COINTEGRATION AND CAUSALITY BETWEEN U.S. TERMS OF TRADE AND EXTERNAL VALUE OF DOLLAR UNDER THE FLOATING EXCHANGE RATE SYSTEM

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ABSTRACT

The bivariate cointegration procedures are applied to examine the long-run equilibrium association and the direction of causality between U.S. terms of trade and real exchange rate using annual data from 1973 through 1996. The evidence indicates the existence of cointegration and unidirectional causality from real exchange rate to terms of trade.

INTRODUCTION

This paper purports to explore the dynamics between U.S. terms of trade (commodity and single factoral) and the trade-weighted real exchange value index of dollar under the flexible exchange rate system. It received inadequate attention relative to the effects of exchange rate changes on trade balance and trade volume. Certain theoretical models dismiss this issue on the assumption that exchange rate depreciation is roughly synonymous with deterioration in terms of trade. The literature on the import price pass-through of dollar changes suggests that the response of terms of trade to depreciation seems neither instantaneous nor obvious (Mann, 1986; Baldwin, 1988; Krugman and Baldwin, 1987). However, various theoretical models differ substantially in their assumptions regarding the dynamic relationship between the exchange rate and the terms of trade.

The terms of trade and real exchange rate are two important macroeconomic variables for the U.S. They are now more important to the U.S. than ever before because of its increasing economic openness which is now slightly above 25 percent of annual gross national product. Several studies have identified strong correlation between the terms of trade and real exchange rate over a considerable period of time (McKenzie, 1986; Koch and Rosensweig, 1992; Blundell-Wignall and Gregory, 1989; Whitelaw, 1983; and Diaz-Alejandro, 1980). Recently, Koya and Orden (1994) have identified strong evidence of cointegration between terms of trade and real exchange rate. But they have not considered the direction of causality between the two macroeconomic variables. They have studied the effects of the terms of trade on the bilateral exchange rate of New Zealand and Australia. They have also evaluated the same for each country in relation to the U.S. Even more recently, In and Menon (1996) have found that the real exchange rate and the terms of the seven major OECD countries are cointegrated. They have also confirmed at least one directional Granger causality when both variables are I(1) and cointegrated. The exchange rate changes are found to Granger-cause changes in the terms of trade for five countries out of the seven OECD countries, while there are evidence of reverse causation for the remaining two countries.

Koch and Rosensweig (1992) explores the dynamic relationship between the dollar and U.S. terms of trade as well as its components (U.S. import and export prices). Import prices are found to respond to the changes in dollar's value, but only after a substantial lag. Export prices display a somewhat weaker response that appears to partially offset dollar's effect on import prices, muting its effect on the terms of trade. But this paper considers only the commodity terms of trade while the current study considers the single factoral terms of trade in addition to the commodity terms of trade. Furthermore, Koch and Rosensweig (1992) simply perform the simple Granger causality test that might be erroneous when two variables are cointegrated. In this case, the associated error-correction models are more appropriate to draw inferences on long-run causality than simple Granger tests for causality, provided the two nonstationary time series are cointegrated. This study, therefore, seeks to estimate the associated error-correction model for long-run causality in the event the two time series variables are individually non-stationary and I(1), and then cointegrated, as stated above. To add further, if the time series variables are stationary then simple Granger causality test is perfectly appropriate. Otherwise, the cointegration framework and the error-correction models should be applicable. So, the authors should have examined the time series property of each variable prior to applying the simple Granger tests of causality. Again, the terms of trade and exchange rate are likely to be non-stationary under the flexible exchange rate system. The remainder of the paper is organized as follows. Section II outlines the empirical framework. Section III reports the empirical results. Finally, section IV offers conclusions and remarks.

THE EMPIRICAL FRAMEWORK

To examine the time series property of U.S. terms of trade (commodity and single factoral) and the trade-weighted real exchange value index of dollar, the ADF and Phillips-Perron tests of unit root are conducted in addition to the KPSS test. Once each variable is found non-stationary, the order of integration is determined by the first or higher order differencing of the level data. It is important because both variables must have the same order of integration to be cointegrated.

A non-stationary time series, x_t, is said to be integrated of order d, if it achieves stationarity after being differenced d times (denoted by $x_t \sim I(d)$). According to Engle and Granger (1987) two I(d) variables, x_t and y_t, are cointegrated if a linear combination between x_t and y_t such as $z_t = x_t - a_0 - a_1 y_t$ is integrated at any order less than d. Usually, z_t represents the residuals from the OLS estimates of the cointegration regressions that are specified as follows:

$$x_t = a_0 + a_1 y_t + z_t \qquad (1)$$

and

$$y_t = b_0 + b_1 x_t + v_t \qquad (2)$$

where $x_t \equiv$ terms of trade (commodity or single factoral), $y_t \equiv$ trade-weighted real exchange value index of dollar, and $z_t \equiv$ stochastic disturbance term. In equation (1), a_0 and a_1 are the intercept and slope parameters, respectively. Likewise, b_0 and b_1 in equation (2) are the intercept and slope parameters, respectively. Equation (2) is the reverse specification of equation (1). The reverse specification is considered to account for possible bidirectional causality.

