Time Series Evidence on U.S. 10-Year T-Bonds, 3-Month T-Bills and the External Value of Dollar

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Abstract

This paper purports to explore the long-run relation and causality between U.S. treasury securities (10-year T-bonds and 3-month T-bills), and the external value of dollar within bivariate and multivariate cointegration frameworks. It uses monthly data from January 1973 through July 1999. The bivariate cointegration results do not depict any long-run association and causality of the 10-year T-bond yields and the 3-month T-bill rates with the external value of U.S. dollar. But there is evidence of two-way short-run Granger causality between in each pair of variables (both nominal and real). The vector cointegration tests reveal that the U.S. exchange rate is driven by at least a single financial factor as a transitory component. It may be either the 3-month T-bill rate or the 10-year T-bond yield or both

Introduction

Markets for foreign exchanges and securities[a] are presumed to be interconnected through the effects of changes in interest rates and bond yields on exchange rates. Portfolio models of exchange rate determination as developed, inter alia, by Allen (1973), Branson (1975, 1980), Allen and Kenen (1976), Copeland (1994), Fama and Farber (1979), Leroy (1982), Murphy and Duyne (1980), and Mussa (1982) which seek to explain how these markets ought to be interrelated. Portfolio models of exchange rate determination are direct descendants of Tobin's portfolio approach in macroeconomics. Like Tobin's models, they assume that financial markets clear more rapidly than commodity markets. Wealth and imperfect substitutability between assets play an important role in explaining the observed variability of exchange rates. An increase in wealth is expected to lift the demand for both domestic and foreign securities including foreign currency holdings. An exogenous increase in the stock of securities tends to increase wealth, reduce prices of securities, and raise interest rates. The increase in wealth should raise the demand for foreign securities, which will tend to drive up the domestic price of foreign exchange. An increase in domestic interest rates, however, reduces the demand for foreign fixed interest earning securities. This, in turn, lowers the external value of foreign currencies (i.e. foreign currencies depreciate against U.S. dollar). Whether the exchange rate rises or falls depends on which factor is dominant. The price of foreign exchange falls if interest rate effect is dominant because of close substitutability between foreign and domestic securities. The price of foreign exchange, on the other hand, rises if the wealth effect is dominant when the demand for foreign securities does not respond to domestic interest rates.

An increase in capital inflow into the dollar denominated securities due to higher return relative to comparable foreign financial assets will cause the demand for U.S. dollar to rise in conjunction with a larger increase in the supply of foreign currencies. As a result, the U.S. dollar is expected to appreciate against the relevant foreign currencies. On the other hand, a capital outflow from the dollar denominated securities will increase the supply of U.S. dollar and a rise in demand for foreign currencies resulting in the depreciation of U.S. dollar against the relevant foreign currencies. Again, if the dollar is expected to erode further, the dollar denominated value of securities will depreciate. It will make the U.S. securities less attractive. As a result, their demand will fall. A continuing expectation that U.S. dollar will strengthen further will make the U.S. securities more attractive and hence their demand will rise. Furthermore, a current strength in U.S. dollar will make the U.S. securities costlier for foreign investors. Consequently, bargain hunting foreign investors would stop or reduce any new purchases of U.S. securities.

To be more precise, the essence of the portfolio models of exchange rate determination is the notion that individuals allocate their wealth among alternative assets that mostly include domestic and foreign money, and foreign and domestic securities. It is usually hypothesized that the demand for domestic securities is positively related to domestic interest rates and negatively to foreign interest rates. By the same token, the demand for foreign securities is positively related to foreign interest rates and negatively to domestic interest rates. The role of the exchange rate is to balance the asset demand and supplies. Therefore, any change in the demand for and supply of assets will change the equilibrium exchange rate (Krueger, 1983; Dornbusch, 1975; Frenkel and Rodriguez, 1975; Boyer, 1977).

The recent developments in terms of a near-continual depreciation of the trade-weighted external value of U.S. dollar[b] and soaring bond market paint a somewhat different picture. The depreciation of dollar vis-a-vis Japanese yen and German mark has been even astounding. This is remarkably paradoxical and puzzling. It thus sparks new interest to re-examine the validity of portfolio balance theory in the determination of exchange rate. Numerous studies investigated the issues of degrees of integration and efficiency of U.S. stock and foreign exchange markets (i.e., Aggarwal, 1981; Bahmani and Sohrabian, 1992) separately or jointly. But the empirical studies investigating the possible long-run and short-run dynamics including simple Granger causality between U.S. Treasury securities and foreign exchange markets within the bivariate and multivariate cointegration frameworks have been scant.

