can be used to trace the effects of a change in one variable on the rest of the variables within the system. The methods encompassed within the VAR model include: (1) Granger-causality tests, (2) the decomposition of variance of forecast error , and (3) Impulse Responses function.

Granger-causality tests show whether the past history of a variable help better predict the movement of the other variables. The decomposition of forecast error variance shows how important a variable is in forecasting the other variables. Finally, Impulse Responses trace out the over-time response of variables in the system to a shock in one of the variables. These three methods combined can provide the information regarding whether a variable is important and, if so, how important that variable is in forecasting other variables. Furthermore, impulse responses indicate in what direction a variable responds following a (positive) shock in the other variables.

Chapter 3 reports The empirical test results based upon the application of the econometric methods discussed in Chapter 2 are then presented in Chapter 3. The test results confirm that the capacity utilization rate, both domestic and foreign, and the inflation rate have a long run stable relationship and any deviation from the long run path quickly disappear in the following periods.

It also reports that capacity utilization rate is an important in measuring future inflationary pressure and any increase in domestic and foreign capacity utilization rate eventually leads to an accelerated inflation rate in the future. Both domestic and foreign capacity utilization rate turned out to have important predictive power regarding domestic inflation rate. As a result, one can legitimately claim that any excess capacity can help restrain inflation.

Overall, support is provided for the view that the capacity utilization rate, both domestic and foreign, is an important factor in the determination of the inflation rate. The results obtained from consideration of various econometric methods are robust in the sense that both long-run and short-run considerations produced consistent empirical support for this view. Finally, chapter 4 provides a conclusion based on empirical findings.

CHAPTER 2

ECONOMETRIC METHODS

Time-series econometrics is concerned with the estimation of relationships among groups of variables, each of which is observed at a number of consecutive points in time. The relationships among these variables may be complicated. For example, the value of each may be dependent upon values assumed by any number of other variables over several previous time periods. As a consequence, the effect that a change in one variable has upon another is dependent upon the time horizon under consideration. Thus, examples may be foreseen in which a change in one quantity has little or no initial effect upon another, only to reflect a substantial effect at a later time; alternatively, a variable may have a substantial effect upon another at one time, but that effect may in time no longer be measurable.

Recent developments in time-series econometrics provide the natural tools for this study, the goal of which is two-fold: (1) Confirmation of long-run stable relationships among the domestic capacity utilization rate, the foreign capacity utilization rate, the foreign inflation rate, and the domestic inflation rate; and (2) study of the short-run effects of changes in domestic foreign-capacity utilization rates and foreign inflation rates upon domestic inflation rates.

One of the most recent development in time-series techniques is concerned with cointegration (CI) and error correction mechanisms (ECM.) Cointegration techniques are used to confirm long-run stable relationships among variables. Short-run adjustments toward long-run stable paths can be investigated using error correction mechanisms. The vector autoregression (VAR) method is useful for the investigation of short-run transmission mechanisms when a variable within the system has been subject to a shock. The technique has been used successfully in the literature of macroeconomics, and is particularly relevant to the purposes of the present study; that is, determination of the effect of changes in (i.e., shocks to) the domestic and foreign capacity utilization rates upon domestic inflation rates. However, it is also true that reverse effects from inflation to capacity utilization rates could be effected. That is, all of the variables in the system contain some degree of endogeneity, and when this is the case, the VAR approach serves as a natural tool for the investigation of short-run shock-transmission mechanisms.

The first types of econometric time-series method used for the present study are CI and ECM. The reason for the use of CI is that relationships among the variable series may have long-run stable relationships. In general, the concept of CI is that it implies that deviations from equilibrium are stationary subject to finite variance, though the time series considered are non stationary with infinite variance. The ECM method is then used to observe short-run adjustments to long-run paths. Two types of CI methods are currently in common use, those of Engle and Granger (1987) and MacKinnon (1991.) The CI method suggested by Engle and Granger is commonly used in the U.S., but the MacKinnon CI is more commonly used in most European countries. One of the conditions for cointegration is that all of the variables reflect the same order of integration (i.e., the same degree of nonstationarity.) To establish equal orders of integration, standard Dickey-Fuller tests or variants thereof are commonly used. Thus, confirming nonstationarity or the unit roots is the first step in the CI method.

The second type of economic time-series method considered is the VAR, used in the current study to investigate the short-run dynamic transmission mechanisms of the variables for domestic capacity utilization, foreign capacity utilization, foreign inflation rates, and domestic inflation rates. Use of the VAR method involves the consideration of three concepts. First, the Granger causality test is employed to determine whether the lagged values of a variable, for example, x_t, help to improve forecasts for other variables, for example, y_t. If this is true, then a variable y_t is said to be Granger-caused by the variable x_t. However, it is worth noting that the Granger definition has been criticized insofar as it is based upon predictability rather than upon cause and effect relationships between or among variables [Judge et al., 1988.]

In addition, forecast error variance decomposition is applied, an approach which provides information on the degree to which the forecast error variance for a variable is explained by (1) its own innovation and (2) innovations originating with other variables used in the VAR model. The third concept most often emphasized within the VAR model is innovation accounting (i.e., the impulse-response function), which in turn demonstrates system variables' responses to shocks in one of the model variables.

The application of these relevant econometric methods is developed and explained in this chapter. The related literature have been scattered around here and there, and the purpose of this review should be considered as an effort to bring in all relevant econometric methods for this study.

2.1. Unit Root Tests

For the following discussion of the basic concepts of unit root tests for the nonstationarity of variables, Hamilton (1994) and other sources are considered, as noted.

2.1.1 Unit Root Tests for Uncorrelated Observations

There are three common cases used to determine whether the process contains unit roots when observations are uncorrelated over time, and the Dickey-Fuller test has been popularly used. From Hamilton (1994) we have:

Case 1:

Estimated regression: $y_t = \rho y_{t-1} + \mu_t$. (2.1)

True process: $y_t = y_{t-1} + \mu_t$, where $\mu t \sim$ i.i.d. $N(0, \sigma^2.)$

Then the testable hypothesis Ho: $\rho = 1$. Then, using OLS, get ρ_T and $t = \rho_{T-1} / S.E(\rho_T)$ where $T(\rho_{T-1})$ and where the critical value will be read from the appropriate table[1].

Case 2:

Estimated regression: $y_t = \alpha + \rho y_{t-1} + \mu_t$. (2.2)

True process: $y_t = y_{t-1} + \mu_t$, where $\mu_t \sim$ i.i.d. $N(0, \sigma^2.)$

Then the testable hypothesis Ho: $\rho = 1$. Then, using OLS, get ρ_T and $t = \rho_{T-1} / S.E(\rho_T)$ where $T(\rho_{T-1})$ and where the critical value will be read from the appropriate table.

Case 3:

Estimated regression: $y_t = \alpha + \delta t + \rho y_{t-1} + \mu_t$. (2.3)

True process: $y_t = \alpha + y_{t-1} + \mu_t$, where $\mu_t \sim$ i.i.d. $N(0, \sigma^2.)$

Then the testable hypothesis Ho: $\rho = 1$. Then, using OLS, get ρ_T and

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[1]Hamilton (1994) provides the critical values for different specifications. See also Fuller (1976) and Dickey-Fuller (1979, 1981.)

$t = \rho_{T-1}$ / S.E(ρ_T) where T(ρ_{T-1}) and where the critical value will be read from the appropriate table.

However, there is a means to read t-statistics immediately from the transformation of equations (2.1)–(2.3) as:

$$\Delta y_t = (\rho - 1) y_{t-1} + \mu_t \qquad (2.1)'$$

$$\Delta y_t = \alpha + (\rho - 1) y_{t-1} + \mu t \qquad (2.2)'$$

$$\Delta y_t = \alpha + \delta t + (\rho - 1) y_{t-1} + \mu t , \qquad (2.3)'$$

then test the hypothesis is H_0: $\rho - 1 = 0$. If the process contains a unit root, then the tests given above can be expected to accept the null hypothesis at least one of these three cases. This way, one dose not have to make efforts to find the true process for a variable.

2.1.2. Unit Root Tests for Serially Correlated and/or Heteroscedastistic Observations

When observations are serially correlated and/or heteroscedastistic, then the augmented Dickey-Fuller test is an appropriate method. For application of this method, corrections for serial correlation were made to the standard OLS coefficients and the t-statistics. Dickey and Fuller (1979) sought to control serial correlation by including higher-order lagged terms. Subsequently, Said and Dickey (1984) provided a test valid for general ARMA errors. However, the test statistics for the latter are the asymptotic equivalents of those originally tabulated by Dickey and Fuller (1979).

Suppose that the data were generated from an AR(p) process,

$$(1 - \phi_1 L - \phi_2 L^2 - \dots - \phi_p L^p)\, y_t = \varepsilon_t , \qquad (2.4)$$

where $\{\varepsilon_t\}$ is an i.i.d. sequence with mean zero, variance σ^2, and a finite fourth moment.

The autoregression (2.4) can equivalently be rewritten as

$$\{(1-\rho L)-(\zeta_1 L+\zeta_2 L^2+\ldots+\zeta_{p-1}L^{p-1})(1-L)\}\, y_t=\varepsilon_t \tag{2.5}$$

or

$$y_t=\rho\, y_{t-1}+\zeta_1 \Delta\, y_{t-1}+\zeta_2 \Delta\, y_{t-2}+\ldots+\zeta_{p-1}\Delta\, y_{t-p+1})+\varepsilon_t\,. \tag{2.6}$$

Suppose that the process that generated y_t contains a single unit root: that is, one root of

$$1-\phi_1 L-\phi_2 L^2-\ldots-\phi_p L^p=0 \tag{2.7}$$

is unity and all other roots of (2.7) are outside the unit circle. Then $\rho = 1$ and

$$(1-\zeta_1 L-\zeta_2 L^2-\ldots-\zeta_{p-1} L^{p-1})=\varepsilon_t \tag{2.8}$$

or

$$(1-\zeta_1 L-\zeta_2 L^2-\ldots-\zeta_{p-1} L^{p-1})=\mu_t\,, \tag{2.8$'$}$$

where $\mu_t = (1-\zeta_1 L-\zeta_2 L^2-\ldots-\zeta_{p-1} L^{p-1})^{-1}\varepsilon_t=\psi(L)\,\varepsilon_t\,.$

The expression in (2.6) as derived from (2.4) demonstrates an important point in specifying the regression model for the unit root test when a true process is AR(p). When a simple Dickey and Fuller (i.e., without Δy_{t-j}) test for a unit root of a true AR(p) process is used, the model is mis-specified and the model as well as the errors tend to be autocorrelated (i.e., serially correlated), which is a violation of the assumption of i.i.d. errors. The Phillips-Person unit root tests[2], using Z_p and Z_t, then provide one means to control for serial correlation, whereas the augmented

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[2]See Phillips and Perron (1988.)

Dickey Fuller (ADF) unit root test is an alternative means. Moreover, when (2.6) is estimated, with (or without) a constant and a time trend, $\Delta y_{t-1}, ..., \Delta y_{t-p+1}$ are all stationary under the null $H_0: \rho = 1$, and the result is a theorem which states that any standard t and/or F tests involving $\zeta_1, \dots, \zeta_{p-1}$ are asymptotically valid. Appropriate lag structure can be determined by examining $\zeta_1, \dots, \zeta_{p-1}$. This is approximately equivalent to the Dickey-Fuller test previously considered, with the exception that the augmented Dickey-Fuller unit root tests include lagged difference terms. For example, if the model is based upon quarterly data, then four lagged terms are usually added according to this approach.

As with Dickey-Fuller tests, there are three different specifications for Augmented Dickey-Fuller tests. The following discussion closely follows Hamilton (1994),

Case 1:

Estimated Regression:

$$y_t = \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \dots\dots + \zeta_{p-1} \Delta y_{t-p-1} + \rho y_{t-1} + \varepsilon_t . \qquad (2.9)$$

True process: The same as estimated with $\rho = 1$:

The testable hypothesis is

$$H_0 = \rho - 1$$

and two alternative tests have been purposed.

$$\text{(i) } Z_{DF} = T(\rho_T - 1)/(1 - \zeta_{1 \cdot T} - \zeta_{2 \cdot T} - \dots\dots - \zeta_{p-1,T}),$$

$$\text{(ii) } t = \rho_T - 1 \, / \, \text{S.E.}(\rho_{T \cdot})$$

where the critical values for (i) and (ii) are provided from the appropriate table. One can use method (ii) since (i) and (ii) generate consistent results.

Case 2:

Estimated Regression:

$$y_t = \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \ldots + \zeta_{p-1} \Delta y_{t-p-1} + \alpha + \rho y_{t-1} + \varepsilon_t \qquad (2.10)$$

True process: The same as estimated with $\rho = 1$ and $\alpha = 0$:

(i) $Z_{DF} = T(\rho_T - 1)/(1 - \zeta_{1,T} - \zeta_{2,T} - \ldots - \zeta_{p-1,T})$,

(ii) $t = \rho_T - 1 / S.E.(\rho_T)$

where the critical values for (i) and (ii) are provided from the appropriate table.

Case 3:

Estimated Regression:

$$y_t = \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \ldots + \zeta_{p-1} \Delta y_{t-p-1} + \alpha + \delta t + \rho y_{t-1} + \varepsilon_t . \qquad (2.11)$$

True process: The same as estimated with $\rho = 1$ and $\delta = 0$:

(i) $Z_{DF} = T(\rho_T - 1)/(1 - \zeta_{1,T} - \zeta_{2,T} - \ldots - \zeta_{p-1,T})$,

(ii) $t = \rho_T - 1 / S.E.(\rho_T)$

where the critical values for (i) and (ii) are provided from the appropriate table.

One can use the models above to consider one of the structural variables used for the present study as applied to the augmented Dickey-Fuller unit root tests. If the variable investigated is the domestic capacity utilization rate (CUD) then the following augmented Dickey-Fuller unit root tests would be executed to confirm the existence of the unit root.

$$\Delta \log(CUD_t) = (\rho - 1) \log(CUD_{t-1}) + \sum_{i=1}^{n} \beta_i \log(CUD_{t-i}) + \mu_t , \qquad (2.12)$$

$$\Delta \log(CUD_t) = \alpha + (\rho - 1) \log(CUD_{t-1}) + \sum_{i=1}^{n} \beta_i \log(CUD_{t-i}) + \mu_t , \qquad (2.13)$$

$$\Delta \log(CUD_t) = \alpha + \delta t + (\rho - 1) \log(CUD_{t-1}) + \sum_{i=1}^{n} \beta_i \log(CUD_{t-i}) + \mu_t , (2.14)$$

where CUD is the vector of the domestic capacity utilization rate, and $(\rho - 1), \alpha, \delta,$ and β_1 to β_i are the parameters to be estimated. The notation "Δ" and "log" represent, respectively, one-time first differences and their logarithms, and the "t" subscripts are the time indices. However, only the t-statistic of the $(\rho - 1)$ parameter estimated is of interest to the present study.

One can go to investigate the existence of more unit roots in the process using the same models discussed above.

2.2. Cointegration and Error Correction Mechanism

An $(n \times 1)$ vector time series y_t is said to be cointegrated if each of the series taken individually is I(1), that is, nonstationary with a unit root, while some linear combination of the series $\mathbf{a}' \mathbf{y_t}$ is stationary, or I(0), for the nonzero $(n \times 1)$ vector **a** (Hamilton, 1994). Then, the components of the vector x_t are said to be cointegrated of the order d, b, denoted by $x_t \sim CI(d, b)$, if

(i) x_t is I(d) and

(ii) there exists a nonzero vector α such that $\alpha' x_t \sim I(d - b)$, where $d \geq b > 0$.

If (i) and (ii) hold, the vector α is called the cointegrating vector (Engle & Granger, 1987).

For example, suppose the two series (CUD and IFLD for the U.S.A., as used for the present study) are both I(1), then a linear combination of the two series might be stationary around a fixed mean. This would imply that the series are somehow drifting together at approximately the same rate. Two series which satisfy this requirement are said to be "cointegrated." Similarly, if four variables are all I(1), that is, $\{X_t, Y_t, Z_t, W_t\}$ become all stationary after first-differencing and if $\varepsilon_t = X_t + \alpha Y_t + \beta Z_t + \gamma W_t$ (with normalization of the coefficient in X_t) become a stationary series, then we say the variables $\{X_t, Y_t, Z_t, W_t\}$ are cointegrated, forming a stable, long-run relationship.

When a group of variables is cointegrated, a natural error correction mechanism is present. If, at one point, the system goes off the stable path, then during the subsequent time period there will be a strong tendency toward that long-run stable path. This tendency should be tested for statistical significance using appropriate methods. Engle and Granger (1987) provides the methods.

2.2.1 Cointegration and Error Correction Models–I

There are two testing steps introduced by Engle and Granger (1987.) First, the long run relationships are fitted in levels, by least-squares. Second, the residual from the static regression (or cointegrating regression) is used as an error correction term in the dynamic, first-difference regression. To understand the Engle-Granger testing procedure, one can begin with the type of problem likely to be encountered in applied studies. Suppose that two variables, y_t and z_t, are integrated of order 1 and the question is whether an equilibrium relationship exists between the two. Engle and Granger (1987) proposed a straightforward test to determine whether two I(1) variables are cointegrated of the order CI(1,1.)

<u>Step 1</u>:

First, pretest each variable to determine its order of integration. The Dickey-Fuller, the augmented Dickey-Fuller, and/or the Phillips-Perron tests can be used to infer the number of unit roots in each of the variables. Second, estimate the long run relationship in the form:

$$y_t = \text{constant} + \beta_1 z_t + \varepsilon_t . \quad (2.15)$$

To determine if the variables are actually cointegrated, obtain the residual sequence from (2.15) by $\{\varepsilon_t\}$. Thus, $\{\varepsilon_t\}$ is the series of residual estimates for the long-run relationship. If these deviations from long-run equilibrium are found to be stationary, then the $\{y_t\}$ and $\{z_t\}$ sequences are cointegrated of the order (1,1.) It would be convenient to perform a Dickey-Fuller test on these residuals to determine their order of integration. However, to obtain consistent performances for the test results, only the three model tests shown below must be performed:

$$\Delta\hat{\varepsilon}_t = a_1\hat{\varepsilon}_{t-1} + \xi_t , \quad (2.16)$$

$$\Delta\hat{\varepsilon}_t = \text{constant} + a_1\hat{\varepsilon}_{t-1} + \xi_t , \quad (2.17)$$

$$\Delta\hat{\varepsilon}_t = \text{constant} + \delta t + a_1\hat{\varepsilon}_{t-1} + \xi_t . \quad (2.18)$$

In this case, one is only interested in the estimated parameter of a_1 in (2.16)–(2.18.) If the null hypothesis $a_1 = 0$ cannot be rejected, then it must be concluded that the residual series contains a unit root and that the $\{y_t\}$ and $\{z_t\}$ sequences are not cointegrated. Moreover, the rejection of the null hypothesis implies that the residual sequence is stationary. The method is basically an application of Dickey-Fuller tests.

If the residual of (2.16)–(2.18) does not appear to be white-noise, an augmented Dickey-Fuller test can be used in place of (2.16)- (2.18.) Suppose that diagnostic checks (i.e., Durbin Watson statistic for the residuals from cointegrating regression) indicate that the $\{\varepsilon_t\}$ sequences of (2.16)– (2.18) exhibit a serial correlation. In place of using the results from (2.16)– (2.18), estimate the autoregression as follows:[3]

$$\Delta\hat{\varepsilon}_t = a_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{n} b_{i+1}\Delta\hat{\varepsilon}_{t-i} + \xi_t, \tag{2.19}$$

$$\Delta\hat{\varepsilon}_t = \text{constant} + a_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{n} b_{i+1}\Delta\hat{\varepsilon}_{t-i} + \xi_t, \tag{2.20}$$

$$\Delta\hat{\varepsilon}_t = \text{constant} + \delta t + a_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{n} b_{i+1}\Delta\hat{\varepsilon}_{t-i} + \xi_t. \tag{2.21}$$

Step 2:

Estimate the error-correction model. If the variables are cointegrated, then the residuals from the equilibrium regression can be used to estimate the error-correction model. For example, if $\{y_t\}$ and $\{z_t\}$ are CI(1,1), the variables have the error-correction terms

$$\Delta y_t = \alpha_1 + \alpha_y(y_{t-1} - \beta_1 z_{t-1}) + \beta_y \Delta z_t + \xi_{yt}, \tag{2.22}$$

$$\Delta z_t = \alpha_2 + \alpha_z(y_{t-1} - \beta_1 z_{t-1}) + \beta_y \Delta y_t + \xi_{zt}, \tag{2.23}$$

where β_1 = the parameter of the cointegrating vector given by (1), ξ_{yt} and ξ_{zt} = white-noise disturbances (which may be correlated with one another), and α_1, α_2, $\alpha_y, \alpha_z, \beta_y$, and β_z are all parameters.

Engle and Granger (1987) proposed a clever means to circumvent the cross-equation restrictions involved in the direct estimation of (2.22) and (2.23.) The

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[3]The difference between Dickey-Fuller test and augmented Dickey-Fuller test is that the augmented Dickey-Fuller test add either 4-quarter or 12-month lagged term in the equation depend on the data using. This will eliminate serial correlation problem in the regression.

value of the residual $\hat{\varepsilon}_{t-1}$ provides an estimate of the deviation from long-run equilibrium in period (t-1). Hence, it is possible to use the saved residuals $\{\hat{\varepsilon}_{t-1}\}$ obtained in Step 1 as instruments for the expression $y_{t-1} - \beta_1 z_{t-1}$ in (2.22)–(2.23.) Thus, using the saved residuals from the estimation of the long-run equilibrium relationship, the long-run equilibrium relationship can be estimates, resulting in ECM estimations of:

$$\Delta y_t = \alpha_1 + \alpha_y \hat{\varepsilon}_{t-1} + \beta_y \Delta z_t + \xi_{yt}, \tag{2.24}$$

$$\Delta z_t = \alpha_2 + \alpha_z \hat{\varepsilon}_{t-1} + \beta_y \Delta y_t + \xi_{zt}. \tag{2.25}$$

The existence of statistically significant error correction is tested using the coefficient on $\hat{\varepsilon}_{t-1}$. The testable hypothesis is $H_0: \alpha_y < 0$ (or $H_0: \alpha_z < 0$.) The negative coefficient on $\hat{\varepsilon}_{t-1}$ mean that "overshooting" in the previous period is now adjusted so that the system could stay closer to the stable path.

