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12-1-1987

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CENTER DISCUSSION PAPER NO. 546

U.S. MILITARY EXPENDITURE AND THE DOLLAR:

A NOTE

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December 1987

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Abstract

In this paper we study the connection between U.S. military expenditure and the Dollar/DMark real exchange rate. Using quarterly data for the period 1951.I-1986.III, we find that there exists a significant relationship linking real exchange rate, real military spending, and real GNP. We base our conclusion on evidence that these three variables are cointegrated.

1. Introduction

Many recent contributions have tried to explain fluctuations in the real exchange rate of the dollar against major currencies, most of all the Japanese Yen and the Deutsche Mark. The findings have not been very encouraging. It seems that the exchange rate is hardly related to any fundamental variable, and that its value evolves according to an unpredictable stochastic process. In a recent paper, Ayanian (1987) studies whether political risk is one fundamental variable to which the value of the dollar can be anchored. He argues that an increase in military expenditure in the United States should increase the foreign demand for dollar-denominated assets (because of a safe-haven argument) and appreciate the dollar. Ayanian claims that this kind of relationship exists between the Fed real exchange rate index and defense expenditure as a percentage of GNP for 1973-1985.

In this note we apply techniques recently developed in the non-stationary time series literature. We believe this to be the correct way to analyze problems related to the real exchange rate. By using a longer time period and a (slightly) different specification of the real exchange rate equation, we find that Ayanian's safe-haven argument can indeed be justified by the data.

The rest of this note is organized as follows. In section two we describe the essential features of the methodology used to analyze the relationship between the real exchange rate and expenditure on military defense. Section three discusses the choice of the data and the sample period. Section four reports our results, and section five concludes.

2. Non-stationary time series econometrics

The work of Nelson and Plosser (1982) showed that a large number of economic time series can be described in terms of non-stationary stochastic processes, of the form:

$$(2.1) \quad y_t = \mu + \alpha y_{t-1} + u_t$$

where μ is a constant drift, $\alpha = 1$, and u an error term. If u is an i.i.d. series, then y_t is a random walk. In general, such a representation is known as an integrated process of order one, or I(1).

Phillips (1986) gave a theoretical foundation to some of the findings of Granger and Newbold (1974), and showed that a spurious relation can emerge when an I(1) process is regressed against another I(1) process. Thus, two non-stationary series may not interact with each other even if the coefficients of the regression are significant according to the traditional t-test. In fact, in this case, the usual t-ratio does not have a limiting distribution, but actually diverges as the sample size increases (Phillips (1986)). The correct econometric methodology for I(1) variables has recently been explored in Engle and Granger (1987), under the name of cointegration. Consequently, it is of considerable importance to decide whether a series is I(0) or I(1) before doing any empirical work.

Phillips (1987) and Phillips-Perron (1986) developed tests of non-stationarity which generalize the original test used in the Nelson-Plosser study, (the Dickey-Fuller or the Augmented Dickey-Fuller test), and other tests proposed in Dickey-Fuller (1981). The new test is more general in that it allows for some degree of autocorrelation and heteroskedasticity in the evolution of the error term, u.

If the hypothesis of non-stationarity can be rejected, then standard econometric procedures can be applied. If not, the theory of cointegration may provide useful information about the relationship between the variables under study. Two variables (x and y) are cointegrated if they are individually of order I(1), but can be linearly combined in a way that the residuals from such linear combination are of order I(0), that is stationary. This means that each series, taken by itself, has a tendency to drift apart, but that there is some relationship between the two which link one to the other. This linear combination can be interpreted as a long-run equilibrium relationship. Moreover, Granger and Engle (1987) showed that, if x and y are cointegrated, there will always exist an 'error correction' representation of these variables of the form:

(2.6a) $\Delta x_t = -\rho_1 u_{t-1} + \text{lagged } (\Delta x_t, \Delta y_t) + A(L)\epsilon_{1t}$

(2.6b) $\Delta y_t = -\rho_2 u_{t-1} + \text{lagged } (\Delta x_t, \Delta y_t) + A(L)\epsilon_{2t}$

where $u_t = y_t - \gamma\, x_t$ are the residual from the cointegrated regression of y on x; A(L) is a finite polynomial in the lag operator L; ϵ_{1t}, ϵ_{2t} are joint white noise; and $|\rho_1| + |\rho_2| \neq 0$. The system (2.6) provides some indication about the short run relation among the variables.

Different tests for cointegration have been recently proposed. Our econometric analysis employs the Augmented Dickey-Fuller test (ADF). We refer the interested reader to Engle and Granger (1987) and Phillips and Ouliaris (1987) for the description and derivation of this and other tests.

3. Description of the data

Ayanian studies the Fed real exchange rate index for the period 1973-1985 (on an annual basis) as the independent variable of a simple ordinary least squares regression. Various dependent variables are considered among which, crucially, the United States defense budget as a percent of GNP and the federal budget deficit as a percentage of GNP. He finds that the defense budget has a significant explanatory power for the real exchange rate on the basis of the t-statistics.