The primary focus of this paper is, therefore, to re-examine the dynamics of causal nexus between U.S. Treasury securities (10-year T-bonds and 3-month T-bills), and foreign exchange markets within the well-known bivariate and vector cointegration frameworks. It considers the monthly trade-weighted averages of spot exchange rates, 3-month T-bill rates and 10-year T-bond yields in both nominal and real terms. The remainder of the paper is organized as follows. Section II outlines the bivariate cointegration methodology and reports the results. Section III outlines the vector cointegration methodology and reports the results. Finally, section IV offers conclusions.

Bivariate cointegration methodology and results

The cointegration regression that has been considered in this paper is as follows:

$$x_t = \alpha_0 + \alpha_1 y_t + z_t$$

Where x_t = dependent variable (nominal or real), y_t = independent variable (nominal or real), and z_t is the stochastic error term. The variables x_t and y_t are cointegrated of order d (i.e., I(d)) if the time series data on x_t and y_t have to be differenced d times to restore stationarity. For d=0, x_t and y_t are stationary in levels and no differencing is necessary. Again, for d=1, first differencing is needed to restore stationarity.

At first, following Engle and Granger (1987) the time series property of each variable is examined by unit root tests. For unit root tests, the following equations are considered:

$$y_t = \theta + \pi T + \psi y_{t-1} + \sum_{i=1}^{k} d_i \Delta y_{t-i} \quad (3)$$

Each time series has a non-zero mean and a non-zero drift. As a result, the estimation should include both a constant term (μ or θ) and a trend term (T) in each specification. The relevant null hypothesis is that |μ|=1 or |ψ|=1 against the corresponding alternative hypothesis that |α|<1 or |ψ|< 1. A failure to reject the null hypothesis would imply that each time series is nonstationary at the level and stationarity can be restored by first differencing of the level data.

$$\Delta z_t = a z_{t-1} + \sum_{i=1}^{m} b_i \Delta z_{t-i} + q_t \quad (4)$$

To search for cointegration, the following ADF regression is considered:

The ADF test is applied on â to accept or reject the null hypothesis of no-cointegration. The null hypothesis is rejected if the calculated pseudo t-value associated with â is greater than its critical value, provided in Engle and Yoo (1987) at various levels of significance.

If x_t and y_t are cointegrated, there must exist an error-correction representation which may take the following form:

$$\Delta x_t = \beta_1 z_{t-1} + \sum_{i=1}^{k} \phi_i \Delta x_{t-i} + \sum_{j=1}^{k} \delta_j \Delta y_{t-j} + u_{1t}$$

The series x_t and y_t are cointegrated if β_1 is non-zero. If $\beta_1 \neq 0$, then the changes in y_t will lead the changes in x_t in the long run. If δ_j's are not all zero, movements in y_t will lead those in x_t in the short run.

A failure to reject the null hypothesis of no-cointegration by ADF tests suggests that the estimation of the error-correction models to search for cointegration should not proceed further. However, model (5) and its reverse specification can be estimated without including the corresponding error-correction terms to pursue a search for simple Granger causality on the basis of F-test (Bahmani and Payesteh, 1993).

The error-correction model (ECM) was first introduced in Sargan (1964). It was subsequently popularized, among others, by Davidson et al. (1978), and Hendry et al. (1984). It has enjoyed a revival in popularity due to the recent work of Granger (1986, 1988) and Engle and Granger (1987) on cointegration. Its importance in the cointegration literature derives from the fact that if two variables are cointegrated of order 1 and are cointegrated, they can be modeled as having been generated by an ECM.

The monthly data are employed in this study. The sample period extends from January, 1973 through July, 1999. The exchange rate and consumer price index (CPI) data have been obtained from various issues of *Federal Reserve Bulletin*. The 10-year T-bond yield and the 3-month T-bill rate data have been collected from various issues of *S&P Basic Statistics*. The monthly nominal data on each variable have been deflated by CPI to obtain their corresponding real magnitudes.