2.2.2. Cointegration Models–II (Response Surfaces for Critical Values)

MacKinnon (1991) claimed that the use of Dickey-Fuller tests, augmented Dickey-Fuller tests, and the Phillips Perron tests based upon Engle and Granger (1987) methods provided for ease of calculation, while at the same time suffering from the serious disadvantage that the test statistics do not follow any standard tabulated distribution, either in finite samples or asymptotically. This was stated though Engle and Yoo (1987) and Phillips and Ouliaris (1990) provided tables for one or more versions of the Engle and Granger test. These tests, however, cover only a limited set of cases. However, the critical values used in the MacKinnon (1991) tests are based on a large number of simulations for extensive set of cases, and therefore should be sufficiently accurate for all practical purposes. The results of the MacKinnon simulation experiments are summarized by means of response surface where the critical values are related to the size of particular sample. A three-step procedure, as suggested by MacKinnon (1991), is used to test the null hypothesis of non-cointegration models:

1. Run cointegrating (OLS) regression and obtain the residuals $\hat{\varepsilon}_t$,

$$y_t = \Sigma \beta_i z_{it} + \varepsilon_t, \quad t = 1, 2, ..., T; \tag{2.26}$$

2. Test whether $\hat{\varepsilon}_t$ is I(1); that is, run one or all of the following:

$$\Delta\hat{\varepsilon}_t = \text{constant} + a_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{4} b_i \Delta\hat{\varepsilon}_{t-i} + \xi_t, \tag{2.27}$$

$$\Delta\hat{\varepsilon}_t = \text{constant} + \delta t + a_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{4} b_i \Delta\hat{\varepsilon}_{t-i} + \xi_t. \tag{2.28}$$

3. To determine the critical value for H_0: $a_1 = 0$, use the following formula:

$$C(p) = \Phi_\infty + \Phi_1 T^{-1} + \Phi_2 T^{-2} \tag{2.29}$$

where C(p) is the p-percent critical value (upper-quartile) estimate, and T is the sample size. The values for $\Phi_\infty, \Phi_1, \Phi_2$ are found in the MacKinnon (1991) tables.

Basically, the procedural steps closely resemble the Engle & Granger (EG) tests, with the exception that MacKinnon (1991) procedural step 1 does not include a constant in the regression. However, the ECM follows STEP 2 for EG tests, as given above. For the present study, the method is applied as follows. The variables, including the domestic capacity utilization rate (CUD), the foreign capacity utilization rate (CUF), the foreign inflation rate (IFLF), and the domestic inflation rate (IFLD) for the U.S.A., Canada, Germany, Italy, and Japan are applied to unit root tests. If the existence of unit roots is confirmed, then the cointegrating relations can be estimated; if the cointegrating relations are confirmed, then the ECM can be estimated. These steps are represented as follows:

1. Unit root tests are performed according to DF or ADF regressions;
2. Follows Step 1, using (2.15) to estimate and save the residuals,

$$(IFLD_{(USA)t}) = \alpha_0 + \beta_0 \log(CUD_t) + \phi_0 \log(CUF_t) + \gamma_0 (IFLF_t) + \varepsilon_{0t}, \quad (2.30)$$

$$(IFLD_{(CAN)t}) = \alpha_1 + \beta_1 \log(CUD_t) + \phi_1 \log(CUF_t) + \gamma_1 (IFLF_t) + \varepsilon_{1t}, \quad (2.31)$$

$$(IFLD_{(DEU)t}) = \alpha_2 + \beta_2 \log(CUD_t) + \phi_2 \log(CUF_t) + \gamma_2 (IFLF_t) + \varepsilon_{2t}, \quad (2.32)$$

$$(IFLD_{(ITA)t}) = \alpha_3 + \beta_3 \log(CUD_t) + \phi_3 \log(CUF_t) + \gamma_3 (IFLF_t) + \varepsilon_{3t}, \quad (2.33)$$

$$(IFLD_{(JPN)t}) = \alpha_4 + \beta_4 \log(CUD_t) + \phi_4 \log(CUF_t) + \gamma_4 (IFLF_t) + \varepsilon_{4t}, \quad (2.34)$$

where IFLD(n) is the domestic inflation rate for, respectively, the U.S.A., Canada, Germany, Italy, and Japan; and where CUD is the domestic capacity utilization rate for the respective countries, CUF is the foreign capacity utilization rate for the respective countries, and IFLF is the foreign inflation rate for the respective countries.

3. Then, after saving the residuals, follow Step 1 using (2.16)–(2.18) as follows:

$$\Delta\hat{\varepsilon}_t = a_1\hat{\varepsilon}_{t-1} + \xi_t, \quad (2.35)$$

$$\Delta\hat{\varepsilon}_t = \eta + a_1\hat{\varepsilon}_{t-1} + \xi_t, \quad (2.36)$$

$$\Delta\hat{\varepsilon}_t = \eta + \delta t + a1\hat{\varepsilon}_{t-1} + \xi_t. \quad (2.37)$$

The procedural concepts from (2.35) to (2.37) are then applied to the regressions in (2.31)–(2.34.)

Note that there is interest only in the t-statistic of the a_1 parameter estimated, regardless of whether the null hypothesis of non co-integration can be rejected. If the null hypothesis can be rejected, the residuals are indicated to be in a stationary process though the structural model behaves as a non-stationary process. In other words, the variables to be tested have long-run relationships between each other or among one another.

The MacKinnon (1991) co-integration method follows almost the same concepts as given in procedures 1, 2, and 3 for the EG test, with the exception of two changes: (1) Run the cointegration OLS regression as (2.26) (without a constant) and (2) use only (2.36) and (2.37.) However, the outstanding feature of the use of this test is that the response surfaces for the critical values are believed to be more accurate than from other tests.

4. Perform an error correction mechanism by following Step 2 above. From equations (2.24) and (2.25), the ECM relationships model among four variables are given: (1) the domestic capacity utilization rate, (2) the foreign capacity utilization rate, (3) the foreign inflation rate, and (4) the domestic inflation rates for the major trading partner countries (i.e., the U.S.A., Canada, Germany, Italy ,and Japan.)

$$\Delta(\mathrm{IFLD}_{(USA)t}) = \alpha_1 + \alpha_{\mathrm{IFLUSA}}\hat{\varepsilon}_{t-1} + \alpha_2\Delta\log(\mathrm{CUD}_t) + \alpha_3\Delta\log(\mathrm{CUF}_t) + \alpha_4\Delta\log(\mathrm{IFLF}_t) + \xi_t, \tag{2.38}$$

$$\Delta(\mathrm{IFLD}_{(CAN)t}) = \alpha_1 + \alpha_{\mathrm{IFLCAN}}\hat{\varepsilon}_{t-1} + \alpha_2\Delta\log(\mathrm{CUD}_t) + \alpha_3\Delta\log(\mathrm{CUF}_t) + \alpha_4\Delta(\mathrm{IFLF}_t) + \xi_t, \tag{2.39}$$

$$\Delta(\mathrm{IFLD}_{(DEU)t}) = \alpha_1 + \alpha_{\mathrm{IFLDEU}}\hat{\varepsilon}_{t-1} + \alpha_2\Delta\log(\mathrm{CUD}_t) + \alpha_3\Delta\log(\mathrm{CUF}_t) + \alpha_4\Delta(\mathrm{IFLF}_t) + \xi_t, \tag{2.40}$$

$$\Delta(\mathrm{IFLD}_{(ITA)t}) = \alpha_1 + \alpha_{\mathrm{IFLITA}}\hat{\varepsilon}_{t-1} + \alpha_2\Delta\log(\mathrm{CUD}_t) + \alpha_3\Delta\log(\mathrm{CUF}_t) + \alpha_4\Delta(\mathrm{IFLF}_t) + \xi_t, \tag{2.41}$$

$$\Delta(\mathrm{IFLD}_{(JPN)t}) = \alpha_1 + \alpha_{\mathrm{IFLJPN}}\hat{\varepsilon}_{t-1} + \alpha_2\Delta\log(\mathrm{CUD}_t)$$

$$+ \alpha_3 \Delta \log(CUF_t) + \alpha_4 \Delta(IFLF_t) + \xi_t . \tag{2.42}$$

Once again, the reason for using the ECM is to see the short-run adjustment to the long-run path. However, we are interested in α_{IFLUSA}, α_{IFLCAN}, α_{IFLDEU}, α_{IFLITA}, and α_{IFLJPN} in the models (2.38)–(2.42.) If the model for these equations follows the ECM method, then the t-statistics for α_{IFLUSA}, α_{IFLCAN}, α_{IFLDEU}, α_{IFLITA}, and α_{IFLJPN} should be significantly different from zero.

2.3. Vector Autoregression

The short-run transmission mechanism among variables can be investigated using the general form of VAR suggested by Judge et al. (1988.) The contemporaneous relations among variables do not show how a system adjusts to disturbances within the system. The VAR approach offers a natural way of tracing the effect of changes in some of the variables within the system upon the remainder of the variables. To understand the basic VAR framework, consider the following econometric model:

$$Y_t = \nu + \Theta_1 Y_{t-1} + \dots + \Theta_p Y_{t-p} + V_t \tag{2.43}$$

where $$Y_t = \begin{bmatrix} Y_{1t} \\ Y_{2t} \\ \vdots \\ Y_{Mt} \end{bmatrix} \quad \nu = \begin{bmatrix} \nu_1 \\ \nu_2 \\ \vdots \\ \nu_M \end{bmatrix} \quad \Theta = \begin{bmatrix} \Theta_{11,i} & \Theta_{12,i} & \cdots & \Theta_{1M,i} \\ \Theta_{21,i} & \Theta_{22,i} & \cdots & \Theta_{2M,i} \\ \vdots & \vdots & & \vdots \\ \Theta_{M1,i} & \Theta_{M2,i} & \cdots & \Theta_{MM,i} \end{bmatrix} V_t = \begin{bmatrix} V_{1t} \\ V_{2t} \\ \vdots \\ V_{Mt} \end{bmatrix}$$

This expression can be used for the definition of VAR(p), the vector autoregressive process of the order p, by appropriately defining the matrix dimensions where Y_t, ν_t, and V_t are $M \times 1$ matrices, and each Θ is an $M \times M$ matrix. In this system of M equations, it is assumed that V_t have a zero mean, $E[V_t] = 0$, and the same covariance matrix, $\Sigma_V = E[V_t V'_t]$ for all t. Furthermore, V_t and V_s are uncorrelated when t and s are different. That is,

$$E[V_t] = 0, \quad E[V_t V_t^T] = \Sigma_V, \ \forall\ t\ E[V_t V_s] = 0, \ \forall\ t = s. \tag{2.44}$$

A process V_t with these properties is often referred to as vector white noise. Normally, the parameters $\nu, \Theta_1, \Theta_2, ..., \Theta_3$, and Σ_V are unknown and these will be estimated (Judge et al., 1988.) However, before discussing estimation procedures, the stationary values of the VAR process must be defined.

2.3.1. Stationarity

A vector stochastic process is stationary if

(i) All the random vectors have the same mean vector μ, $E[y_t\} = \mu$, for all t;

(ii) The variances of all involved random variables are finite, $VAR(y_{mt})$ finite, for $m = 1, \ldots, M$ and all t; and

(iii) The covariance matrices of vectors y_t and y_{t+k} that are k periods apart are not dependent upon t, but are dependent only upon k.

For practical purposes, these conditions imply that the time series under consideration must not have trends (deterministic or stochastic), fixed seasonal patterns, or variances that are time-variant. Application of the data transformation process discussed in the previous sections is necessary to ensure these properties. It can be shown that VAR(p) process given above is stationary if it has bounded means and covariance matrices and the polynomial is defined by the determinant

$$\det (I - \Theta_1 z - \Theta_2 z^2 - \Theta_p z^P) = 0, \tag{2.45}$$

which has all its roots outside the unit circle.

2.3.2 Estimation and Determination of Lag Length

As it is clear from the model, VAR places minimal demands on the structure of a model. With a VAR, only two requirements must be specified: (1) the set of variables that is believed to interact and hence which should be included as part of the economic system being modeled, and (2) the largest number of lags that are required to capture most of the effects that the variables have upon one another. Following these conventions, a four-variable VAR model was used since the models use four lags (i.e., quarterly data) and are four-variable VAR(4) processes. Specifically, it is generally accepted that the OLS for each equation can be used (Hamilton, 1994.)

2.3.3 Granger Causality

A variable Y_t is said to be Granger-caused by a variable X_t if the information in the past and present X_t helps to improve the forecasts of the variable Y_t. To formalize, suppose that Ω_t contains all the (relevant) information in the universe up to period t. The variable Y_t is said to be Granger-caused by X_t if for some t (Granger & Newbold, 1977):

$$\sigma^2(Y_t(1) \mid \Omega_t) < \sigma^2(Y_t(1) \mid \Omega_t \backslash (X_s)_{s \leq t}), \qquad (2.46)$$

where $\sigma^2(Y_t(1) \mid \Omega_t)$ is the Mean Square Error (MSE) of the conditional forecast, given Ω_t. In other words, Y is Granger-caused by X if it can be more efficiently predicted when information in the past and present X is taken into account in addition to all other (relevant) information.

That is, a Granger-causality test examines whether the variable to be tested adds explanatory power to an existing relationship between one (or more) other variable(s) and its (their) lags. For example, if Z_t is a dependent variable and Z_{t-1} is the variable lagged one period, then $Z_t = f(Z_{t-1}, v_t)$ would represent a statistical relation between the two, where v_t is some unknown source of variation in the functional relation between them. For the Granger test, a known variable would be put into the functional relation between the two, and a known source of variation in the functional relation of Z_t and Z_{t-1} with various lags and leads is used to determine whether it helps to reduce v_t.

For the present study, two variables are used for the Granger-causality test of the relationship between the CUD and the IFLD. To test that whether the CUD has a Granger-causality relationship to IFLD and vice versa, the reduction from the model for the bivariate VAR(p) would be:

$$\log(CUD_t) = a_0 + a_1 \text{ trend} + \sum_{i=1}^{4} \alpha_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \beta_i (IFLD_{t-i}) + \varepsilon_{1t}, \quad (2.47)$$

$$(IFLD_t) = b_0 + b_1 \text{ trend} + \sum_{i=1}^{4} \gamma_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \delta_i (IFLD_{t-i}) + \varepsilon_{2t}, \quad (2.48)$$

where CUD is a vector of the domestic capacity utilization rate, IFLD is a vector of the domestic inflation rate, and ε_{1t} and ε_{2t} are orthogonal disturbances.

Then, from (2.47) and (2.48), it can be shown that the IFLD does not have a Granger-causal relationship to CUD if and only if

$$\beta_1 = \beta_2 = \dots = \beta_p = 0. \quad (2.49)$$

In turn , the CUD dose not have a causal relationship to the IFLD if and only if

$$\gamma_1 = \gamma_2 = \dots = \gamma_p = 0. \tag{2.50}$$

In other words, IFLD does not Granger-cause the CUD if the IFLD lags do not appear in the first (CUD) equation of (2.47) and CUD does not Granger-cause the IFLD if the CUD lags do not appear in the second equation of the system (2.48.)

Hence, the relationships here test for lack of causality whether or not the VAR coefficients from (2.47) and (2.48) differ significantly from zero. The null hypothesis of no Granger causality is from IFLD to CUD, and it may be tested using an F-test for the test statistic

$$F = \frac{(SSE_r - SSE_u) / p}{SSE_u / T-k} \sim F(p, T\text{-}k), \tag{2.51}$$

where SSE_r and SSE_u are the sums of squared errors obtained from the least-squares estimation of equations (2.47) and (2.48) both with and without imposing the restrictions that "p" is the number within the restricted model, "k" is the number of regressors in the unrestricted model ($k = 2p + 1$), and "T" is the total number of observations.

2.3.4. Innovation Accounting and Forecast Error Variance Decomposition

Sims (1980) derived two important tools, that is, innovation accounting and impulse response function and variance decomposition, that can be obtained from VAR models. These are results of simulations of the estimated VAR model and provide us with information transmission mechanisms.

Impulse response refers to tracing system reactions to shocks (i.e., innovations) in one of the variables. In applied work it is often of interest to know the response of one variable to a change in other variables. The concept is especially relevant in this study since one of the objectives is to investigate the effects of changes in CUD, CUF, and/or IFLF upon the IFLD. When there is a shock in one of either CUD, CUF, and/or IFLF, then the domestic inflation rate responds over time. The common belief is that if the CUD rises, then the domestic inflation rate responds positively since an increase in CUD will have upward pressure upon input prices. Similarly, there is pressure upon the domestic inflation rate through its effect upon import prices. Finally, foreign inflation may be imported to domestic economies subject to use of flexible exchange rate systems. Consequently, an increase in foreign inflation should have a positive effect upon the domestic inflation rate. Thus, the impulse response function (or multiplier analysis) developed by Sims (1980) provide a measure of the response of domestic inflation to any change in CUD, CUF, and/or IFLF over time. The dynamic nature of the VAR structure allows the over-time adjustment process one to be traced.

Judge, Griffiths, Hill, Lutkepohl, and Lee (1985) suggested that if the errors in the equations are correlated, then we are confronted with logical problem. Such a problematic assumption in this type of impulse response analysis is that a shock occurs only in one variable at a time. However, this assumption may be reasonable if shocks to different variables are independent. If they are not independent, it may be argued that the error terms consist of all the influences and variables that are not directly included in the set of, for instance, the CUD variables. Thus, in addition to forces that affect all of the variables, there may be forces that can affect, for example, only variable 1. If a shock in the first variable is due to such a force, it may be reasonable to interpret multiplier analysis as dynamic responses. On other hand, correlation of the error terms may indicate that a shock in one variable is likely to be accompanied by a shock in another variable. In that case, setting all other residuals to zero may provide a misleading picture of the actual dynamic relationships between and among the variables.(Lütkepohl, 1993.)

To overcome this problem, Cholesky factorization can be used to orthogonalize the matrix to derive uncorrelated errors and a corresponding covariance matrix. In other word, innovation accounting is often performed within a transformed VAR model, for example, taking differences and/or logarithms where the white noise process has a diagonal covariance matrix to the end that there are no instantaneous correlation among the components (Judge et al., 1988.)

When we make an h-step ahead forecast, the contribution of innovation in, for instance, the i-th variable to variance of the J-th variable's forecast error, can be calculated. Suppose that we have an h-step ahead forecast of certain variables for a VAR system. Obviously, a number of factors will contribute to the variance in forecast errors. Fortunately, from the VAR system, this forecast variance can be expressed in terms of the squared sum of individual innovations, and therefore can be decomposed into the components accounted for by innovations in the individual variables. These innovations are orthogonalized innovations from Cholesky factorization. That is, the variance decomposition of a forecast for a certain variable, X, shows the importance of an innovation in the variable, Y, for providing an explanation of forecast errors for X. Thus, the variable Y is important for forecasting (or explaining) the variable X.

In this chapter, the concepts of Granger-causality, impulse response, and variance decomposition have been developed and explained. If one variable (X) really helps to better predict other variables (Y), then application of these three techniques should provide consistent results. The variable (X) should Granger-cause variable (Y) or vice versa, the impulse response should result in a consistent pattern with a proper sign, and the forecast error variance decomposition should produce high explanatory powers. Again, Judge et al. (1988) are cautious in the use and interpretation of these tests, but if they are used jointly with other techniques to dispute and/or reinforce specific findings, then the results should be satisfactory.

To summarize the VAR system process used for the present study, the model is based upon a VAR(4) process in which the relationships among four variables, including CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan, are simulated. The sample data using this simulation are run quarterly from 1978:I to 1992:II:

The 4 variable VAR to be estimated are as follows:

$$\log(CUD_t) = a_0 + b_0 \text{ trend} + \sum_{i=1}^{4} \alpha_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \beta_i \log(CUF_{t-i}) + \sum_{i=1}^{4} \gamma_i (IFLD_{t-i}) + \sum_{i=1}^{4} \delta_i (IFLF_{t-i}) + \varepsilon_{0t} \quad (2.52)$$

$$\log(CUF_t) = a_1 + b_1 \text{ trend} + \sum_{i=1}^{4} \chi_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \eta_i \log(CUF_{t-i}) + \sum_{i=1}^{4} \iota_i (IFLD_{t-i}) + \sum_{i=1}^{4} \varphi_i (IFLF_{t-i}) + \varepsilon_{1t} \quad (2.53)$$

$$(IFLF_t) = a_2 + b_2 \text{ trend} + \sum_{i=1}^{4} \kappa_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \lambda_i \log(CUF_{t-i}) + \sum_{i=1}^{4} o_i (IFLD_{t-i}) + \sum_{i=1}^{4} \nu_i (IFLF_{t-i}) + \varepsilon_{2t} \quad (2.54)$$

$$(IFLD_t) = a_3 + b_3 \text{ trend} + \sum_{i=1}^{4} \pi_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \theta_i \log(CUF_{t-i}) + \sum_{i=1}^{4} \tau_i (IFLD_{t-i}) + \sum_{i=1}^{4} \upsilon_i (IFLF_{t-i}) + \varepsilon_{3t} \quad (2.55)$$

where CUD is a vector of domestic capacity utilization variables, CUF is a vector of the weight average of capacity utilization(the foreign capacity utilization), IFLF is vector of the foreign inflation, IFLD is vector of the domestic inflation, and a, b, α, $\beta, \gamma, \delta, \chi, \eta, \iota, \varphi, \kappa, \lambda, \nu, o, \pi, \theta, \tau, \upsilon$ are parameters to be estimated, and $\varepsilon_{0t}, \varepsilon_{1t}, \varepsilon_{2t}$, and ε_{3t} are orthogonal disturbances[4]. The notations "log" represent logarithms, and the "t" subscripts are time indexes (in quarters.) All variables in this part are run from 1978:I to 1992:II.