The estimated residual terms are then retrieved to estimate the Augmented Dickey-Fuller regressions (ADF, hereafter) by OLS. The ADF regressions for bivariate cointegration are specified as follows:

$$\Delta z_t = \beta z_{t-1} + \sum_{i=1}^{k} \beta_i \Delta z_{t-i} + u_t \qquad (3)$$

$$\Delta v_t = \alpha v_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta v_{t-i} + w_t \qquad (4)$$

where $\Delta \equiv$ first difference operator, $u_t \equiv$ random disturbance term in ADF regression (3), $w_t \equiv$ random disturbance term in ADF regression (4), and $k \equiv$ optimum number of lags in each ADF regression that ensures white noise in the system. It is determined by the final prediction error (FPE) criterion. ADF test is performed on

$|\hat{\beta}|$ or $|\hat{\alpha}|$ to see if it is significantly different from zero at 1 or 5 or 10 percent level of significance. If $|\hat{\beta}|$ or $|\hat{\alpha}|$ is not significantly different from zero, then the null hypothesis of no-cointegration cannot be rejected. Conversely, the null hypothesis of no-cointegration can be rejected implying that x_t and y_t are cointegrated. Once it is established that the two variables are cointegrated, it is inevitable to estimate an error-correction model associated with each cointegration regression (Engle and Granger, 1987). The error-correction model associated with cointegration regression (1) is as follows:

$$\Delta x_t = v_0 z_{t-1} + \sum_{i=1}^{m} v_{1i} \Delta x_{t-i} + \sum_{i=1}^{n} v_{2i} \Delta y_{t-i} + e_t \qquad (5)$$

where z_{t-1} is the error-correction term and the cointegration test is applied on $|\hat{v}_0|$. If it is significantly different from zero, then the null hypothesis of no-cointegration can be rejected at some of the aforementioned conventional levels of significance as stated above. The error-correction term z_{t-1} in equation (5) is the stationary residual from the OLS estimate of cointegration regression (1). In the above model, the direction of long-run causality is presumed to run from y_t to x_t not only if v_0 is significant and even if v_{2i}'s are insignificant.

A reverse specification of error-correction model (5) can be estimated as follows:

$$\Delta y_t = \phi_0 v_{t-1} + \sum_{i=1}^{m} \phi_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \phi_{2i} \Delta x_{t-i} + v_t \qquad (6)$$

In equation (6), the cointegration test is applied to $|\hat{\phi}_0|$. In this case, the direction of long-run causality is presumed to run from x_t to y_t even if φ_{2i}'s are not jointly significant as long as $\hat{\phi}_0$ is significant (Granger, 1988). In error-correction models (5) and (6), the evidence of long-run causation are based on joint F-tests.

This study employs annual data from 1973 through 1996. The trade-weighted real exchange rate and productivity data are obtained from various issues of the *Economic Report of the President*. The commodity terms of trade data are collected from various issues of the *International Financial Statistics*. The annual data are preferred to the monthly or quarterly data for greater reliability and precision because the high frequency trade data (monthly or quarterly) are slippery in presence of leads and lags as well due to incomplete trade accounting information.

To describe the terms of trade, the commodity, or net barter, terms of trade (N) are defined as the ratio of the price index of the nation's exports (P_x) to the price index of its imports (P_M) multiplied by 100 (to express the terms of trade in percentages). That is,

$$N = (P_x / P_M)100$$

A nation's single factoral terms of trade (S) are given by:

$$S = (P_x / P_M)Z_x$$

where Z_x is a productivity index in the nation's export sector. Thus, S measures the amount of imports the nation gets per unit of domestic factors of production embodied in its exports.

The trade-weighted index of exchange value of U.S. dollar was revised in August 1978 with March 1973=100 (the base period). The index includes the geometric weighted average of currencies of 10 industrial countries. The weights are 1972-76 average total trade shares of each of the 10 countries. The currencies of

Germany, Japan, France, U.K., Canada, Italy, Netherlands, Belgium, Sweden and Switzerland are included in the index (Board of Governors of the Federal Reserve System, 1978).