Next, the unit root test results that correspond to equations (2) and (3) are reported as follows:

Table 1 shows that the null hypothesis of unit root (nonstationarity) cannot be rejected for any of the above individual time series at 5 percent level of significance. This is based upon a comparison of the critical value at -3.410 with the calculated ADF values (with trend). Again, the same conclusion is arrived at by comparing the critical value at -2.860 with the calculated ADF statistics (without trend) at 5 percent level of significance. It implies that exchange rates as well as 3-month T-bill rates and 10-year T-bond yields (both nominal and real) are nonstationary at 5 percent level of significance.

Subsequently, the ADF tests are conducted for pairwise cointegration by using equation (4). The results are reported as follows:

Table 2 reveals that the null hypothesis of no-cointegration cannot be rejected at 1 percent and higher levels of significance in any of the above cases. This conclusion is arrived at by comparing Engle and Yoo (1987) critical values with the calculated ADF statistics. It implies that there is no long-run association between: (i) nominal exchange rate and nominal 3-month T-bill rate, (ii) nominal exchange rate and nominal 10-year T-bond yield, (iii) real exchange rate and real 3-month T-bill rate, and (iv) real exchange rate and 10-year T-bond real yield.

Despite a lack of cointegration between X_t and Y_t, equation (5) and its reverse specification have been estimated for simple Granger causality following Bahmani and Payesteh (1993). They suggest that these equations be estimated with an exclusion of the respective error-correction term. The results are now reported as follows:

On the basis of F-tests, table 3 depicts that there is two-way short-run Granger causality between: (i) nominal exchange rate and nominal 10-year T-bond nominal yield at 5 percent and higher levels of significance, (ii) real exchange rate and real 3-month T-bill rate at 1 percent and higher levels of significance, and (iii) real exchange rate and 10-year T-bond real yield at 1 percent and higher levels of significance. But there is no solid evidence of unidirectional or bidirectional Granger causality between nominal exchange rate and nominal 3-month T-bill rate. In essence, the above results indicate that the exchange rates (both real and nominal) and 10-year T-bond yields (real and nominal) have short-run bidirectional causal relation in Granger sense. So, the exchange rate determination with respect to interest rates of varying maturities, in general, is a short-term phenomenon within a bivariate cointegration framework. Furthermore, a lack of cointegration between foreign exchange market and the markets for U.S. 3-month T-bills and 10-year T-bonds suggest that these two markets reveal a weak-form joint efficiency (Engle and Granger, 1987). To add further, the final prediction error (FPE) criterion has been applied to determine the optimum lag-lengths because of its ability to trade-off bias that arises from underparameterization of a model against a loss of efficiency resulting from overparameterization of the model (Akaike, 1969; Mahdavi and Sohrabian, 1993).

Vector cointegration and results

The use of a bivariate model may sometimes fail to provide evidence of cointegration. But an alternative model of vector cointegration may produce a different picture. So, this paper applies the vector cointegration procedure, developed in Johansen (1988) and Johansen and Juselius (1990).

The following is a brief empirical exposition of Johansen and Juselius (1990) methodology:

$$\Delta X_t = \delta + \pi X_{t-1} + \sum_{j=1}^{K-1} T;\, \Delta X_{t-j} + m_t \quad (6)$$

where X_t denotes a vector of exchange rate, short-term interest rate and long-term interest rate either in nominal or real term, and $\pi = \alpha\beta'$. α is the speed of adjustment matrix and β is the cointegration matrix. Equation (6) is subject to the condition that π is less than full rank matrix, i.e. $r < n$. The procedure boils down to testing for the value of r on the basis of the number of significant eigenvalues of π. For this purpose, the maximum eigenvalue test (λMax) and the trace test (λTrace) are applied. The following table 6 presents a summary of the vector error-correction model (VECM) parameter estimates:

A comparison of the above critical values at 10 and 5 percent levels of significance for the λTrace and λMax tests show that the null hypotheses of r 2 and r 1 cannot be rejected. But the null hypothesis of r 0 relating to λMax test is rejected at 10 percent level of significance. It implies that the U.S. exchange rate is basically driven at least by a single financial factor. It may be either the 3-month T-bill rate or the 10-year T-bond yield or both. To add further, the trace statistic generally identifies more cointegrating vector than the maximum eigen value test. But the maximum eigen value test is probably more reliable (Johansen and Juselius, 1990).