For these models, Granger-causality and impulse response tests, as well as variance decomposition analysis will be performed. As previously observed, if CUD, CUF, and IFLF are important factors in determining the domestic inflation rate (IFLD), then these tests should provide consistent analytical results of their interrelationships.

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[4]All estimations in this study use ordinary least squares (OLS)

CHAPTER 3

EMPIRICAL RESULTS

Econometric methods and techniques for this study have been presented and discussed in the previous chapter. In this chapter, these techniques are used to investigate: (1) long-run relationships and error-adjustment processes among the domestic capacity utilization rate (CUD), the foreign capacity utilization rate (CUF), the foreign inflation rate (IFLF), and the domestic inflation rate (IFLD) and (2) short-run shock-transmission mechanisms among the same variables. As indicated in the previous chapter, cointegration (CI) and the error correction mechanism (ECM) are used for (1), whereas vector autoregression is used for (2.)

To discuss long-run relationship among the variables involved, it is necessary to define the kind of equilibrium that is investigated in the study. First, the equilibrium state is defined as one in which there is no inherent tendency to change; in turn, disequilibrium is any situation that does not represent equilibrium, hence characterizes a state that contains the seeds of its own destruction. An equilibrium state may or may not have the property of either local or global stability, thus it may or may not be true that the system tends to return to the equilibrium state when it is perturbed. However, only stable equilibria are generally considered, since unstable equilibria will not persist given any number of stochastic shocks to the economy. That is, the equilibrium is a state to which systems are attracted, other things being equal.

It may also be possible in some circumstances to view the forces tending to push the system back into equilibrium as depending upon the magnitude of the deviation from equilibrium at a given point in time. When the system of the variables is off the equilibrium at some point in time, there may be some inherent forces within the system that lead to the equilibrium in the following periods. In the present study, long-run equilibrium is used to denote the equilibrium relationship toward which a system can be expected to converge over time. Thus, over finite periods of time, long-run equilibrium relationships may fail to hold, but they will eventually hold to any degree of accuracy if the equilibrium is stable, and if the system does not experience further shocks from outside.

The discussion above leads one to formulate first question of the current study this way: are there long run stable relationships among the CUD, CUF, IFLF, and the IFLD? It has been argued that the concept of cointegration and error correction can naturally be used to answer the question. To establish cointegration relationships, the order of integration of the variables was investigated. For this purpose, unit root tests were performed, the results of which are presented in the next section.

Cointegration demonstrates a long-run relationship, but cannot demonstrate short-run fluctuations or shock-transmitting processes over time. In particular, cointegration method cannot answer the following question: what is the over-time effect on IFLD of the shocks of the CUD, CUF, and the IFLF? To answer this question, it has been argued that the VAR method is an ideal tool. The VAR method was used for reason of its particular relevance to short-run fluctuations. VAR provides variable responses to shocks in other variables; this approach is basically a multiplier analysis (i.e., impulse response) using simulations based upon estimates of the VAR system. The VAR method can be used to accomplish what the CI method cannot: the tracing out of responses to the shocks within the system.

3.1 The Data and the Unit Root Tests

Figures 1 though 5 show the movement of the time series selected for this study; that is, the quarterly series of CUD, CUF, IFLF, and the IFLD for the U.S.A., Canada, Germany, Italy, and Japan for the period from the first quarter of 1978 through the second quarter of 1992.[5] It is obvious to see that the variables in consideration all have noticeable trend components. That is, there is a strong indication even from a casual inspection that the variables in this study have unit roots. Of course, the existence of unit roots should be confirmed using standard Dickey-Fuller type tests.

It has been explained that the confirmation of the same degree of integration (or nonstationarity) of the variables is the very first step toward cointegration method. The existence of a unit root is investigated using Dickey-Fuller tests and one can continue to test further existence of unit roots using Dickey-Fuller tests for the first-difference series, second-difference series, and so on. However, Durbin Watson statistic from the first unit root tests can be used to roughly detect further existence of unit roots.

The variable series used are with CUD, the CUF, the IFLF, and the IFLD for the U.S.A., Canada, Germany, Italy, and Japan. The concept and method for checking a unit root are exactly the same as presented in the previous chapter, with the exception that four lagged additions to the equations are used since all the variables considered are based upon quarterly data. For example, the augmented Dickey-Fuller tests in (2.12), (2.13), and (2.14) are again used to show the method of checking a unit root process for the CUD:

$$\Delta \log(CUD_t) = (\rho - 1)\log(CUD_{t-1}) + \sum_{i=1}^{4} \beta_i \Delta \log(CUD_{t-i}) + \mu_t, \qquad (2.12)$$

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[5]The quarterly data are derived from various OECD publications.

FIGURE 1. The domestic capacity utilization rate(CUD), foreign capacity utilization rate(CUF), foreign inflation rate(IFLF), domestic inflation rate(IFLD) for U.S.A., 1978:I- 1992:II

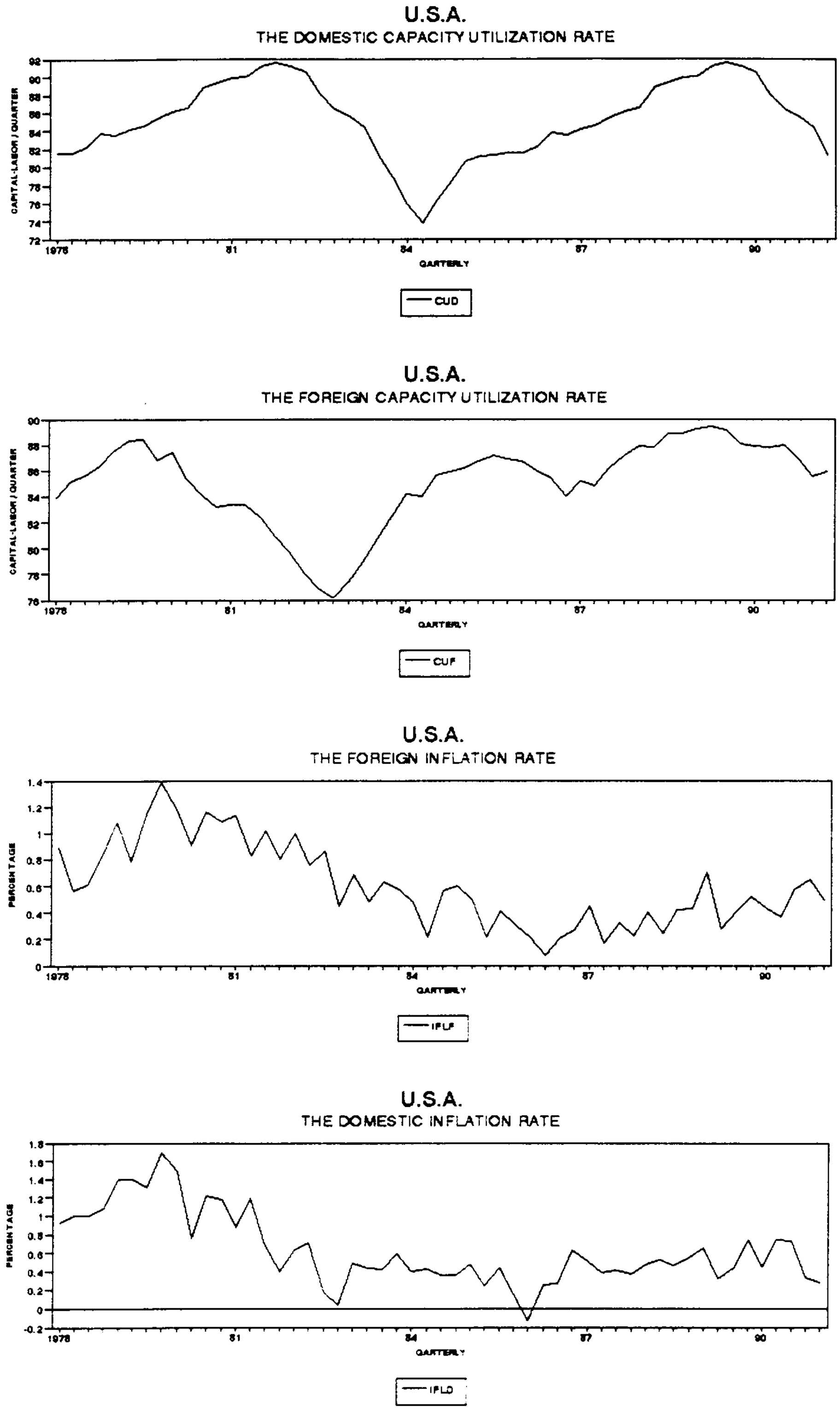


FIGURE 2. The domestic capacity utilization rate(CUD), foreign capacity utilization rate(CUF), foreign inflation rate(IFLF), domestic inflation rate(IFLD) for Canada, 1978:I- 1992:II

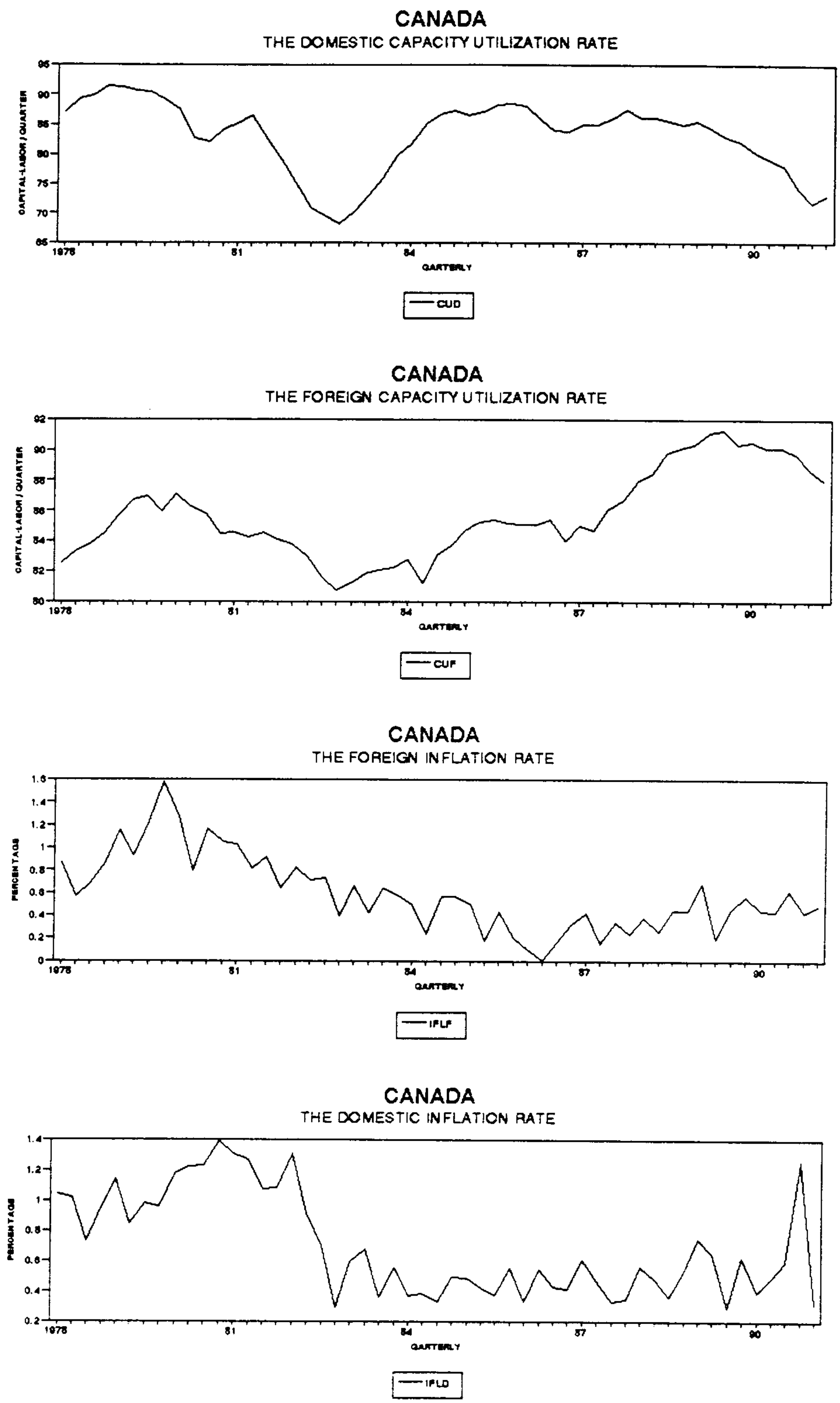


FIGURE 3. The domestic capacity utilization rate(CUD), foreign capacity utilization rate(CUF), foreign inflation rate(IFLF), domestic inflation rate(IFLD) for Germany, 1978:I- 1992:II

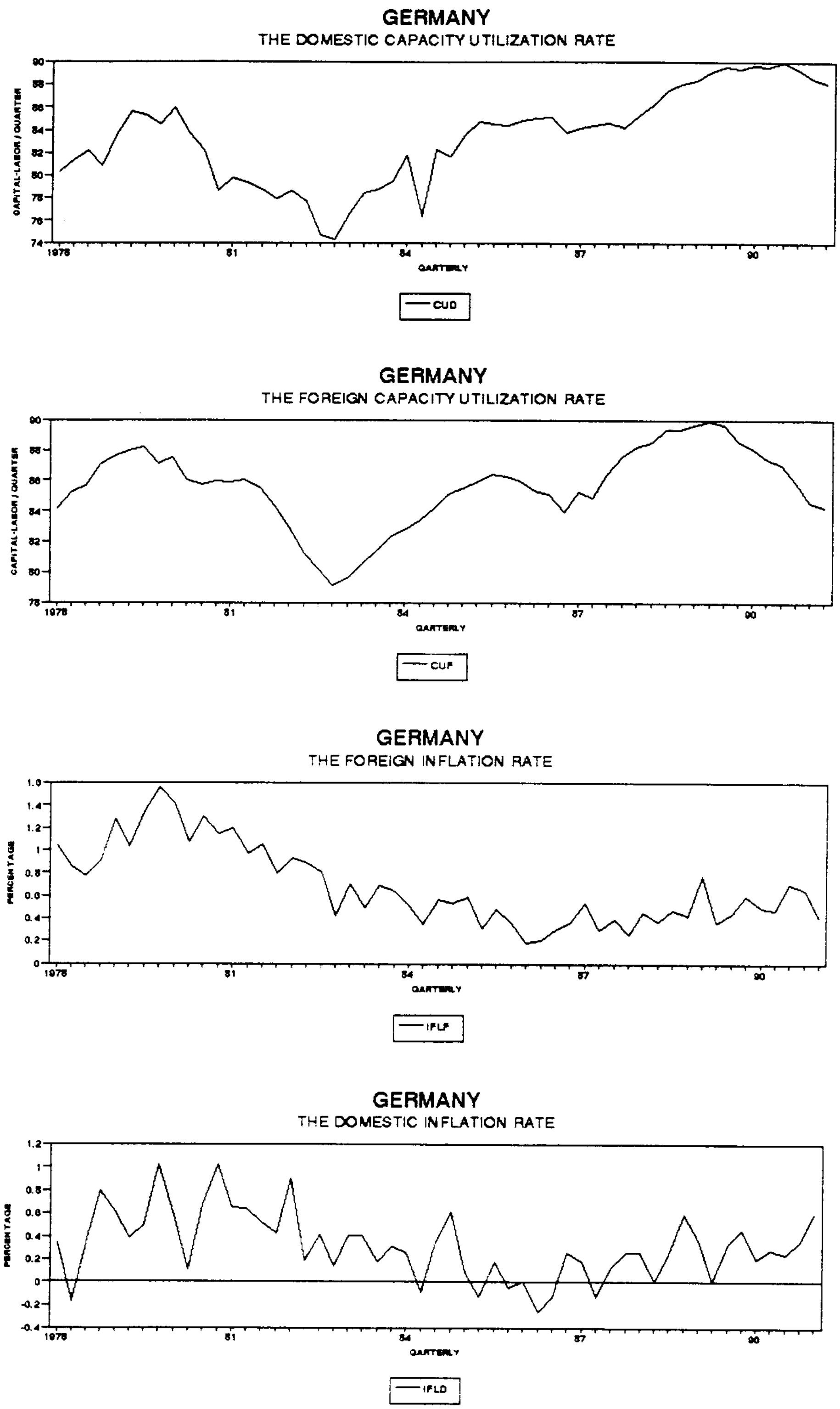
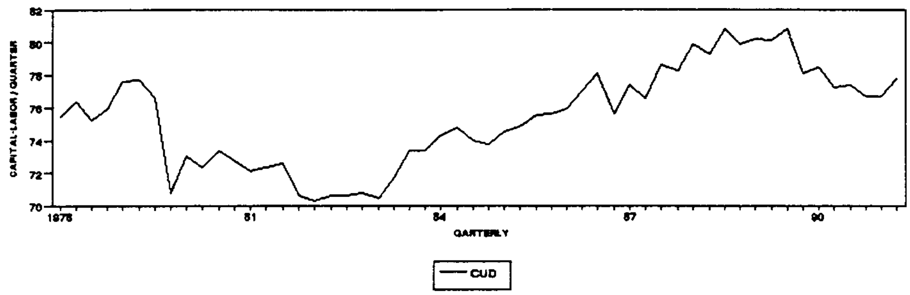
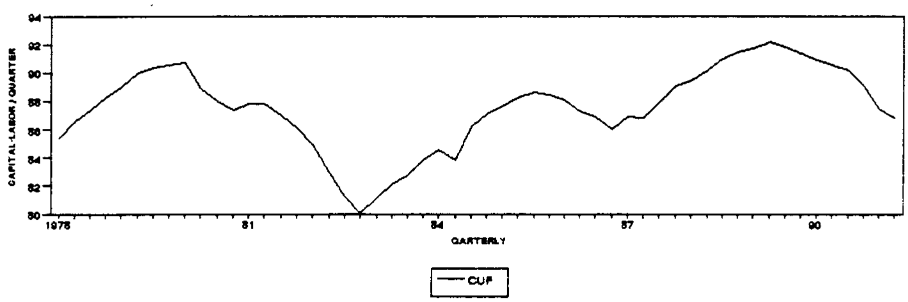


FIGURE 4. The domestic capacity utilization rate(CUD), foreign capacity utilization rate(CUF), foreign inflation rate(IFLF), domestic inflation rate(IFLD) for Italy, 1978:I- 1992:II

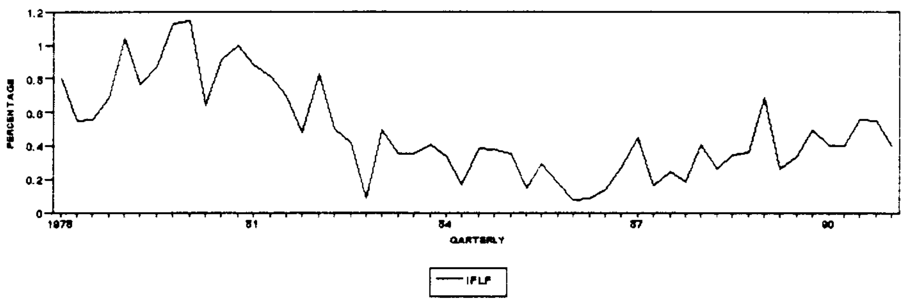
ITALY
THE DOMESTIC CAPACITY UTILIZATION RATE