THE EMPIRICAL RESULTS

The unit root test results for non-stationarity in each time series are reported as follows:

Table 1*
Unit Root Tests
Annual Data (1973-1996)

Variable	ADF Test	Phillips-Perron Test	KPSS Test
RER	-2.1328(4)	-6.448(4)	0.1512(1)
TOT	-1.763(4)	-10.5469(4)	0.1206(3)
STOT	-2.00679(4)	-11.866(4)	0.1745(1)
	First Difference		
ΔRER	-3.508(3)	-12.37038(4)	0.0800(4)
ΔTOT	-3.977(1)	-27.5(3)	0.0787(3)
ΔSTOT	-4.895(2)	-22.32761(4)	0.1025(3)

where, RER = real trade-weighted exchange rate, TOT = terms of trade as given in *International Financial Statistics*, STOT = single factorial terms of trade=TOTxZ_x, and Z_x = productivity index in the nation's export sector.
ADF regressions include a constant and a time trend. The optimum lag lengths are in parentheses.
For ADF and Phillips-Perron tests, the 5 percent and 10 percent critical levels are -3.50 and -3.18, respectively [see Fuller, 1996]. For KPSS test, lag window size, l=4 and the 5 percent and 10 percent critical values, η_τ, are 0.146 and 0.119 respectively.

It is evident from table 1 that each time series is nonstationary in levels at 5 percent and higher levels of significance. This affirmation is uniformly based on the findings from the ADF, Phillips-Perron and KPSS tests. Furthermore, each time series becomes stationary on the first differencing of the level data as shown in the lower panel of table 1. In other words, each time series depicts I(1) behavior.

Next, the ADF test results for bivariate cointegration are reported as follows:

Table 2*
Cointegration Test Based On Adf Procedures

	Dependent Variable	Independent Variable	ADF Statistics	DW	Adj R^2
(i)	TOT	RER	-4.389(4)	2.201	0.59
(ii)	RER	TOT	-1.96(2)	1.83	0.14
(iii)	STOT	RER	-4.752(4)	1.905	0.16
(iv)	RER	STOT	-2.016(4)	1.887	0.176

The critical values of ADF statistics reported in Engle and Yoo (1987) are -4.07, -3.37 and -3.03 at 1, 5 and 10 percent levels of significance respectively. The optimum lag-lengths are reported within parentheses.

Obviously, the null hypothesis of no-cointegration can be rejected only in cases (i) and (iii) revealing a long-run equilibrium relationship between commodity terms of trade and real exchange rate as well as between single factoral terms of trade and real exchange rate at 1 percent and higher levels of significance. To state further, cases (i) and (iii) relate to cointegration regression (1). But there are no evidence of cointegration in cases (ii) and (iv) that correspond to cointegration regression (2).

Finally, pursuant to Engle and Granger (1987) the error-correction models associated with cases (i) and (iii) are estimated. The results are reported as follows:

Table 3
Causality Test

	Dependent Variable	"Causal" Variable	Lag Orders	F-Statistics	t-statistics of the Coefficient of Error-Correction Term
(i)	ΔTOT	ΔRER	m=4 n=3	F(3,11)=12.938*	-6.159*
(iii)	ΔSTOT	ΔRER	m=4 n=1	F(2,13)=12.424*	-4.608*

where, (*) indicates statistical significance at 99 percent confidence level.

Notes: a. Lag orders are selected based on the FPE criterion, m = lag length of dependent variable, n = lag length of "causal variable".
b. The F-statistics (with degrees of freedom in parentheses) tests the joint null hypothesis that all coefficients of the "causal variable" are simultaneously equal to zero.

Table 3 reveals that based upon the joint F-test there are strong evidence on long-run unidirectional Granger causality springing from the real exchange rate to the commodity and single factoral terms of trade under the flexible exchange rate system. Furthermore, there are no evidence on the long-run reverse causality. However, this does not preclude the likelihood of short-run causality and two-way feedbacks between real exchange rate and terms of trade that correspond to cointegration regression (2).

CONCLUSIONS AND REMARKS

To recapitulate, each time series on U.S. commodity terms of trade, single factoral terms of trade and real exchange rate is nonstationary in levels. They also reveal I(1) behavior individually. There is strong evidence on pairwise cointegration between (i) commodity terms of trade and real exchange rate, and (ii) single factoral terms of trade and real exchange rate. The findings of the error-correction models confirm unidirectional long-run causality springing from real exchange rate to both types of terms of trade. The response of terms of trade to the changes in real exchange rate is not instantaneous and the response lag is quite substantial. However, there is no evidence on long-run reverse causality. But it should not rule out the possibility of short-run dynamics from the terms of trade to the real exchange rate and bidirectional feedbacks.

The implications of the above findings here are: (i) U.S. terms of trade and real exchange rate are nonstationary under the flexible exchange rate system, and (ii) the cointegration framework for this investigation is more appropriate than the traditional vector autoregressive (VAR) model. The policy implication is that the U.S. may be able to manipulate the real exchange rate to induce desirable changes in the terms of trade and hence to improve the U.S. trade balance. To close, exchange rate management still deems to be a useful policy tool to influence the terms of trade and hence the U.S. trade balance.

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