Conclusions

To summarize, the unit root tests reveal that U.S. exchange rate, 3-month T-bill rates and 10-year T-bond yields are nonstationary both in real and nominal terms at 5 percent level of significance. It is noted further that the nonstationarity in each variable is valid both with and without trend. The ADF results fail to reject the null hypothesis of no-cointegration at 1 percent and higher levels of significance. The estimates of model (5) and its reverse specification without the error-correction terms show that there is two-way short-run Granger causality between variables (both nominal and real) in each pair. The vector cointegration estimates indicate at 10 percent level of significance that U.S. exchange rate is virtually driven at least by one financial factor.

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Table 1 adf test of unit root

VARIABLE	ADF (with Trend)	ADF (without Trend)	Number of Lags
NER	-1.58994	-1.40951	4
RER	-1.5953	-1.40722	4
NSI	-2.94936	-1.72938	4
RSI	-3.03501	-1.73115	4
NLI	-2.43463	-1.40900	4
RLI	-2.54186	-1.43426	4

*Critical values at 5% level of significance are -3.410 (with trend) and -2.8600 (without trend). Here, NER = trade-weighted nominal exchange rate (percent), NSI = nominal 3-month T-bill rates, NLI = nominal average yield on 10-year T-bonds, RER = trade-weighted real exchange rate, RSI = real 3-month T-bill rates, and RLI = weighted-average real yield on 10-year T-bonds.

Table 2 cointegration tests based on adf procedures

DEPENDENT VARIABLE (X_t)	INDEPENDENT VARIABLE (Y_t)	ADF STATISTICS	DW
i)NER	NSI	-1.862 (8)	1.998
ii)NER	NLI	-2.284 (22)	1.996
iii)RER	RSI	-2.066 (24)	2.00
iv)RER	RLI	-2.557 (23)	1.997

*The critical values of ADF statistics, as 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. They are chosen by the final prediction error (FPE) criterion.

Table 3 bivariate granger-causality test

DEPENDENT VARIABLE	"CAUSAL" VARIABLE	LAG ORDERS[a]	F-STATISTICS[b]
NER	NSI	m = 10, n = 14	(8,181) = .2956
NSI	NER	m = 10, n = 14	(8,181) = 1.738
NER	NLI	m = 21, n = 21	(7,182) = 3.3078**
RER	RSI	m = 23, n = 21	(6,186) = 3.394*
RER	RLI	m = 21, n = 23	(13,181) = 3.0026*
NLI	NER	m = 24, n = 22	(7,178) = 1.714***
RSI	RER	m = 21, n = 23	(2,184) = 2.868*
RLI	RER	m = 21, n = 23	(7,186) = 2.3931*

@(i)Lag orders are selected based on the final prediction error (FPE) criterion, m = lag length of dependent variable, n = lag length of "causal variable".

(ii)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.

(iii)* significant at the 1% level, ** significant at the 5% level, and *** significant at the 10% level.

Table 4 multivariate cointegration tests

DATA VECTOR	NULL HYPOTHESIS	□MAX	□TRACE
(i)(NER, NSI)	r 1 r 0	4.02721 5.8173	4.02721 9.84452
(ii)(NER, NLI)	r 1 r 0	1.3611 11.20346	1.3611 12.56457
(iii)(RER, RSI)	r 1 r 0	1.68292 10.11063	1.6829 8.42771
(iv)(NER, NSI, NLI)	r 2 r 1 r 0	3.58182 6.7183 39.1854	3.58182 10.30014 49.48562
(v)(RER, RSI, RLI)	r 2 r 1 r 0	2.10259 18.36250 24.8126	2.10259 20.46508 45.2771

CRITICAL VALUES@

	λ Trace		**λ Max**	
Ho	10%	5%	10%	5%
r 2	28.44	31.26	18.96	21.28
r 1	45.25	48.42	24.92	27.34
r 0	65.96	69.98	30.82	33.26

@Johansen and Juselius (1990), Table 2.

[a] This paper considers only U.S. Treasury securities because of their higher attractiveness to foreign investors on account of safety from default risk. The full faith Treasury securities studied here are 3-month T-bills and T-bonds of 10-year maturity. They both continually enjoy Moody's AAA rating.

[b] Index of trade-weighted average exchange value of U.S. dollar against the currencies of 10 industrial countries. The weight for each of the 10 countries is the 1972-76 average world trade of that country divided by the average world trade of all 10 countries combined (Federal Reserve Bulletin, 1978).