ITALY
THE FOREIGN CAPACITY UTILIZATION RATE



ITALY
THE FOREIGN INFLATION RATE



ITALY
THE DOMESTIC INFLATION RATE

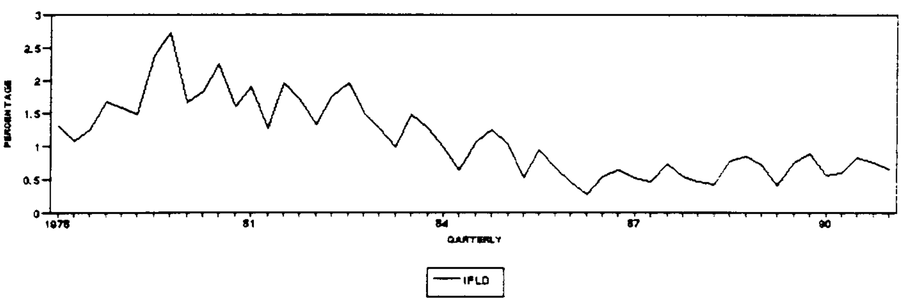
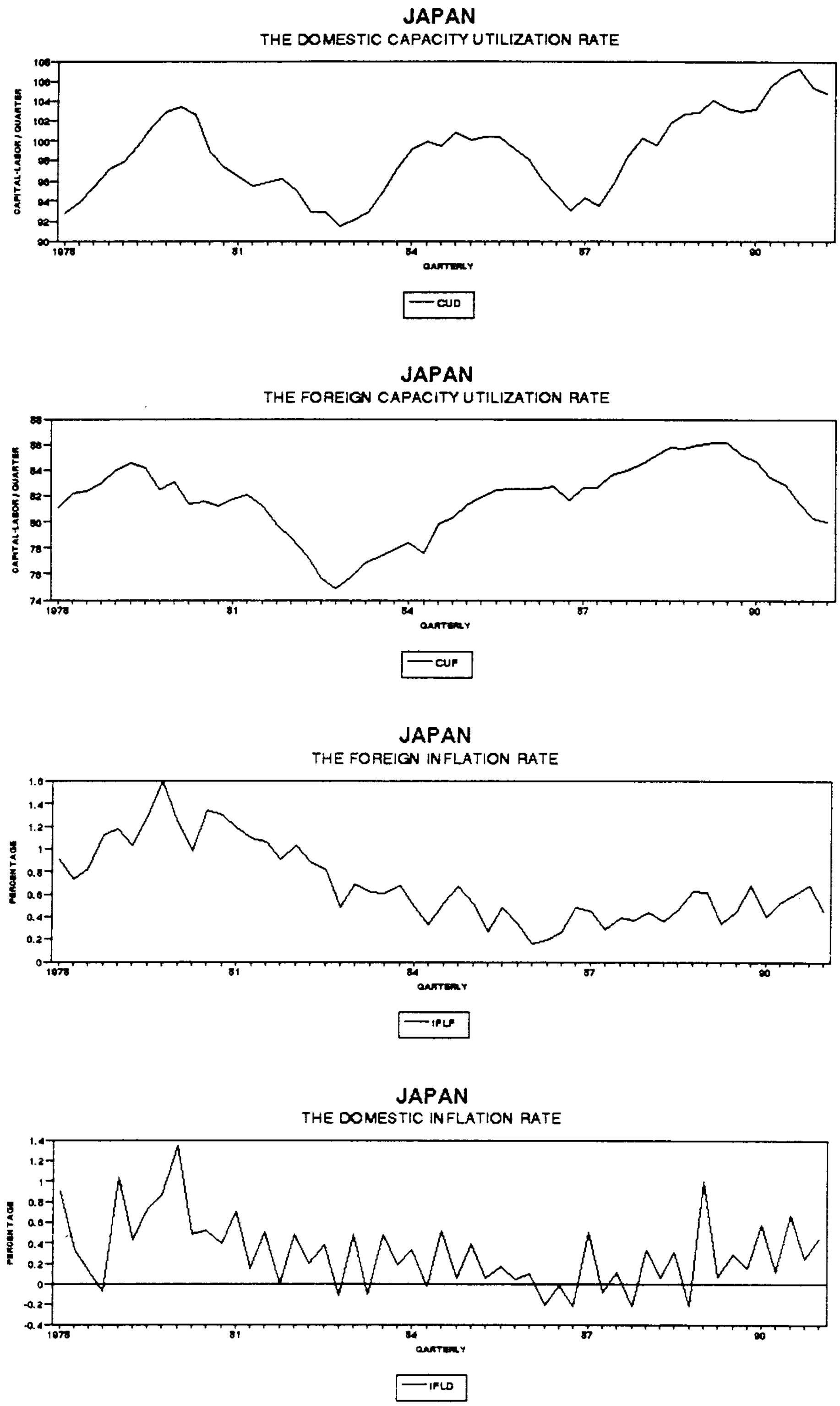


FIGURE 5. The domestic capacity utilization rate(CUD), foreign capacity utilization rate(CUF), foreign inflation rate(IFLF), domestic inflation rate(IFLD) for Japan, 1978:I- 1992:II



$$\Delta \log(CUD_t) = \alpha + (\rho-1) \log(CUD_{t-1}) + \sum_{i=1}^{4} \beta_i \Delta \log(CUD_{t-i}) + \mu_t , \qquad (2.13)$$

$$\Delta \log(CUD_t) = \alpha + \delta t + (\rho-1) \log(CUD_{t-1}) + \sum_{i=1}^{4} \beta_i \Delta \log(CUD_{t-i}) + \mu_t , \quad (2.14)$$

where CUD is the domestic capacity utilization rate, and $(\rho-1)$, β_1 to β_4, and α are the parameters to be estimated. The notations Δ and "log" represent, respectively, one-quarter of the first differences and the logarithms, and the "t" subscripts are the time indices (in quarters). All variables are calculated from 1978:I to 1992:II. Moreover, The other three structural variables, including the CUF, the IFLF, and the IFLD for the U.S.A., Canada, Germany, Italy, and Japan follow the same methodology. For the purposes of the present analysis, we are interested only in the t-statistic of the $(\rho-1)$ parameter estimate.

Using the conventional OLS estimated for null hypothesis testing, where the hypothesis is $\rho - 1 = 0$, should tell us whether the variable contains a unit root. To reject the null hypothesis at the 5% level of significance, indicating that there is a unit root contained in the process, the t-statistic value should be less (or more negative) than the critical value, as provided from the appropriate table.
From Table 1, to reject the null hypothesis at the 5% level of significance, indicating that there is a unit root contained in the process, the t-statistic value should be less than the critical value of -1.95, -2.93, -3.50 in the cases, respectively, 1, 2, and 3. Notice that the critical values are different from standard t-statistics. These critical values are tabulated from a large number of simulations (Fuller, 1976.) Table 1, part A, shows that the structural variable series for the CUD, CUF, IFLF, and IFLD for the U.S.A. contains a unit root, since the null hypothesis of a unit root cannot be rejected. The DW are all nearly 2.0, indicating that no signs of autocorrelations in the residuals are apparent. This means that there is no more

TABLE 1: Augmented Dickey-Fuller Unit Root Tests

$$\Delta X_t = (\rho - 1) X_{t-1} + \sum_{i=1}^{4} \beta_s \Delta X_{t-s} + \mu_t, \qquad \text{(case 1)}$$

$$\Delta X_t = \alpha + (\rho - 1) X_{t-1} + \sum_{i=1}^{4} \beta_s \Delta X_{t-s} + \mu_t, \qquad \text{(case 2)}$$

$$\Delta X_t = \alpha + \delta t + (\rho - 1) X_{t-1} + \sum_{i=1}^{4} \beta_s \Delta X_{t-s} + \mu_t, \qquad \text{(case 3)}$$

where X_t = [CUD, CUF, IFLF, IFLD], and where

CUD = the domestic capacity utilization rate,
CUF = the foreign capacity utilization rate,
IFLF = the foreign inflation rate, and
IFLD = the domestic inflation rate.

Variables	t - statistic for $\rho - 1 = 0$			Durbin Watson tests		
	case 1	case 2	case 3	case 1	case 2	case 3
A. U.S.A.						
CUD	-0.341	-2.515	-2.390	1.87	1.96	1.98
CUF	0.120	-1.623	-2.362	1.78	1.77	1.83
IFLF	-1.133	-1.262	-2.380	1.97	1.96	1.96
IFLD	-1.321	-1.567	-1.909	1.87	1.87	1.89
B. Canada						
CUD	-0.615	-2.086	-2.058	1.81	1.87	1.87
CUF	-0.048	-2.034	-2.597	1.89	1.93	1.94
IFLF	-1.198	-1.299	-2.245	1.97	1.97	1.95
IFLD	-0.970	-1.503	-1.485	1.90	1.91	1.92
C. Germany						
CUD	0.352	-1.331	-2.400	1.98	1.97	2.00
CUF	-0.210	-1.925	-2.096	1.85	1.85	1.85
IFLF	-1.263	-1.594	-1.967	1.85	1.83	1.83
IFLD	-1.370	-2.280	-2.230	1.99	1.99	1.99
D. Italy						
CUD	0.074	-1.054	-2.965	1.95	1.97	2.12
CUF	-0.125	-2.230	-2.420	1.88	1.87	1.87
IFLF	-1.323	-1.544	-2.250	1.95	1.94	1.82
IFLD	-1.053	0.353	-1.998	2.09	2.00	2.03
E. Japan						
CUD	0.684	-1.596	-2.520	1.98	1.96	1.97
CUF	-0.230	-1.820	-2.056	1.84	1.84	1.85
IFLF	-1.167	-1.150	-2.393	1.98	1.98	1.96
IFLD	-0.996	1.969	-2.570	1.72	1.75	1.81

presence of unit roots. Therefore, it is concluded that the CUD, CUF, IFLF, and IFLD for the U.S.A. reflect a non-stationary process which contains only one unit roots.

From Table 1, parts B, C, D and E, show that the CUD, CUF, IFLF and IFLD structural variable series for, respectively, Canada, Germany, Italy, and Japan also follow the same behavior as the structural variable series for the U.S.A.. That is, the null hypothesis for a unit root process is accepted for each since the t-statistics are all greater than the critical value at the 5% level of significance for all three cases. Again, the DW values are all nearly 2.0, thus confirming that the CUD, CUF, IFLD, and IFLF for Canada, Germany, Italy, and Japan each contains one unit root. Unit root tests confirm that the variables in consideration all have one unit root, that is, all the variables are I(1), integrated of order 1. The result is robust in the sense that all the different specification for unit root tests led to the consistent result. The finding that the variables in the system all have the same degree of order leads one to investigation of long run relationship among the variables using Cointegration and Error correction.

3.2. Long-Run Relationships

A principle feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long-run equilibrium, and the movements of at least some of the variables must respond to the magnitude of this disequilibrium. For example, a hypothesis has been purposed that the domestic inflation rate (IFLD) used for this study has a long-run stable relationship with the domestic capacity utilization rate (CUD), the average of foreign capacity utilization rate (CUF) for the remaining four countries, and the average of foreign inflation rate (IFLF) for the remaining four countries. If the gap between, say, the IFLF and the IFLD is "large" relative to their long-run relationship, then the IFLF must have tendency toward the IFLD. Here, there are four variables in the consideration of cointegration and the linear combination of the variables should behave so that all of them do not stay too far away from one another over time. The key for having all the variables in the system stay close to one another is that the variables have common stochastic trends. Of they have the same stochastic trends, then it is easy to see that these variables are closely related. Of course, the confirmation of such possibility should be based on econometric tests and cointegration methods provide the means.

Evidence has been presented in Table 2 and 3 for the CI and ECM models among the CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan. First, equations (2.30)–(2.34) are reintroduced here for cointegration of the model for five countries among the four variables of consideration, as follows:

$$(IFLD_{(USA)t}) = \alpha_0 + \beta_0 \log(CUD_t) + \phi_0 \log(CUF_t) + \gamma_0(IFLF_t) + \varepsilon_{0t}, \quad (2.30)$$

$$(IFLD_{(CAN)t}) = \alpha_1 + \beta_1 \log(CUD_t) + \phi_1 \log(CUF_t) + \gamma_1(IFLF_t) + \varepsilon_{1t}, \quad (2.31)$$

$$(IFLD_{(DEU)t}) = \alpha_2 + \beta_2 \log(CUD_t) + \phi_2 \log(CUF_t) + \gamma_2(IFLF_t) + \varepsilon_{2t}, \quad (2.32)$$

$$(IFLD_{(ITA)t}) = \alpha_3 + \beta_3 \log(CUD_t) + \phi_3 \log(CUF_t) + \gamma_3 (IFLF_t) + \varepsilon_{3t}, \quad (2.33)$$

$$(IFLD_{(JPN)t}) = \alpha_4 + \beta_4 \log(CUD_t) + \phi_4 \log(CUF_t) + \gamma_4 (IFLF_t) + \varepsilon_{4t}, \quad (2.34)$$

and where $\alpha_i, \beta_i, \phi_i$, and γ_i are parameters to be estimated. The test method for cointegration have been purposed and discussed in the previous chapter.

A different kind of CI method popularly used in most European countries, believed to be more accurate than previously available tests, has been introduced by MacKinnon (1991.) The results of simulation experiments are summarized by the means of response surface regressions, asymptotic critical value can be read directly, and the critical values for any finite sample size can be easily computed using a hand calculator.[6] The procedure is as follows. First, run the cointegrating regression for IFLD on CUD, CUF, and IFLF for the U.S.A., Canada, Germany, Italy, and Japan with and without a constant, as described in (2.30)–(2.34.)[7] Second, changes in the residuals on past level and four lagged changes are regressed, and the t-statistic of the lags were not significance at the 5% level used in the ADF tests. Thus, the DF regression was run, as given in the following equations, where the residuals only for the past levels were used. Two methods use basically the same procedures for the testing of stationarity of the residuals. The stationarity of the residuals from cointegrating regression guarantees that the linear combination of the variables follows a stable path over time toward which any deviation of any variable is adjusted to move in the subsequent time periods.

As a result, the testing of cointegration is tantamount to testing the unit root of the residuals from the cointegrating equation. If the residuals contain unit roots, then any linear combination of the variables dose not have a stable long run path. If the residuals turn out to be stationary, then the variables are found to have common stochastic trend around which a long run stable path is formed.

The following specifications, then, suffice for cointegration test.

Case 1 $$\Delta\varepsilon_t = a_1\hat{\varepsilon}_{t-1} + \xi_t, \tag{2.35}$$

Case 2 $$\Delta\varepsilon_t = \eta + a_1\hat{\varepsilon}_{t-1} + \xi_t, \tag{2.36}$$

Case 3 $$\Delta\varepsilon_t = \eta + \delta t + a_1\hat{\varepsilon}_{t-1} + \xi_t. \tag{2.37}$$

---

[6]The tables of critical values are provided in Appendix A.

[7]The cointegrating regression for the MacKinnon test was run without a constant.

TABLE 2: The t-Statistic Results for the Dickey-Fuller Tests of Residuals Among CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan, 1978:I to 1992:II Quarterly.

Equations: $\Delta\varepsilon_t = a_1\hat{\varepsilon}_{t-1}\xi_t$ (case 1),

$\Delta\varepsilon_t = \eta + a_1\hat{\varepsilon}_{t-1}\xi_t$ (case 2),

$\Delta\varepsilon_t = \eta + \delta t + a_1\hat{\varepsilon}_{t-1}\xi_t$ (case 3),

where

ε = residuals of regression among CUD, CUF, IFLF, and IFLD, and
Δ = an operator designating the quarter-to-quarter first difference.

t- statistic for $a_1 = 0$	case 1	case 2	case 3
A. EG tests			
U.S.A	-6.482	-6.416	-6.988
Canada	-5.867	-5.810	-6.095
Germany	-6.579	-6.512	-6.646
Italy	-6.960	-6.896	-6.967
Japan	-11.365	-11.258	-11.229
B. MacKinnon tests			
U.S.A		-5.032	-5.027
Canada		-5.810	-6.079
Germany		-6.514	-6.651
Italy		-4.473	-5.208
Japan		-10.267	-10.194

Note: In MacKinnon CI test, the constant term was not included in the cointegrating regression. Therefore, case 1. (without constant) has been excluded from consideration.

where ε_t are residuals from cointegrating regression. The testable hypothesis is H_0: $a_1 = 0$.

Some of the essential statistical results are presented in Table 2 using both the Engle and Granger (1991) approaches and MacKinnon (1991) approaches, based upon equations (2.35)–(2.37) from Chapter 2. However, the MacKinnon approaches were confined to the use of equations (2.36) and (2.37) wherein the critical value were provided from the appropriate MacKinnon table.

To reject the null hypothesis for "no cointegration," the t-statistic for the MacKinnon test should be greater than -3.45, and -3.96 in cases 2 and 3, in absolute value, respectively, reflected in approximately 50 of the sample data. However, the critical value for the two tests was based on the 5% level of significance. If the null hypothesis of "no cointegration" at the 5% level was rejected, the residual behaviors would reflect a stationary series; though the variables themselves were nonstationary, their linear combination behaves like a stationary series. In other words, the variables have a long run relationship or they will somehow be settled at some point to an equilibrium state.

Table 2 reports both Dickey-Fuller type and MacKinnon cointegration test results. The relationship among the CUD, CUF, IFLF, and IFLD for the five countries indicates that the null hypothesis of no cointegration cannot be accepted. Hence, at the 5% significance level, failure to accept the null hypothesis of no cointegration indicates acceptance of the alternative that the variables are cointegrated.

Part A of Table 2. reports Dickey-Fuller type cointegration test results. It is clear that the t-statistic values for all three cases are greater than the critical value. Thus, the null hypothesis of a "no cointegration" relationship among the CUD, CUF, IFLF, and IFLD residuals for the U.S.A, Canada, Germany, Italy, and Japan cannot be accepted. Nonetheless, a second series of test was performed to assure the accuracy of these long-run relationships based upon the MacKinnon approach. From Table 2, part B, it may be seen that all the t-statistic values are in excess of the 5% response surface estimates of the critical values using the MacKinnon approach. Thus, these relationships are apparently cointegrated. Based upon these two approaches, it is apparent that the CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan are cointegrated, and there is thus a stable long-run relationship among the variables.

Once a cointegration is established, one can go on and fit Error-correction for the variables of the system. As discussed before, error correction shows the tendency of the system toward the stable path when at some point in time the system is off the path. It has been argued that the coefficient on lagged residuals should be significantly negative, which means that any previous deviation from the stable path would be quickly corrected for. Adjustment occurs in a way that any positive (or negative) deviation from the stable path declines (or increases.)

From Table 3, the coefficients for the lagged residuals have appropriate signs and sizes for an error correction term and are individually significant. The DW provided a good explanation for the fact that there were no autocorrelations among the errors, indicated as 1.85, 1.55, 1.82, 1.99 and 1.80 for, respectively, the U.S.A., Canada, Germany, Italy, and Japan.

Here, standard t-statistics are used for the hypothesis test, H_O: $e_1 < 0$, since all the variables in the ECM regression are all stationary. First, the first differences of the variables had been found to be stationary using unit root tests and the DW tests. Second, the lagged residuals were found to be stationary using cointegration tests.

TABLE 3: ECM Regressions among CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan.

$$\text{Equation:} \quad \Delta(Y_t) = a_1 + b_1 \Delta\log(W_t) + c_1 \Delta\log(X_t) + d_1 \Delta(Z_t) + e_1\, RESIDS_{t-1} + \varepsilon_t,$$

where
Y = the IFLD rate for the U.S.A., Canada, Germany, Italy, and Japan,
W = the CUD rate for the U.S.A., Canada, Germany, Italy, and Japan,
X = the CUF rate for the U.S.A., Canada, Germany, Italy, and Japan, and
Z = the IFLF rate for the U.S.A., Canada, Germany, Italy, and Japan.

Dep. Variables.	U.S.A.	Canada	Germany	Italy	Japan
Estimated e_1	-0.7883	-0.7890	-0.9763	-0.9089	-1.4640
Standard error	0.1513	0.1360	0.1546	0.1455	0.1292
t-Statistic for $e_1 < 0$	-5.2145	-5.7830	-6.3146	-6.2442	-11.3233
DW	1.85	1.55	1.82	1.99	1.80
$\overline{R}^2$	0.48	0.46	0.51	0.50	0.74

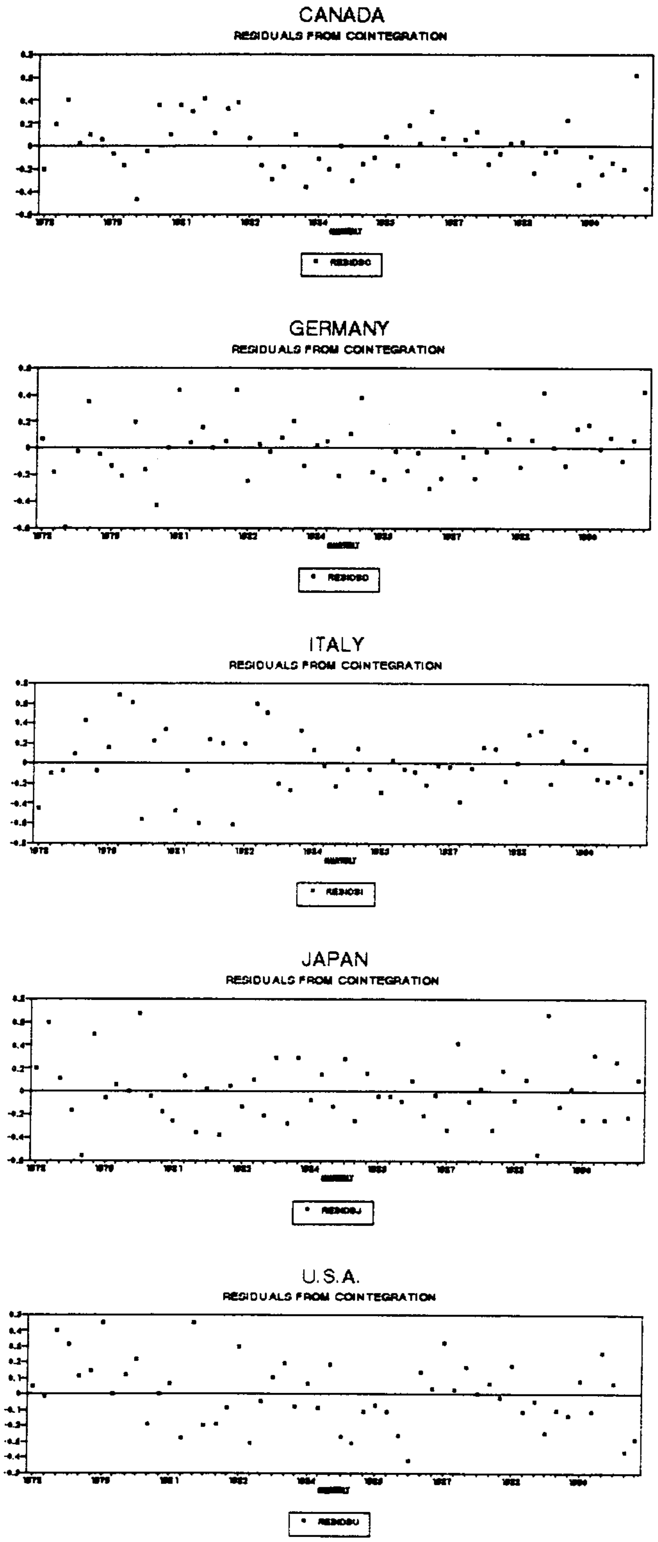
The coefficients on lagged residuals are consistently negative and show a strong tendency to correct for previous periods' errors. These coefficients are statistically significantly different from zero and negative, as expected from a stable relationship among the variables.

Notice the discrepancy among the magnitudes of these five adjustment coefficient speeds; in absolute values, wherein the Japanese coefficient was the fastest speed and the U.S. coefficient was the slowest speed to adjust to the long-run path. That is, the Japanese coefficient was approximately twice that of the U.S. coefficient. Moreover, the error correction term was about 5 standard deviations from zero for the U.S.A. (0.7883/0.1511 = 5.22) and approximately 11 standard deviations from zero for Japan (1.464/0.1292 = 11.33). Hence, at the 5% significance level, it may be concluded that the speed of the adjustment term was significantly different from zero for both the U.S. and Japan, as well as the remaining three countries.

Japan demonstrated the fastest adjustment to the long-run path and the U.S. demonstrated the slowest adjustment. In fact, the results for Japan reveal an over adjustment: a deviation from the long-run path for a previous period led to more than a one-for-one correction during the following period. The remaining countries do not show the kind of overshooting demonstrated by the results for Japan, and for them the adjustment occurred rather more quickly. The second point to examine is the German coefficient, which was the second fastest in speed adjustment, approximately 1.2 times more rapid than the U.S. coefficient. The error correction term was about six standard deviations from zero for Germany (0.9763/0.1546 = 6.31).

Figure 6 shows the plot of the residuals from the cointegrating regressions among the CUD, CUF, IFLF, and the IFLD for the U.S.A., Canada, Germany, Italy, and Japan. The residuals show the pattern typical for any stationary series. They do not show any tendency of persistence in the positive or negative. They are scattered around zero and do not stay too far away from it. The result is remarkable since the variables in the system were all I(1), unit root processes, but their linear combination turned out to be I(0), a stationary process. This confirmed that there was a cointegration among the variables. Clearly, though many developments can cause temporary or even permanent changes in the individual elements of the CUD, CUF, IFLF, and IFLD variables, there is a long-run equilibrium attractor which ties the individual components together.

FIGURE 6. The Cointegrating residuals among the domestic capacity utilization rate(CUD), the foreign capacity utilization rate(CUF), the foreign inflation rate(IFLF), and the domestic inflation rate(IFLD) for five countries



3.3. Short-Run Dynamics

Cointegration and Error correction are about a single equation and show how a system of variables tend to move together over time. However, this single equation model cannot adequately describe how a change in one element (variable) of the system is spread over to the other elements (variables) over an extended period of time. The reason is that cointegration is basically a contemporaneous relation and error correction considers only changes in two adjacent periods. If an investigators' objective is to look at what happens to the system over relatively long period following a shock to one of the system variables, this single equation model cannot adequately explain the transmission process.

Therefore, a structural economic model using "structural vector autoregression" is specified and estimated to examine short-run dynamics among the variables CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan. Following the procedure described in Chapter 2, the investigation of the model is based upon (1) Granger-causality, (2) variance decomposition of forecast errors, and (3) impulse response function.

Since the variables were found to be nonstationary, there is a temptation to use the first-difference series for the VAR. However, recent econometric studies (e.g., Hamilton, 1994) have found that if the variables are cointegrated, using levels data for the VAR is appropriate. Therefore, levels data were used for VAR estimation with the addition of constants and trends. The trend terms were intended to capture common trend movements among the variables.

The four variable VARs to be estimated are as follows:

$$\log(CUD_t) = a_0 + b_0 \text{ trend} + \sum_{i=1}^{4} \alpha_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \beta_i \log(CUF_{t-i})$$

$$+ \sum_{i=1}^{4} \gamma_i (IFLD_{t-i}) + \sum_{i=1}^{4} \delta_i (IFLF_{t-i}) + \varepsilon_{0t}, \tag{2.52}$$

$$\log(CUF_t) = a_1 + b_1 \text{ trend} + \sum_{i=1}^{4} \chi_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \eta_i \log(CUF_{t-i})$$

$$+ \sum_{i=1}^{4} \iota_i (IFLD_{t-i}) + \sum_{i=1}^{4} \varphi_i (IFLF_{t-i}) + \varepsilon_{1t}, \tag{2.53}$$

$$(IFLF_t) = a_2 + b_2 \text{ trend} + \sum_{i=1}^{4} \kappa_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \lambda_i \log(CUF_{t-i})$$

$$+ \sum_{i=1}^{4} o_i (IFLD_{t-i}) + \sum_{i=1}^{4} \nu_i (IFLF_{t-i}) + \varepsilon_{2t}, \tag{2.54}$$

$$(IFLD_t) = a3 + b_3 \text{ trend} + \sum_{i=1}^{4} \pi_i \log(CUD_{t-i}) + \sum_{i=1}^{4} \theta_i \log(CUF_{t-i})$$

$$+ \sum_{i=1}^{4} \tau_i (IFLD_{t-i}) + \sum_{i=1}^{4} \upsilon_i (IFLF_{t-i}) + \varepsilon_{3t}, \tag{2.55}$$

where CUD is a vector of domestic capacity utilization variables, CUF is a vector of the weighted average of capacity utilization (foreign capacity utilization), IFLF is a vector of foreign inflation, IFLD is vector of domestic inflation, and a, b, $\alpha, \beta, \gamma, \delta, \chi, \eta, \iota, \varphi, \kappa, \lambda, \nu, o, \pi, \theta, \tau, \upsilon$ are the parameters to be estimated, and where ε_{0t}, ε_{1t}, ε_{2t}, and ε_{3t} are orthogonal disturbances. The notations "log" and "t" represent, respectively, logarithms and time indexes (in quarters.) All the variables are from 1978:I to 1992:II. Note that the right-hand side variables are the same for all the equations, and they are all predetermined.

From these reduced form models, the estimated dynamic responses of the economy to shocks to these alternative variables measures were interpreted as reflecting the structural effect among their relationships for the CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan during a specific historical period.

Results for the Granger-causality tests are reported in Table 4 for the current and four past lags variable and $\overline{R}^2$ results. Each test for causality required a total of four regressions for determination of casual relationships between CUD, CUF, IFLF, and IFLD: (1) CUD was regressed for current and four past or lagged values of CUF regression, four past or lagged values of IFLF regression, four past or lagged values of IFLD regression, and four past or lagged values for itself; (2), (3), and (4) are identical with the exception that CUF was used as the dependent variable and was regressed for current and past values of CUD, IFLF, IFLD; then, IFLF was used as the dependent variable and was regressed for current and past values of CUD, CUF, IFLD; and then, IFLD was used as the dependent variable and was regressed for current and past values of CUD, CUF, and IFLF, and four past or lagged values for itself. To satisfy Granger-causality, one should find that according to an F-test the current and past values of CUD are significantly different from zero in the regression of, say, IFLD for CUD, CUF, IFLF.

Three principal conclusions have been reached. First, the CUD does Granger-cause the domestic inflation rate for the cases of Italy and Japan. In other words, the past lagged domestic capacity utilization rates for Italy and Japan have predictive powers for the forecasting of their current values of domestic inflation rates. Second, the CUF does not seemingly affect the inflation rates of any of the countries, with the exception of Italy. Third, foreign inflation rates do Granger-cause the Italian and Japanese inflation rates. Hence, a change in the inflation rate in one country does seemingly have an effect upon the domestic inflation rates of specific other countries.

Though Table 4 reports all of the variables which involved in the use of the Granger-causality test for this model, focus for the present study is directed only at

<u>TABLE 4</u>: Marginal Significance Levels for CUD, CUF, IFLF, and IFLD for Forecasting Alternative Measures of Economic Activity.

$$\text{Equation: } \log Y_t = a_0 + \sum_{i=1}^{4} b_i \log (Y_{t-i}) + \sum_{i=1}^{4} c_i \log (W_{t-i})$$

$$+ \sum_{i=1}^{4} d_i \log (X_{t-i}) + \sum_{i=1}^{4} e_i \log (Z_{t-i}) + \varepsilon_t,$$

where Y = [CUD, CUF, IFLF, IFLD],
W = [CUF, IFLF, IFLD, CUD],
X = [IFLF, IFLD, CUD, CUF], and
Z = [IFLD, CUD, CUF, IFLF].

Dependent Variables	Independent Variables F - statistics & (Significance level)				
A. U.S.A.	CUD	CUF	IFLF	IFLD	$\bar{R}^2$
1. CUD	57.71 (0.00)	0.64 (0.63)	0.46 (0.76)	0.79 (0.53)	0.93
2. CUF	0.77 (0.55)	80.67 (0.00)	0.84 (0.50)	1.44 (0.24)	0.98
3. IFLF	0.62 (0.64)	0.31 (0.86)	3.78 (0.01)	4.44 (0.00)	0.82
4. IFLD	1.18 (0.33)	1.52 (0.21)	0.65 (0.62)	1.62 (0.19)	0.71

B. Canada.	CUD	CUF	IFLF	IFLD	$\bar{R}^2$
1. CUD	52.86 (0.00)	0.73 (0.57)	1.39 (0.53)	1.36 (0.26)	0.94
2. CUF	3.93 (0.01)	97.32 (0.00)	2.11 (0.10)	2.25 (0.08)	0.98
3. IFLF	1.46 (0.23)	2.61 (0.05)	1.28 (0.29)	0.43 (0.77)	0.71
4. IFLD	0.39 (0.81)	1.43 (0.24)	1.27 (0.29)	0.21 (0.93)	0.67

C. Germany.	CUD	CUF	IFLF	IFLD	$\bar{R}^2$
1. CUD	92.58 (0.00)	2.19 (0.09)	1.61 (0.19)	1.75 (0.16)	0.99
2. CUF	0.53 (0.71)	102.93 (0.00)	0.80 (0.53)	0.58 (0.67)	0.97
3. IFLF	4.18 (0.01)	2.15 (0.09)	0.95 (0.44)	4.12 (0.01)	0.84
4. IFLD	2.02 (0.11)	0.87 (0.48)	0.87 (0.49)	2.08 (0.10)	0.47

D. Italy.	CUD	CUF	IFLF	IFLD	$\bar{R}^2$
1. CUD	41.33 (0.00)	0.73 (0.57)	0.31 (0.86)	0.33 (0.85)	0.98
2. CUF	3.84 (0.01)	90.06 (0.00)	0.58 (0.67)	1.01 (0.41)	0.98
3. IFLF	2.18 (0.09)	1.76 (0.15)	1.88 (0.13)	1.02 (0.40)	0.76
4. IFLD	4.87 (0.00)	4.24 (0.00)	3.55 (0.01)	4.48 (0.01)	0.87

E. Japan.	CUD	CUF	IFLF	IFLD	$\bar{R}^2$
1. CUD	129.29 (0.00)	1.30 (0.29)	1.51 (0.22)	0.33 (0.85)	0.98
2. CUF	3.16 (0.02)	344.83 (0.00)	3.42 (0.02)	1.85 (0.14)	0.98
3. IFLF	2.22 (0.08)	2.44 (0.06)	2.93 (0.03)	1.37 (0.26)	0.85
4. IFLD	5.07 (0.00)	1.23 (0.31)	5.27 (0.00)	12.28 (0.00)	0.73

the particular interests shown in Table 4, parts A through E, row four (IFLD = f (CUD, CUF, IFLF, 4 past lags).) First, from Table 4A4, the current and lagged values of the U.S. CUD have no predictive forecast powers for U.S. inflation. Second, the current and lagged values for CUF also have no predictive forecast powers for current U.S. inflation (IFLD.) These values clearly do not exceed the 5% critical value F-test, thus the null hypothesis can be accepted. In other words, there is no causality from U.S. CUF to U.S. IFLD. Third, the current and lagged values of weighted average inflation rates have no predictive forecast powers for the current U.S. inflation rate. That is, there is no causality from the foreign inflation to the U.S. inflation.

From Table 4B4, the current and lagged values for CUD had no predictive forecast powers for the current Canadian inflation rate, and the current and lagged values of for CUF had no predictive forecast powers for the current Canadian inflation rate. Moreover, the current and lagged values for the IFLF also had no predictive forecast powers for the current Canadian inflation rate. That is, these relations showed no causality from the Canadian CUF and IFLF to the Canadian inflation rate. Thus, no casual relationship from CUD, CUF, IFLF, to IFLD was demonstrated for Canada at the 5% significance level.

From Table 4C4, the current and lagged values for the CUD, the current and lagged values for the CUF, and the current and lagged values for the IFLF for Germany did not have a Granger-causal forecast relationship for the current German inflation rate. Thus, the null hypothesis of no casual relation from German CUD, CUF, and IFLF to IFLD at the 5% significance level could not be rejected.

From Table 4D4 and 4E4, the lagged values of the CUD rates for Italy and Japan had predictive forecast powers for the current inflation rates of the two countries. That is, the null hypothesis, at the 5% significance level, that there was no causality from the CUD of Italy and Japan to inflation rates in the two countries were rejected. Only the lagged value of the foreign capacity utilization rate in Italy had predictive forecast powers for the current Italian inflation rate. Moreover, the current and lagged IFLF for Italy and Japan did have a Granger causal relationship for forecasts of the inflation rates for the two countries. Thus, the null hypothesis that there was no causality from the foreign inflation rate to Italian and Japanese inflation rates at the 5% significance level was rejected.

To this point, Granger-causality tests have been used to assess predictive forecast powers for the variables of concern. However, there are several explanation for the inconsistency of the causal finding since the results do not uniformly follow the same predictive paths. First, poor Granger causality results may be a consequence of mis-specification. There could be other variables that should have been included in the determination of inflation rates. But the nature of VAR considered for the present study required the exclusion of such potentially important variables as the money supply. More comprehensive specifications could lead to improved Granger-causality results, but only at the cost of less reliable VAR results.

Second, there may be a lag problem since only four lags were added using this method. Adding more lags may lead to different conclusions from VAR(4) results, but a lag structure which is too long may not be appropriate for short-run adjustment dynamics. Finally, the Granger-causality tests provide little information about the relative effectiveness of predictive powers in explaining individual variables or their relationship to other variables considered in the model. For that type of result, it would be necessary to move to simulations from the VAR model. This is one reason why Sims (1980) focused on a different measure of predictive power for forecasting short-run fluctuations, or one constructed from a VAR with orthogonalized residuals. In this case, the percentage of variance of forecast variables attributable to alternative right-hand-side variable at different horizons is examined. This metric approach also has its drawbacks, including dependence on the horizon as well as low levels of statistical significance.

Variance decomposition reveals how important a variable is for forecasting other variables. The correlation/covariance among the residuals from each equation are used for the analysis. The following results are based on exactly the same data, models, and specifications as before, with the exception that variance decomposition requires that we estimate complete vector autoregressions, rather than single equations. Thus, each row in Table 5 summarizes a complete VAR, each of which includes four lags of the variable to be forecast, as well as the CUD, CUF, IFLF, and IFLD for the U.S.A., Canada, Germany, Italy, and Japan. The entries in the table are the percentages of variance of the row variables at the 24-quarter horizon, wherein only the 2-, 4-, 8-, 12-, and 20-quarter horizons are indicated in Table 5. The results obtained strongly support the view that the CUD, CUF, and IFLF are an informative variables of predictive forecast powers for the IFLD for all five countries.

For the U.S., the foreign capacity and foreign inflation were very significant even within a year (or 4 quarters). More than 2/5 of the forecast error of domestic inflation rate are explained by the innovations in the CUF and IFLF. Domestic capacity utilization rate (CUD) is slightly less important than others. However, this phenomenon is an exception. for other countries, the importance of innovation in CUD grows significantly over time and it explains about 20% of forecast errors of the domestic inflation rate in 2 years.

Overall, innovations in CUD, CUF, and IFLF are almost equally important in explaining forecast errors of domestic inflation, although each country reveals slightly different pattern.

TABLE 5: Variance Decomposition of Forecast Errors for Domestic Inflation.

Equation: $X_t = \sum_{s=1}^{4} \beta_s X_{t-s} + \mu_t$, where X_t = [CUD, CUF, IFLF, IFLD].

A. Forecast Horizon (quarter) for U.S.A.	CUD	CUF	IFLF	IFLD
2 quarter	8.87	15.75	22.77	52.59
4 quarter	7.16	22.91	20.18	49.73
8 quarter	9.51	28.80	19.38	42.32
12 quarter	9.63	27.83	21.97	40.55
20 quarter	10.87	27.71	21.26	39.64
B. Forecast Horizon (quarter) for Canada	CUD	CUF	IFLF	IFLD
2 quarter	9.11	1.65	4.66	84.56
4 quarter	11.59	1.66	6.22	80.52
8 quarter	12.70	18.10	7.25	61.94
12 quarter	17.96	28.23	6.09	47.70
20 quarter	20.58	29.32	7.03	43.05
C. Forecast Horizon (quarter) for Germany	CUD	CUF	IFLF	IFLD
2 quarter	10.73	9.03	35.65	44.58
4 quarter	13.22	14.40	29.90	42.44
8 quarter	17.51	13.44	31.77	37.76
12 quarter	22.93	13.15	28.77	35.14
20 quarter	24.64	13.38	27.99	33.97
D. Forecast Horizon (quarter) for Italy	CUD	CUF	IFLF	IFLD
2 quarter	19.82	2.00	1.46	76.69
4 quarter	14.32	6.78	20.69	58.18
8 quarter	17.59	11.07	24.13	47.18
12 quarter	20.03	11.33	23.19	45.44
20 quarter	20.44	12.50	24.54	42.50
E. Forecast Horizon (quarter) for Japan	CUD	CUF	IFLF	IFLD
2 quarter	9.31	5.3	15.23	70.14
4 quarter	20.91	4.85	14.01	60.15
8 quarter	19.69	8.25	15.72	56.32
12 quarter	20.93	8.14	15.36	55.56
20 quarter	27.18	6.83	16.13	49.84

From this VAR method using forecast error decomposition, it is concluded that: (1) domestic capacity utilization rate strongly impact domestic inflation rates, (2) foreign capacity utilization rates have a significant impact upon domestic inflation rates, especially for the United States, and (3) foreign inflation rates strongly impact domestic inflation rates. Thus, the VAR method using forecast error variance of decomposition provides a concrete evidence for the impact of the CUD, CUF and the IFLF on IFLD in the present study.

Table 5. shows that in explaining the forecast error of domestic inflation rate, its own innovation (shock) is the most important component for all the countries at all since a history of its own past would have a lasting effects far into the future when a variable is a unit root process (Blanchard and Fischer, 1989.)

Second, the CUD for Canada, Germany, Italy, and Japan contributed from 10 to 30 percent of the forecast error variance of decomposition to the domestic inflation rates for the 2-, 4-, 8-, 12-, and 20-quarter horizons in each country. Thus, domestic capacity utilization seemingly had an impact upon the Canadian, German, Italian, and Japanese inflation rates. On the other hand, the CUD for the U.S.A. contributed somewhat less than 10 percent of the forecast error variance of the U.S. inflation rate (IFLD) from the 2- to 20-quarter horizons. One possible explanation for these findings is that since the mid-1970s, most U.S. manufacturing has been shifted to foreign countries due to higher production costs within the United States.

Third, the CUF for the cases of the U.S.A., Canada, Germany, and Italy contributed at least 10 percent of the forecast error variance of decomposition to their respective domestic inflation rates from the 2- to 20-quarter horizons. This indicated that foreign capacity utilization rates impact on domestic inflation rates, especially in the U.S.A. and Canada (accounting for nearly 30 percent at the 20-quarter horizon.) This may be because the U.S.A and Canada are largely open economies and are heavily reliant upon imported goods. For the foreign capacity utilization rate in Japan case, it contributed less than seven percent of the forecast error variance of decomposition to the Japanese domestic inflation rate from the 2- to 20-quarter horizons. One possible reason was that Japanese people apparently consumed most of their own domestic product, and were less reliant upon foreign products, facts which were statistically evident in the Current Account for Japan since 1980.

Finally, the IFLF for the U.S.A., Germany, Italy, and Japan contributed about one-fourth of the overall percentage of forecast error variance of decomposition to their respective domestic inflation rates. From these finding, it is clear that these countries behave more like open economic systems. Hence, the foreign inflation rate seemingly has an impact upon domestic inflation rates. However, the foreign inflation rate for Canada contributed less than eight percent of the forecast error variance of decomposition to the Canadian inflation rate from the 2- to 20-quarter horizon.

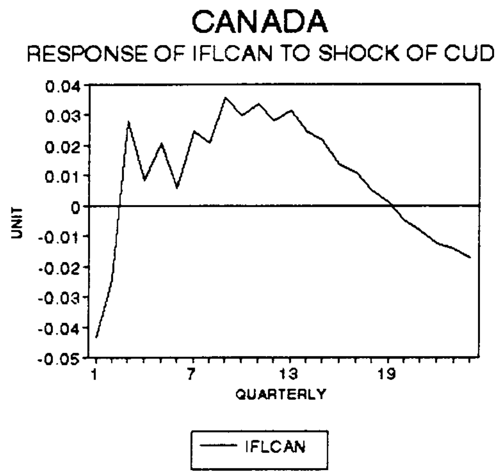
The most popular method within the VAR approach is the so-called "impulse response function." This is a multiplier analysis using simulations based on estimated VAR systems which trace out responses to shocks in the system. Figure 7 depicts the impulse-response functions that show what might occur at the level of the domestic inflation rates in Canada, Germany, Italy, Japan, and the U.S.A. if there were a one-time, one-standard-deviation positive shock to each CUD variable. Again, limiting the shock to one standard deviation ensures that it will be within the purview of the data from which the model is estimated. Figure 8 shows the response of the IFLF to a one-time, one unit shock to the CUF, which is another way to look at the effect of capacity utilization rate upon inflation from an overall view. Figures 9 and 10 use the same methodology of impulse-response function, except for use of a one-time, one-standard-deviation shock to the CUF and to the IFLF, respectively.

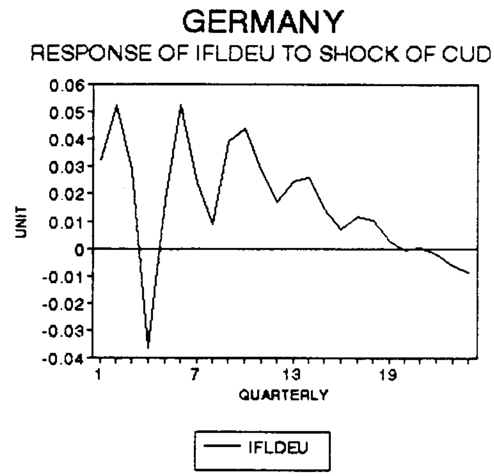
One could deal with one-unit shock to a variable but the problem is the units of the variables are not comparable. For example, the capacity utilization is an index whose base year figure is 100, whereas the inflation rate is in some percentage. As a result, deal with one-standard-deviation shock is much more meaningful and makes economic sense.

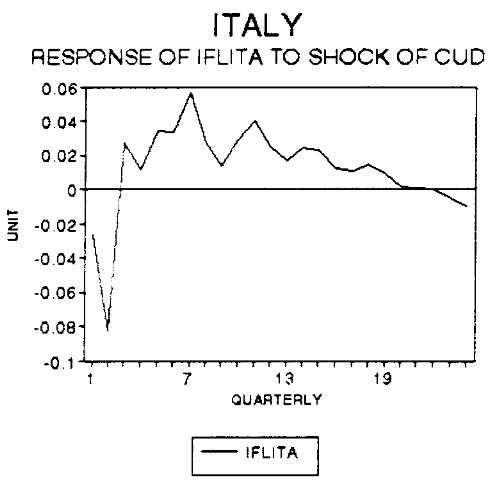
Figure 7 starts with the effect upon the Canadian inflation rate ($IFLD_{CAN}$) of one-standard deviation shock to domestic capacity utilization rate. Although, there is a delayed response for about two quarters, the finding still favors the predictive ability of the VAR. Note that after 2 quarters, there will be an increase in the domestic inflation rate after the domestic capacity utilization rate increases. For the response of the German inflation rate ($IFLD_{DEU}$) to a one-time, one-unit shock to the CUD, domestic capacity utilization pushed the German inflation rate up to 0.053 units, holding a positive response for about three quarters before changing to a negative response. Thus, this finding also favors predictive powers for this method of analysis.

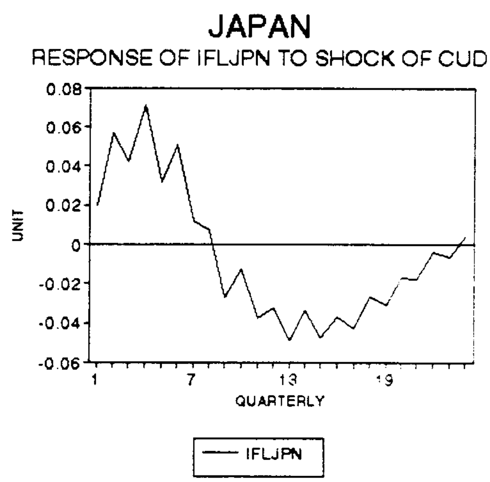
For the response of the Italian inflation rate ($IFLD_{ITA}$) and the U.S. inflation rate ($IFLD_{USA}$) to a one-time, one-standard-deviation shock to their respective CUD, the results demonstrate that there was a negative response for the inflation rates for the two countries at first. However, the negative response only held for about three quarters and then maintained a positive response for about eight quarters in the United State case and for more than 19 quarters before it died out in Italy. Thus, the finding are in general in favor of prediction for both the cases of both countries.

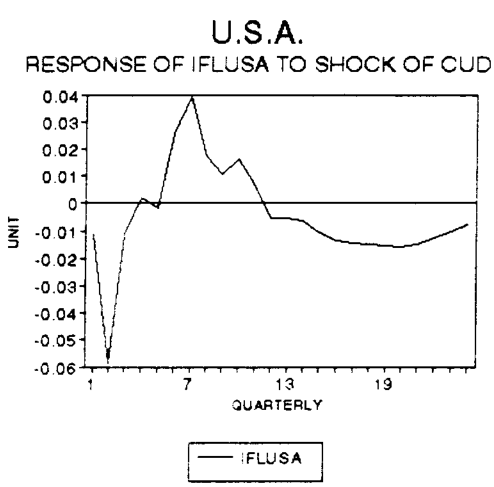
FIGURE 7. Response of IFLD for 5 Countries to a Shock from CUD











Where,

CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

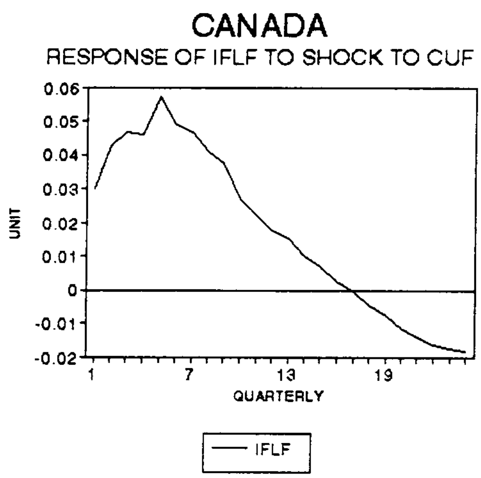
The final relationship from Figure 7 is the effect response of the Japanese inflation rate ($IFLD_{JPN}$) to a one-time, one-standard-deviation shock to the Japanese CUD. There was a one-time 0.077 increase in the Japanese inflation rate (IFLDJPN) with a peak coming in the 4th quarter, holding a positive response for about eight quarters or two years, and thus finding predicted movement.

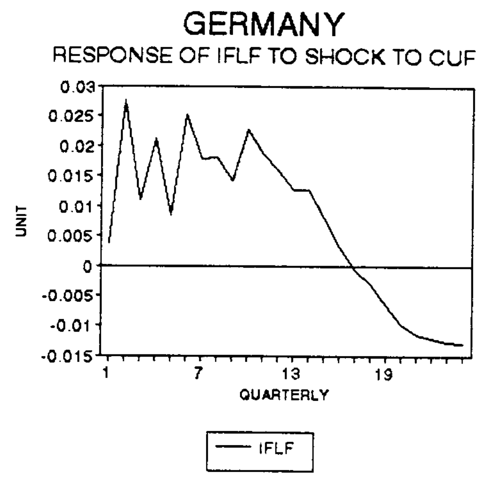
From these findings, it was concluded that there were uniformly predictive abilities for each country. Though the responses in the first few quarters did not shows a clear picture of reflections between domestic capacity utilization rates and domestic inflation rates, especially in the cases of Canada, Italy, and the U.S.A., the nonetheless followed a positive pattern, as was predicted. There is one possible reason to explain this phenomena, especially in the case of the U.S.A.. It is true in the real world that the domestic capacity utilization rate does not necessary have a full impact upon the inflation rate because of the effect of technological break-throughs. For example, there was the innovation of the development of computer-ized systems since the 1970s, an effect or impact would could have reduced the ef-fect of excess in capacity upon the inflation rate. Moreover, there has been a shift of manufacturing production to other foreign countries since the late 1970s, espe-cially in the United State.

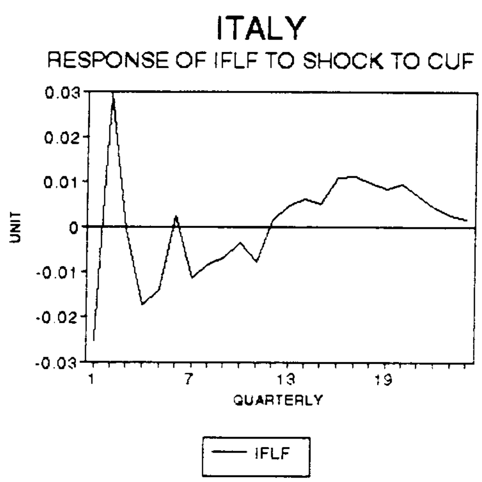
In general, one can conclude that excess domestic capacity can moderate domestic inflation rates since the evidence has shown a significant relationship be-tween the two variables for all of the five countries used for the present study.

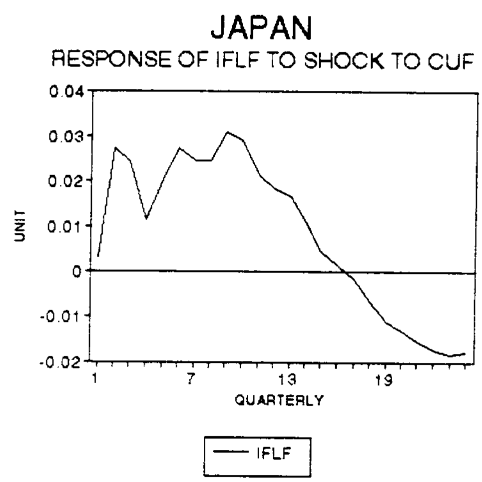
There is another way to look at the capacity utilization rate and the inflation rate. When the VAR for Canada is run, foreign countries' average inflation rates (IFLF) are positively affected by a positive shock in their countries' average capac-ity utilization rates (CUF), leading to an upward pressure upon the inflation rate. The same is true for the other countries considered, with the possible exception of

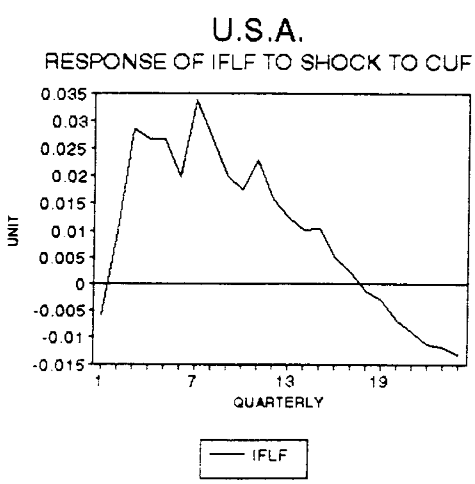
FIGURE 8. Response of IFLF for 5 Countries to a Shock from CUF











Where,

CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

Italy. The response of inflation rates to positive shocks in capacity utilization is more apparent in the VAR based upon averages than the case where individual countries' inflation rate responses to domestic capacity utilization rate is determined. It may be that averages are a better reflection of overall movement, eliminating the erratic behaviors of individual countries. When there is a one-time one-standard deviation shock to foreign countries' average CUF, the response of the foreign countries' average IFLF are positive even within a short horizon, with a slightly delayed response before reaching a peak for all five countries. This finding confirms that a shock to capacity utilization rates for all countries does impact the inflation rates within those countries in the expected direction over time.

Therefore, Figure 7 and 8 support the view that excess domestic capacity can moderate domestic inflation. An increase in capacity utilization rate has led to an increase in inflation rate. An increase in capacity utilization rate means there is less excess capacity available. Less excess capacity leads to accelerated inflation, according to impulse responses represented by Figure 7 and 8.

Figure 9 shows the responses in the domestic inflation rates for Canada, Germany, Italy, Japan, and the U.S.A. to shocks to the foreign capacity utilization rate (CUF.) The effect upon the Canadian domestic inflation rate ($IFLD_{CAN}$) positively responds to a shock in the foreign capacity utilization rate. Again, there was a delayed response which took about one quarter to reach a positive response level, whereupon it held for about 17 quarters before changing to a negative response. Thus, the finding favors the prediction that a one-time positive shock to CUF will cause an increase in the Canadian inflation rate ($IFLD_{CAN}$.)

The response of the German inflation rate ($IFLD_{DEU}$) to a one-time shock to the CUF pushed $IFLD_{DEU}$ up to a 0.055 unit increase with a peak in the 3rd quarter, continuing to hold for approximately the next two years. This result favored the prediction that a shock to CUF will cause a positive response to the German inflation rate ($IFLD_{DEU}$.) The response of the Italian inflation rate ($IFLD_{ITA}$) to a one-time shock to the CUF push $IFLD_{ITA}$ in an opposite direction. This finding belied the prediction that a one-time, one-standard-deviation shock to CUF should cause a positive response to $IFLD_{ITA}$ rather than a negative response. However, the inflation rate in Italy eventually respond positively in the longer horizon.

The response of the Japanese inflation rate($IFLD_{JPN}$) to a one-time shock to the CUF pushed the Japanese domestic inflation rate($IFLD_{JPN}$) higher. However, the pattern of response was zigzag-shaped, but held to a positive pattern for about 18 quarters. For the United State, it is clear that there was an effect response to a one-time 0.07 increase in the U.S. inflation rate ($IFLD_{USA}$) with a peak in the 2^{nd} quarter. Thus, the findings favor prediction.

The U.S. response of inflation rate to foreign capacity utilization rate is more dramatic than other countries, strongly supporting the view that excess capacity abroad can restrain domestic inflation rate. One reason that the U.S. inflation rate was sensitive to foreign capacity utilization is that the United State is the most open economy country in the world, and in comparison to the rest of the world, most of the goods used domestically originate from foreign countries.

One can conclude that with the exception of Italy, there was uniform favoring of predictable effects of foreign capacity utilization rate upon these industrialize countries' inflation rates. An increase in foreign capacity utilization rate means less excess capacity abroad. The finding in Figure 9. suggests that a reduction in foreign excess capacity leads to an accelerated inflation. Therefore, excess capacity abroad can restrain domestic inflation rates. One reason that these industrialized countries' inflation rates are sensitive to the foreign capacity utilization rate is that, once again, they are an open economy countries under flexible exchange rate regime.

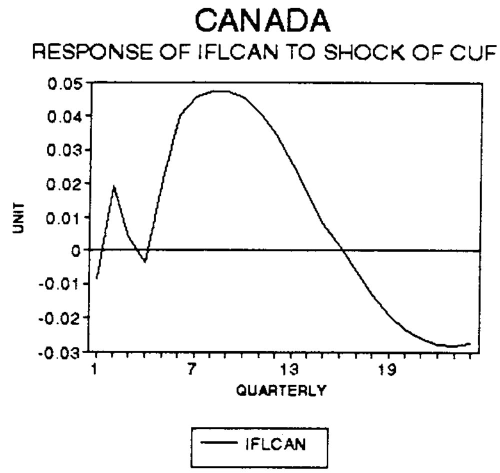
Though none are as open as the U.S., their import goods accounted for large percentages in each year since the early 1980s.

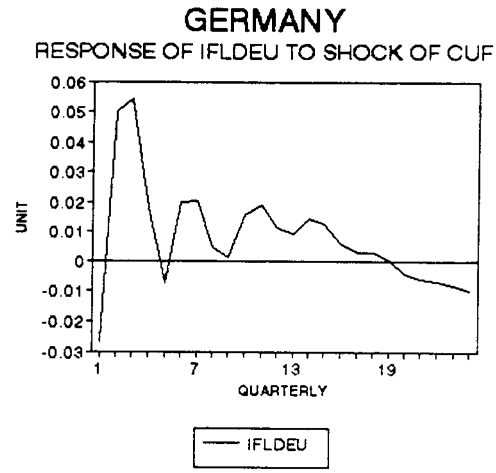
Figure 10 shows the responses in the domestic inflation rate for Canada, Germany, Italy, Japan, and U.S.A. to shocks in the foreign inflation rate (IFLF.) There was a response in the Canadian inflation rate ($IFLD_{CAN}$) of a one-time 0.034 unit increase in the Canadian inflation rate($IFLD_{CAN}$) with a peak in the 2^{nd} quarter holding for about 2.5 quarters before changing to a negative response. The response of the German inflation rate ($IFLD_{DEU}$) was also positive, holding for the short period of three quarters following a one-time shock to the foreign inflation rate(IFLF). Both finding favor the prediction.

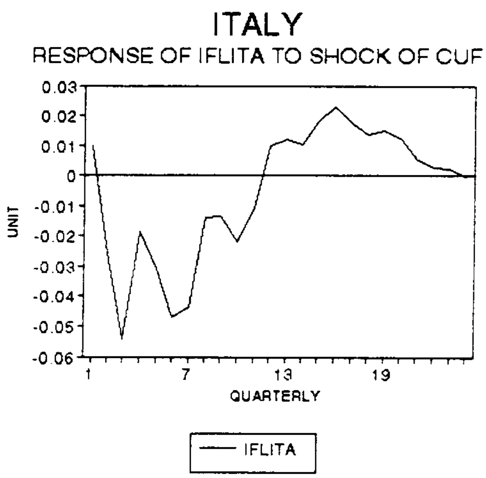
There was a response in the Italian inflation rate ($IFLD_{ITA}$) of a one-time 0.09 unit increase in the Italian inflation rate with a peak after 3^{rd} quarter and holding positive for about 12 quarters before changing to a negative response. Thus, the finding is a favor of prediction. In the case of the Japanese inflation rate, there was a response of a one-time 0.075 unit increase in the Japanese inflation rate with a peak coming before the 2^{nd} quarter and holding only for about three quarters. Finally, the one unit shock to the IFLF pushed the U.S. inflation rate ($IFLD_{USA}$) higher, lasting for about seven months before obtaining a negative response. Thus, in each of the above cases, the findings favored the prediction.

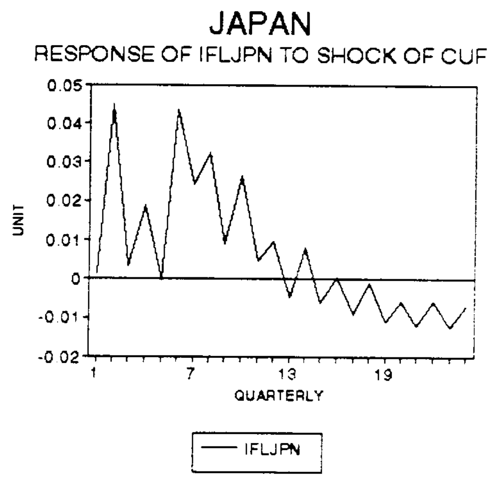
It is thus concluded that from all five countries' inflation rates when a shock to the foreign inflation rate occurs, the results are uniformly in favor of prediction. However, the shock to the IFLF does not seem to have a lasting impact on the domestic inflation rate since a positive responses held for only short periods of time. The evidence has shown positive relationships between the foreign and the domestic inflation rates when a shock occurs to the former. In other words, the foreign inflation rate does have a positive effect upon the domestic inflation rate.

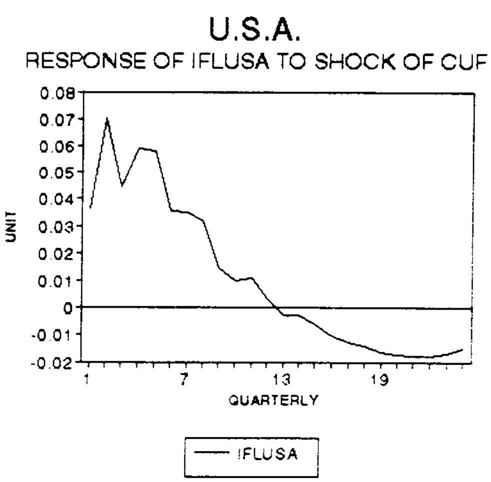
FIGURE 9. Response of IFLD for 5 Countries to a Shock from CUF











where,

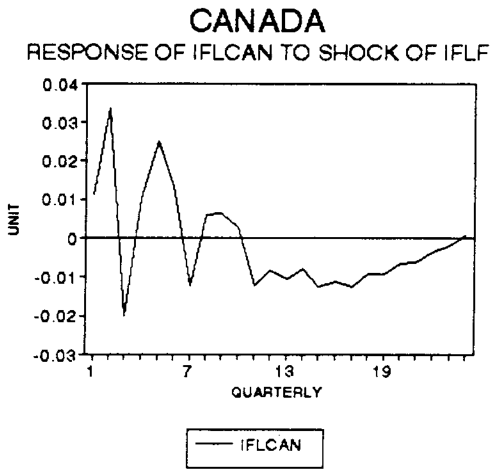
CUD is the domestic capacity utilization rate

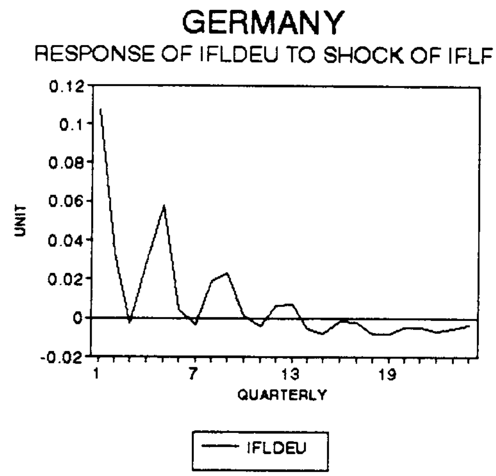
CUF is the foreign capacity utilization rate

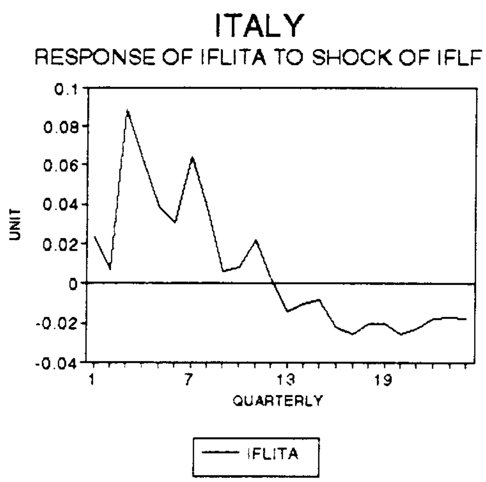
IFLF is the foreign inflation rate

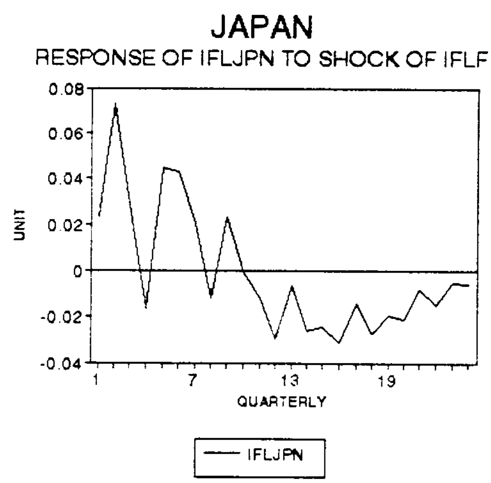
IFLD is the domestic inflation rate

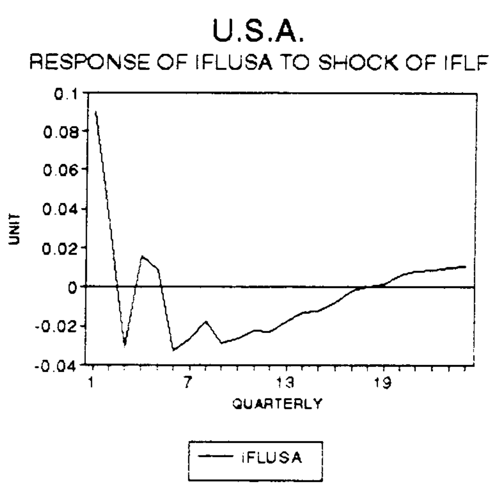
FIGURE 10. Response of IFLD for 5 Countries to a Shock from IFLF











where,

CUD is the domestic capacity utilization rate

CUF is the foreign capacity utilization rate

IFLF is the foreign inflation rate

IFLD is the domestic inflation rate

3.4. Summary of Findings

Recently developed time series methods have been used to discuss the relevance of capacity utilization rate, both domestic and foreign, in terms of forecasting domestic inflation rates. Both long-run and short-run analysis for five industrialized countries confirmed that the capacity utilization rate is still an important determinant of inflation rate. An increase in the domestic and foreign capacity utilization, turned out to have lasting, although somewhat delayed, positive effect on the domestic inflation rate over time. Foreign inflation also has positive effect on domestic inflation rate.

In particular, it has been found that the domestic capacity utilization rate, the foreign capacity utilization rate, the foreign inflation rate, and the domestic inflation rate for these five industrialized countries are cointegrated. In other words, the linear combination of the variables have a long run stable path toward which each individual component are attracted. A further investigation using Error correction mechanism has found that the deviation from a long-run path are quickly eliminated in the subsequent periods, and the adjustment process is statistically significant. It means that there is a strong tendency of the system toward a long run stable path. This is a contradiction to the growing belief that capacity utilization is no longer particularly relevant in forecasting inflation rate.

To investigate the short run transmission mechanism in the system of variables, the Vector Autoregression method has been used. Three different concepts, Granger-causality, Variance Decomposition, and the Impulse Response, has been used in the VAR framework. It has been found that domestic and foreign excess capacity can actually help restrain domestic inflation rate. The evidence is consistent for the sample of five industrialized countries. This is another contradiction that one can discount the importance or even ignore the importance of capacity utilization rate.

One can conclude that (1) excess domestic capacity can moderate domestic inflation, (2) excess capacity abroad can restrain domestic inflation, and (3) the foreign inflation dose transmit to domestic economy. This finding is important since previous studies found suggested otherwise.

CHAPTER 4

CONCLUSION

The present study raises two important questions that have not been settled yet. These are (1) Dose the domestic capacity utilization rate remain an important indicator of inflationary pressure in the future? and (2) Will international excess capacity restrain U.S. inflation?

Various econometric techniques have been applied for five industrialized countries to answer these questions. The present study found that (1) the domestic capacity utilization rate is still important in measuring inflationary pressure, (2) the effect on inflation rate of an increase in domestic capacity utilization rate occurs with some lags, (3) international excess capacity help restrain domestic inflation rate, and (4) foreign capacity utilization rate also has some delayed but persistent effects on domestic inflation rate.

The natural answer to the questions raised in the beginning of the study is strong yes. The previous studies tended to focus on the contemporaneous relations among the variables involved. The present study argues that these studies are misleading since the questions are in dynamic nature rather than static. Appropriate selection and application of econometric methods generated convincing support for the conventional view that capacity utilization figures remain important in measuring future inflationary pressure.

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APPENDICES

Appendix A.1
Critical Values for the Dickey-Fuller Test Based on Estimated OLS Autoregressive Coefficient

Sample size T	*Probability that $T(\hat{\rho} - 1)$ is less than entry*							
	0.01	*0.025*	*0.05*	*0.10*	*0.90*	*0.95*	*0.975*	*0.99*
				Case 1				
25	−11.9	−9.3	−7.3	−5.3	1.01	1.40	1.79	2.28
50	−12.9	−9.9	−7.7	−5.5	0.97	1.35	1.70	2.16
100	−13.3	−10.2	−7.9	−5.6	0.95	1.31	1.65	2.09
250	−13.6	−10.3	−8.0	−5.7	0.93	1.28	1.62	2.04
500	−13.7	−10.4	−8.0	−5.7	0.93	1.28	1.61	2.04
∞	−13.8	−10.5	−8.1	−5.7	0.93	1.28	1.60	2.03
				Case 2				
25	−17.2	−14.6	−12.5	−10.2	−0.76	0.01	0.65	1.40
50	−18.9	−15.7	−13.3	−10.7	−0.81	−0.07	0.53	1.22
100	−19.8	−16.3	−13.7	−11.0	−0.83	−0.10	0.47	1.14
250	−20.3	−16.6	−14.0	−11.2	−0.84	−0.12	0.43	1.09
500	−20.5	−16.8	−14.0	−11.2	−0.84	−0.13	0.42	1.06
∞	−20.7	−16.9	−14.1	−11.3	−0.85	−0.13	0.41	1.04
				Case 3				
25	−22.5	−19.9	−17.9	−15.6	−3.66	−2.51	−1.53	−0.43
50	−25.7	−22.4	−19.8	−16.8	−3.71	−2.60	−1.66	−0.65
100	−27.4	−23.6	−20.7	−17.5	−3.74	−2.62	−1.73	−0.75
250	−28.4	−24.4	−21.3	−18.0	−3.75	−2.64	−1.78	−0.82
500	−28.9	−24.8	−21.5	−18.1	−3.76	−2.65	−1.78	−0.84
∞	−29.5	−25.1	−21.8	−18.3	−3.77	−2.66	−1.79	−0.87

The probability shown at the head of the column is the area in the left-hand tail.

Source: James D. Hamilton, "Time Series Analysis", Princeton: Princeton Univ. Press (1994), p 762.

Appendix A.2
Critical Values for the Dickey-Fuller Test Based on Estimated OLS t Statistic

Sample size T	*Probability that $(\hat{\rho} - 1)/\hat{\sigma}_{\hat{\rho}}$ is less than entry*							
	0.01	*0.025*	*0.05*	*0.10*	*0.90*	*0.95*	*0.975*	*0.99*
				Case 1				
25	−2.66	−2.26	−1.95	−1.60	0.92	1.33	1.70	2.16
50	−2.62	−2.25	−1.95	−1.61	0.91	1.31	1.66	2.08
100	−2.60	−2.24	−1.95	−1.61	0.90	1.29	1.64	2.03
250	−2.58	−2.23	−1.95	−1.62	0.89	1.29	1.63	2.01
500	−2.58	−2.23	−1.95	−1.62	0.89	1.28	1.62	2.00
∞	−2.58	−2.23	−1.95	−1.62	0.89	1.28	1.62	2.00
				Case 2				
25	−3.75	−3.33	−3.00	−2.63	−0.37	0.00	0.34	0.72
50	−3.58	−3.22	−2.93	−2.60	−0.40	−0.03	0.29	0.66
100	−3.51	−3.17	−2.89	−2.58	−0.42	−0.05	0.26	0.63
250	−3.46	−3.14	−2.88	−2.57	−0.42	−0.06	0.24	0.62
500	−3.44	−3.13	−2.87	−2.57	−0.43	−0.07	0.24	0.61
∞	−3.43	−3.12	−2.86	−2.57	−0.44	−0.07	0.23	0.60
				Case 3				
25	−4.38	−3.95	−3.60	−3.24	−1.14	−0.80	−0.50	−0.15
50	−4.15	−3.80	−3.50	−3.18	−1.19	−0.87	−0.58	−0.24
100	−4.04	−3.73	−3.45	−3.15	−1.22	−0.90	−0.62	−0.28
250	−3.99	−3.69	−3.43	−3.13	−1.23	−0.92	−0.64	−0.31
500	−3.98	−3.68	−3.42	−3.13	−1.24	−0.93	−0.65	−0.32
∞	−3.96	−3.66	−3.41	−3.12	−1.25	−0.94	−0.66	−0.33

The probability shown at the head of the column is the area in the left-hand tail.

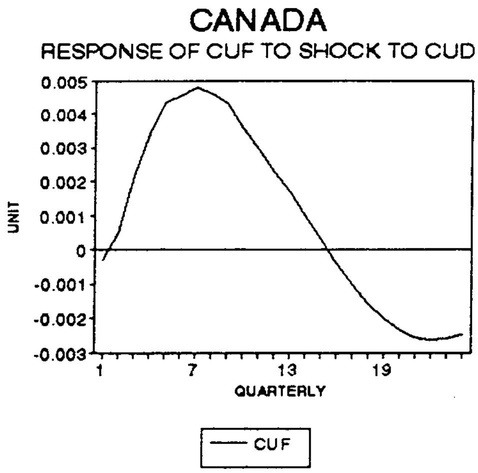
Source: James D. Hamilton, "Time Series Analysis", Princeton: Princeton Univ. Press (1994), p 763.

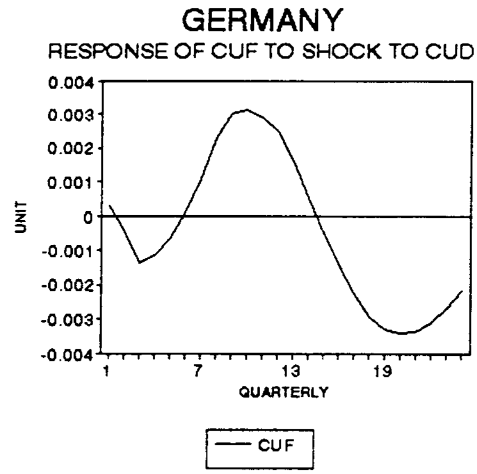
Appendix A.3 Response surfaces for critical values of co-integration tests

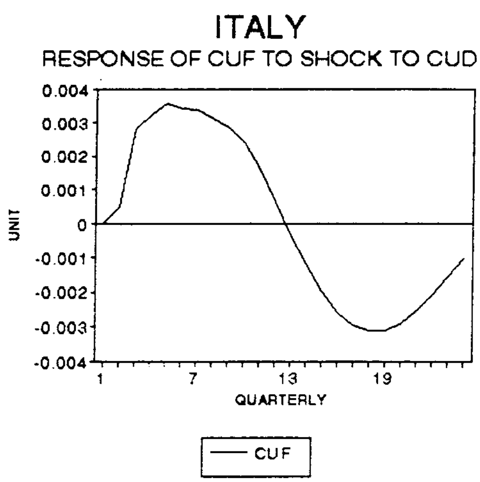
n	Model	Point (%)	ϕ_∞	SE	ϕ_1	ϕ_2
1	No constant, no trend	1	−2.5658	(0.0023)	−1.960	−10.04
		5	−1.9393	(0.0008)	−0.398	0.0
		10	−1.6156	(0.0007)	−0.181	0.0
1	Constant, no trend	1	−3.4336	(0.0024)	−5.999	−29.25
		5	−2.8621	(0.0011)	−2.738	−8.36
		10	−2.5671	(0.0009)	−1.438	−4.48
1	Constant + trend	1	−3.9638	(0.0019)	−8.353	−47.44
		5	−3.4126	(0.0012)	−4.039	−17.83
		10	−3.1279	(0.0009)	−2.418	−7.58
2	Constant, no trend	1	−3.9001	(0.0022)	−10.534	−30.03
		5	−3.3377	(0.0012)	−5.967	−8.98
		10	−3.0462	(0.0009)	−4.069	−5.73
2	Constant + trend	1	−4.3266	(0.0022)	−15.531	−34.03
		5	−3.7809	(0.0013)	−9.421	−15.06
		10	−3.4959	(0.0009)	−7.203	−4.01
3	Constant, no trend	1	−4.2981	(0.0023)	−13.790	−46.37
		5	−3.7429	(0.0012)	−8.352	−13.41
		10	−3.4518	(0.0010)	−6.241	−2.79
3	Constant + trend	1	−4.6676	(0.0022)	−18.492	−49.35
		5	−4.1193	(0.0011)	−12.024	−13.13
		10	−3.8344	(0.0009)	−9.188	−4.85
4	Constant, no trend	1	−4.6493	(0.0023)	−17.188	−59.20
		5	−4.1000	(0.0012)	−10.745	−21.57
		10	−3.8110	(0.0009)	−8.317	−5.19
4	Constant + trend	1	−4.9695	(0.0021)	−22.504	−50.22
		5	−4.4294	(0.0012)	−14.501	−19.54
		10	−4.1474	(0.0010)	−11.165	−9.88
5	Constant, no trend	1	−4.9587	(0.0026)	−22.140	−37.29
		5	−4.4185	(0.0013)	−13.641	−21.16
		10	−4.1327	(0.0009)	−10.638	−5.48
5	Constant + trend	1	−5.2497	(0.0024)	−26.606	−49.56
		5	−4.7154	(0.0013)	−17.432	−16.50
		10	−4.4345	(0.0010)	−13.654	−5.77
6	Constant, no trend	1	−5.2400	(0.0029)	−26.278	−41.65
		5	−4.7048	(0.0018)	−17.120	−11.17
		10	−4.4242	(0.0010)	−13.347	0.0
6	Constant + trend	1	−5.5127	(0.0033)	−30.735	−52.50
		5	−4.9767	(0.0017)	−20.883	−9.05
		10	−4.6999	(0.0011)	−16.445	0.0

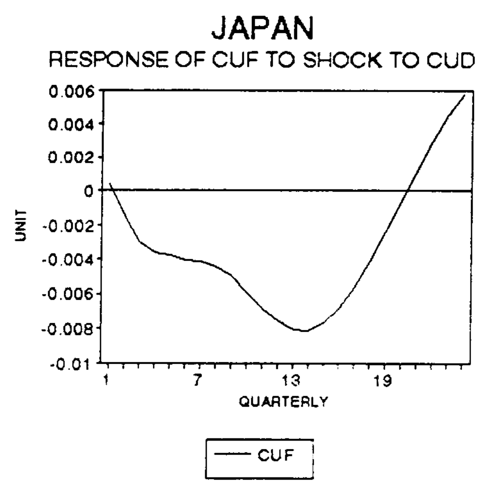
Source: MacKinnon (1991).

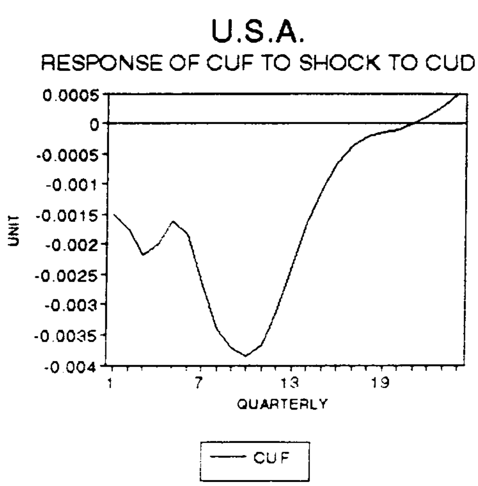
Appendix B.1 Response of CUF for 5 Countries to a Shock from CUD







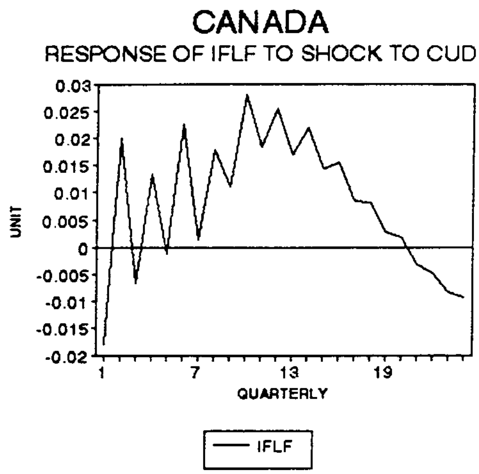


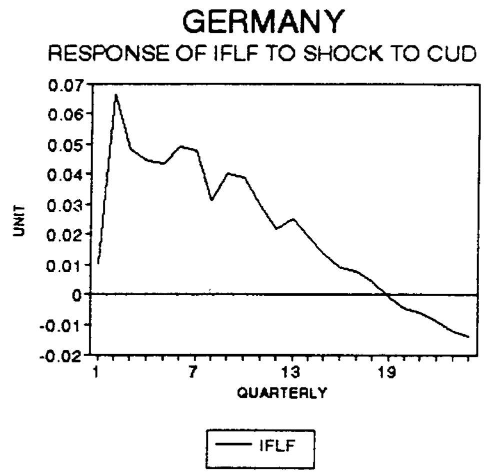


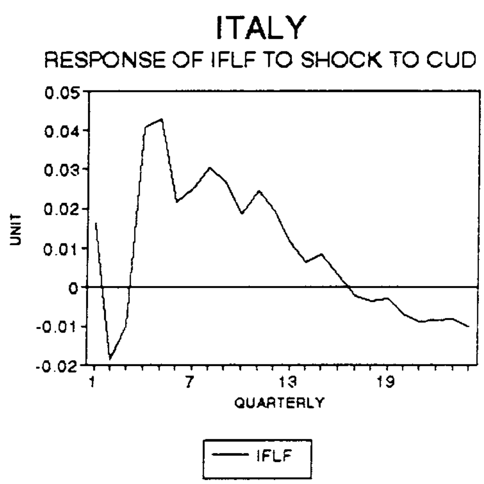
Where,

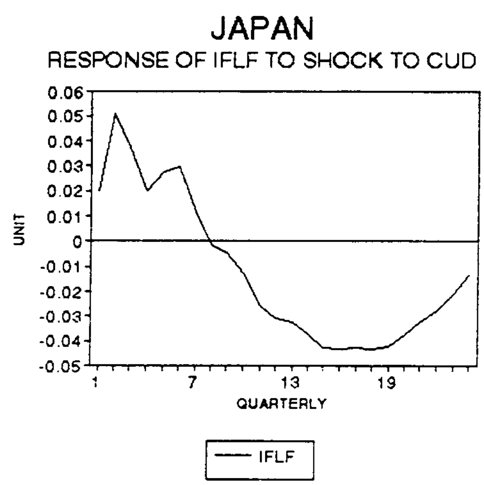
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

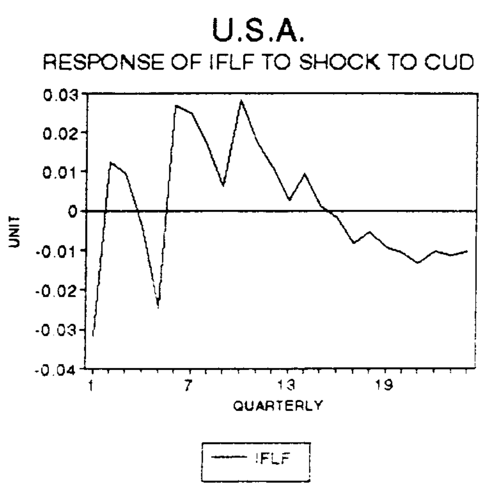
Appendix B.2 Response of IFLF for 5 Countries to a Shock from CUD







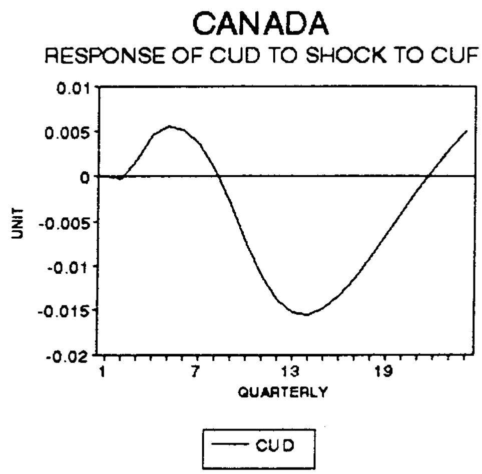


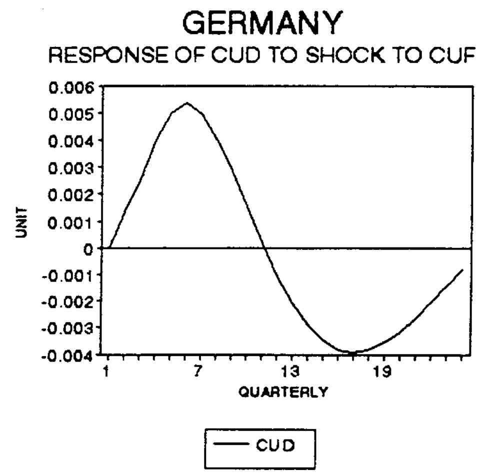


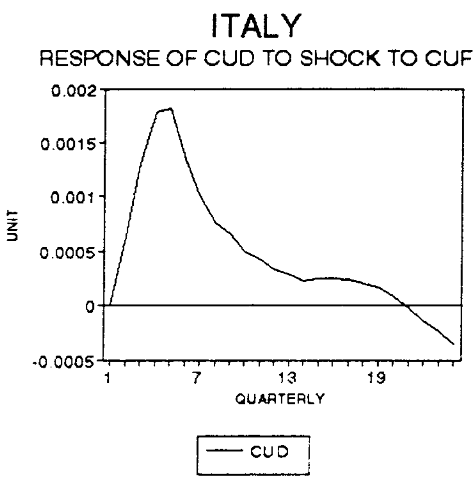
Where,

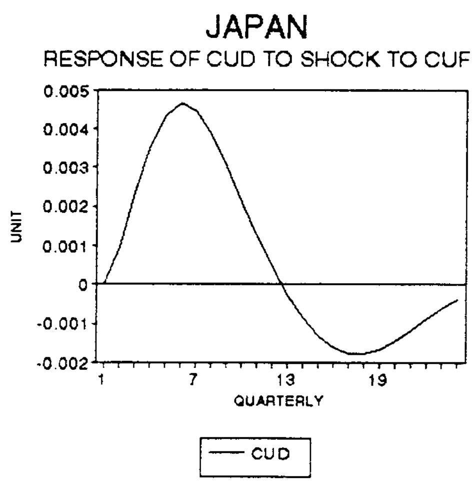
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

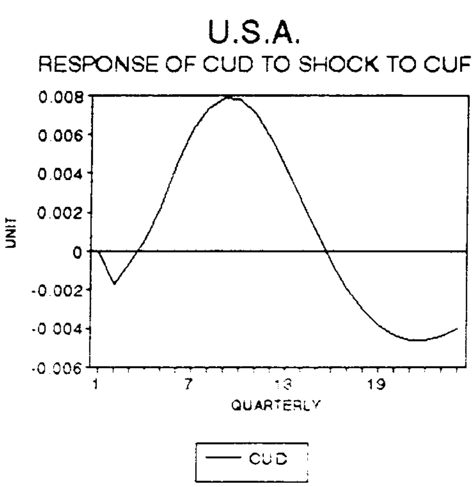
Appendix B.3 Response of CUD for 5 Countries to a Shock from CUF







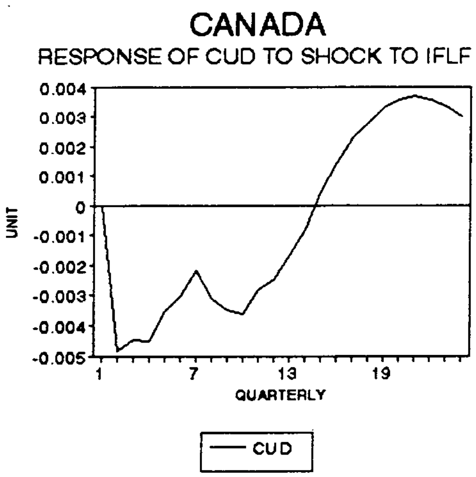


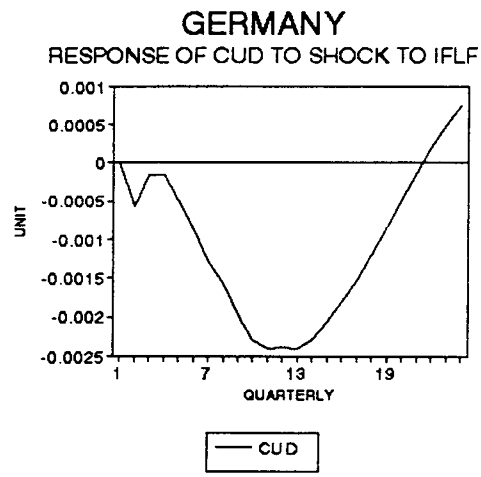


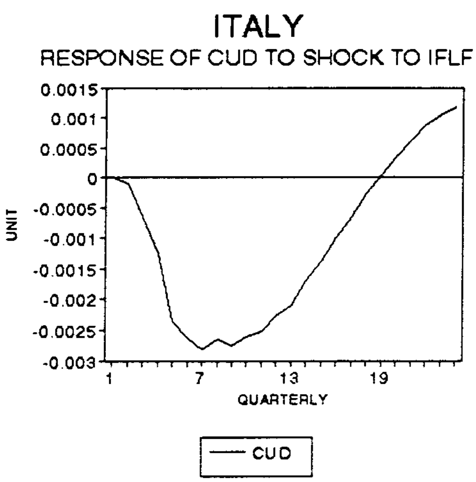
Where,

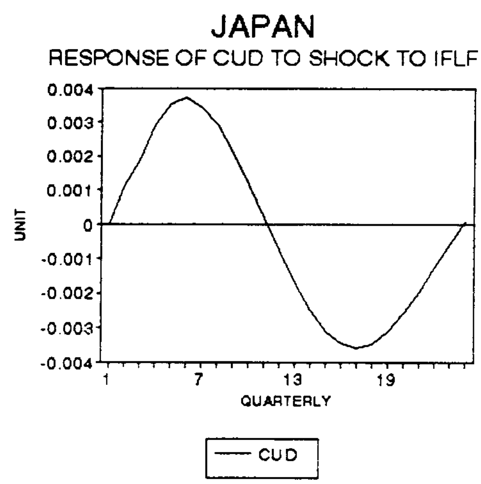
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

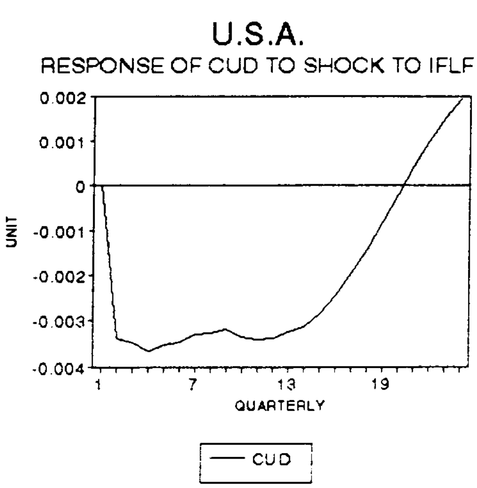
Appendix B.4 Response of CUD for 5 Countries to a Shock from IFLF







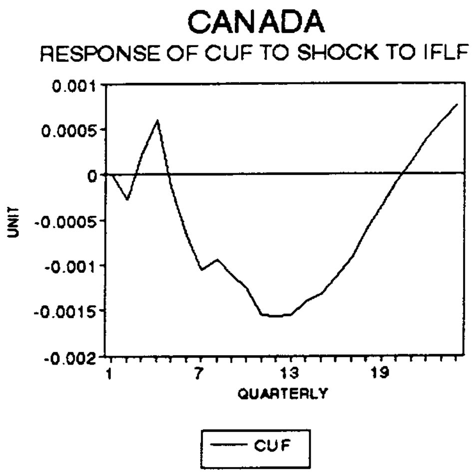


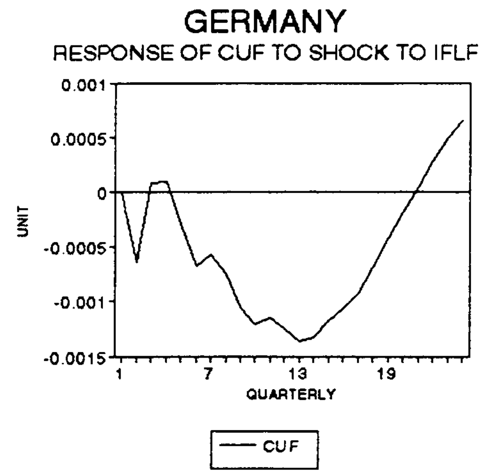


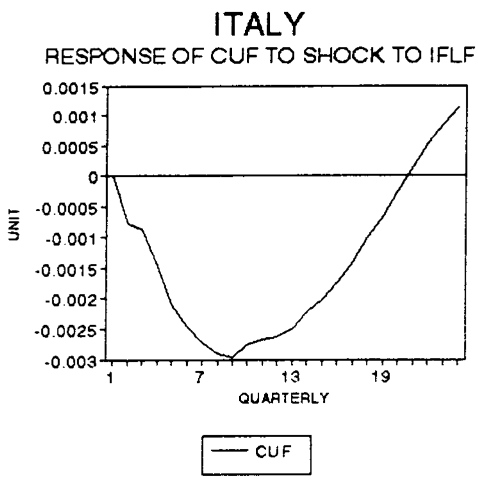
Where,

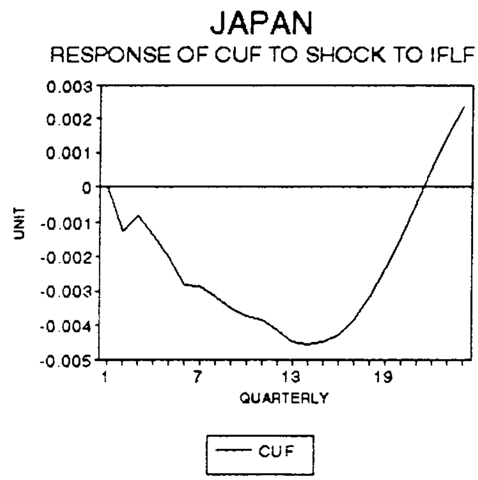
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

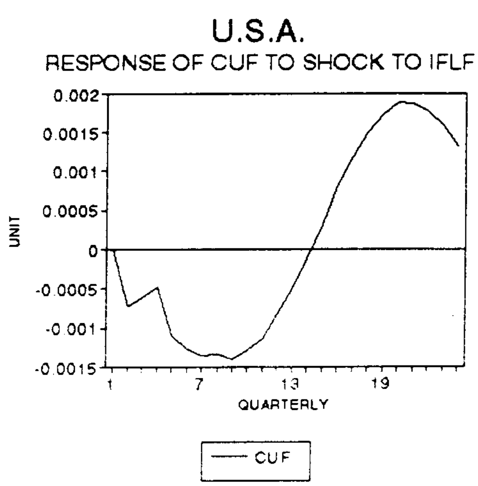
Appendix B.5 Response of CUF for 5 Countries to a Shock from IFLF







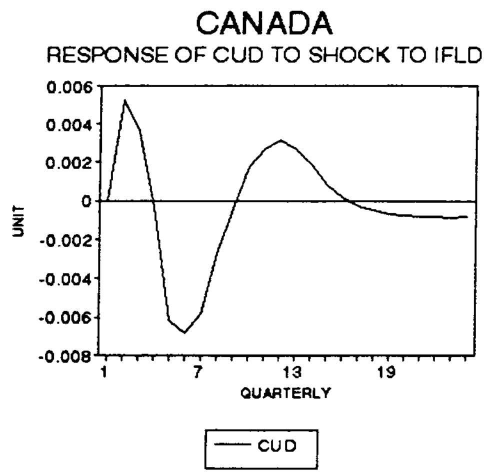


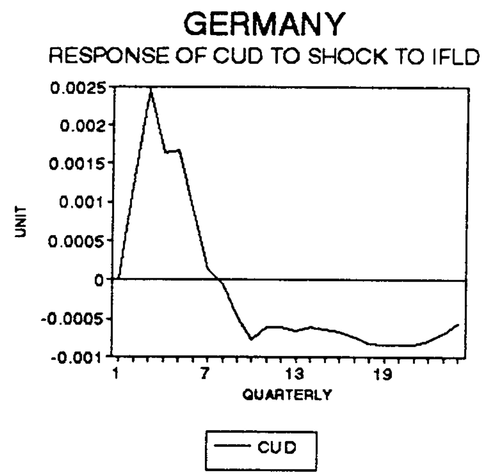


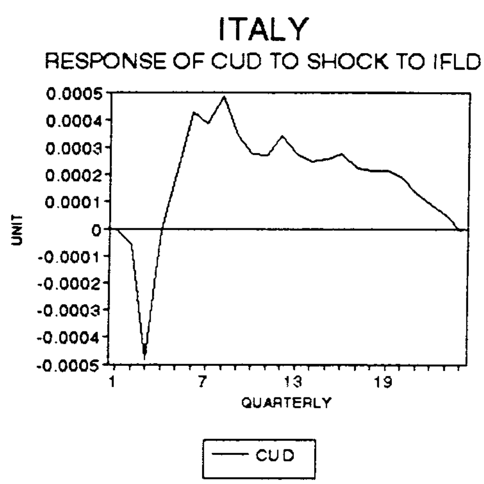
Where,

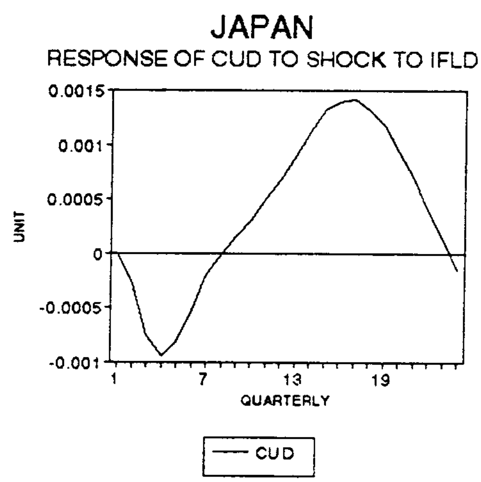
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

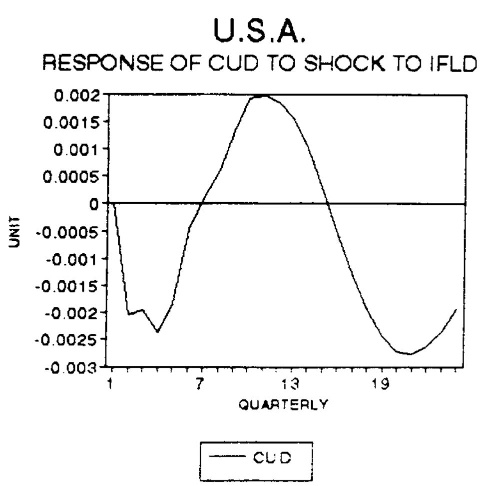
Appendix B.6 Response of CUD for 5 Countries to a Shock from IFLD







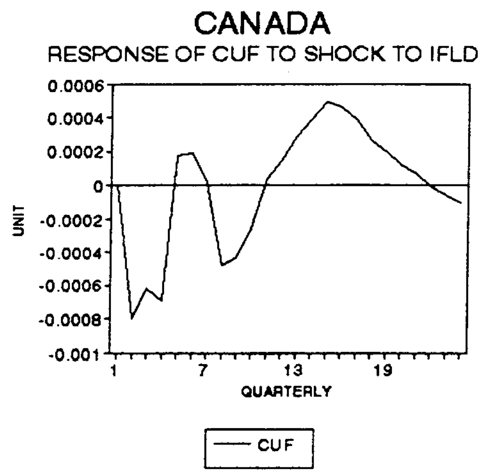


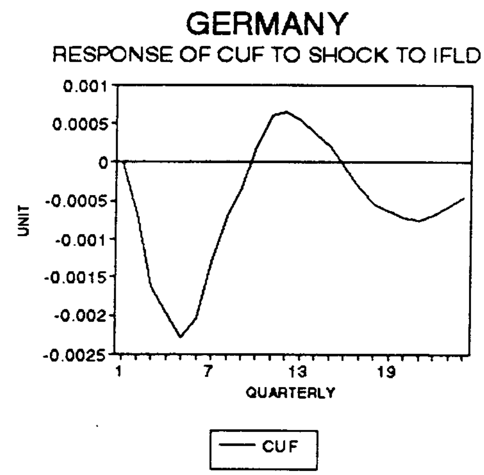


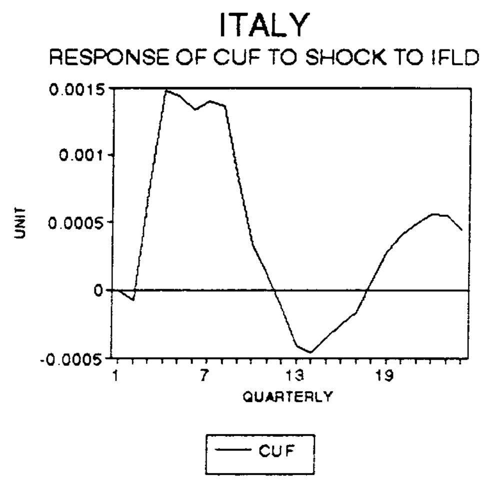
Where,

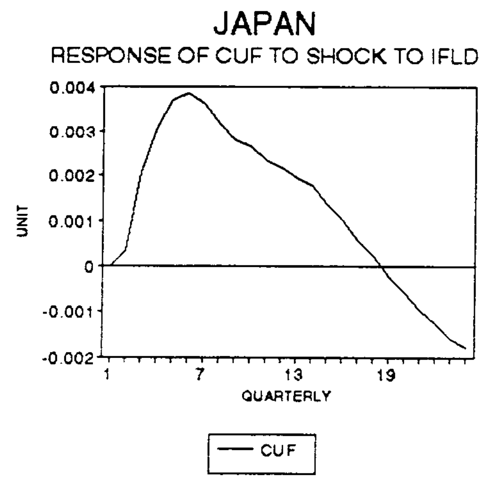
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

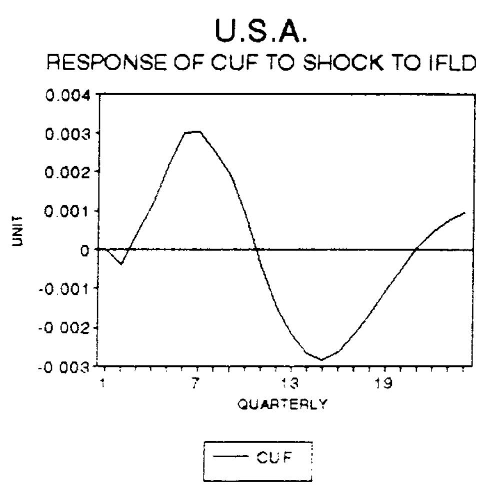
Appendix B.7 Response of CUF for 5 Countries to a Shock from IFLD







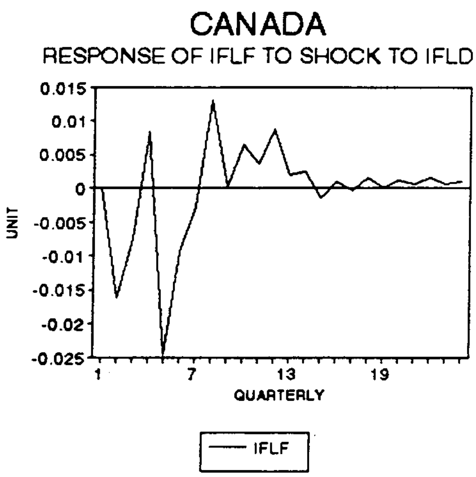


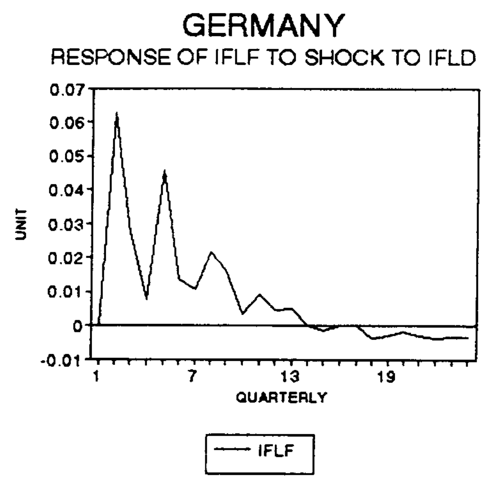


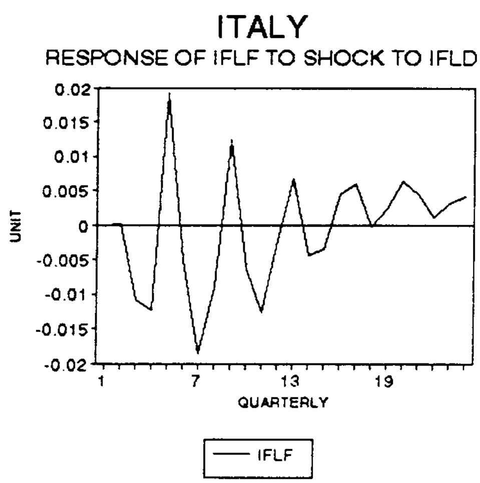
Where,

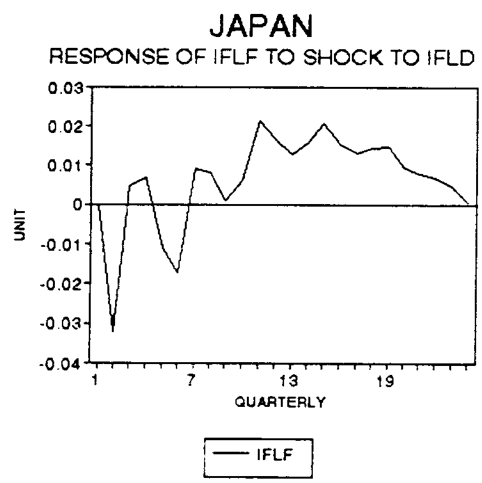
CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate

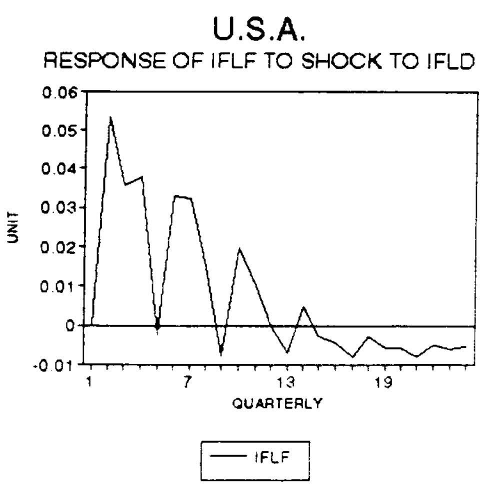
Appendix B.8 Response of IFLF for 5 Countries to a Shock from IFLD











Where,

CUD is the domestic capacity utilization rate
CUF is the foreign capacity utilization rate
IFLF is the foreign inflation rate
IFLD is the domestic inflation rate