This methodology, however, is unsatisfactory for several reasons. First of all the number of observations (13) is very small and does not leave sufficient degrees of freedom to make a significant statistical inference. Moreover, some of the variables included in the regressions may be non-stationary, so that statistical inference cannot be made on the basis of standard procedures. In the following, we improve Ayanian's analysis in two directions. First, we extend the sample, which now consists of quarterly observations on the mark-dollar exchange rate[1] for the period 1951.1-1986.3. This has the effect of dramatically increasing the power of the tests. Second, we explicitly test for non stationarity of the variables and for cointegration when this is appropriate according to the unit-root test results.

It should be noted that the period 1951.1-1986.3 is characterized by different nominal exchange rates regimes. However, this is of no concern to us since we consider the real exchange rate. One might think that this is going to affect the tests for non-stationarity, since flexible exchange rate regimes are distinguished by a higher variability of the real exchange rate than fixed exchange rate regimes (Mussa, 1986). But, as we mentioned in the previous paragraph, Phillips and Perron (1986) and Phillips (1987) tests can handle a variety of processes for the error term, including the kind of heteroskedasticity which is likely to arise in this context. Also, note that the increased power of the test derives not so much from the increased periodicity of the data (from annual to quarterly observations) as from the extended length of the total sample (Shiller and Perron, 1985).

The variables which are considered are the end-of-period DM real exchange rate, military expenditure as a percentage of GNP, total expenditure as a percentage of GNP, real GNP, real military expenditure, and real total government expenditure.

4. Results

Table 1 summarizes the results of testing for non-stationarity of the series. The statistic $Z(t_\alpha)$ is a test of the hypothesis that in equation (2.1) $\alpha = 1$, with a possible non-zero drift. The statistic $Z(\phi_3)$ is a test of the joint hypothesis that $\alpha = 1$ and that a time trend of the form $(t - T/2)$ is absent. The unit root hypothesis cannot be rejected for the real exchange rate, real military expenditure, real total expenditure or real GNP. Some doubts arise about the expenditure variables when considered as a percentage of GNP. According to $Z(t_\alpha)$ one can reject the unit root hypothesis at a level between 2.5 and 1% if the minimum and the median values of the statistics are considered. The null hypothesis cannot be rejected if the maximum value is considered. Analogous results come from $Z(\phi_3)$; the only difference is that the joint hypothesis of unit root and no trend can be rejected more strongly.

Even if the hypothesis that the expenditure ratios are non-stationary cannot be rejected firmly, it could be argued that from a theoretical point of view, these ratios have to be stationary. Even if this were the case, however, it would make no sense to regress the real exchange rate (an I(1) variable) on the military expenditure to GNP ratio (an I(0) variable), since "dependent and independent variables have such vastly different temporal properties" (Granger (1986) p. 216). The residual from such a regression would be non-stationary, indicating that the I(0) variable doesn't have any power in reducing the uncertainty of the dependent variable. Note, also, that the distribution of the t-ratio will be different from its standard distribution, so that the usual critical values would not be the correct ones in this case.

The next step was testing for cointegration: we ran the cointegrating regression of the real exchange rate on a constant and the potentially cointegrated variables, and we calculated the ADF test. Because of space limits, we report the results for the ADF test first (see table 2), and the results of the cointegrating regression only for those combinations of variables which are of interest on the basis of the ADF. (The ratios of military and total expenditure to GNP were considered but did not give any sign of cointegration with the real exchange rate, and for this reason the results are not reported.)

The real exchange rate appears to be cointegrated with real military expenditure and real GNP when the two are considered together, and with real military and total expenditure and GNP, when the three are considered together. There is no sign of cointegration if one drops real military expenditure or real GNP, suggesting that cointegration for the set of three variables might be due mostly to these two variables.

The cointegrating regression for the exchange rate against real military expenditure and real GNP is reported in the third table. The third table also reports an estimate of the error correction mechanism, relating the change in the real exchange rate to the disequilibrium component prevailing in the previous year (the estimated error from the cointegrating regression) and to the changes in the other variables involved in the cointegrating regression. According to the error correction equation, the particularly significant variables are the level of past disequilibrium (u_{t-1}), the change in military expenditure lagged three and four quarters, and the one-lagged change in the real exchange rate

5. Conclusions

This paper finds a significant relationship between the Mark-Dollar real exchange rate and the levels of U.S. real GNP and real military expenditure for the period 1951.1-1986.3. Ayanian (1987) reached a similar conclusion. However, we believe that the evidence he presented was unquestionably weak (given the extremely small number of observations), and probably incorrect (since it was derived ignoring the non-stationarity of the series under consideration).

Finally, we would like to warn against a theoretical interpretation of this relationship. The "military safe-haven" argument may be a politically tempting and certainly controversial way of reading the evidence. However, our results cannot be interpreted as a test of this (or any other) theory. They just provide an additional stylized fact that should be taken into account when theoretical models of the real exchange rate are developed.

NOTES

1. When Ayanian regressions are run using the Mark-Dollar real exchange rate, instead of the Fed index, the results are not significantly different.

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Table 1: $Z(t_\alpha)$ and $Z(\phi_3)$ Statistics

	Military Expenditure as a Percentage of GNP		Total Expenditure as a Percentage of GNP		Real Exchange Rate	
	$Z(t_\alpha)$	$Z(\phi_3)$	$Z(t_\alpha)$	$Z(\phi_3)$	$Z(t_\alpha)$	$Z(\phi_3)$
Minimum Value	-3.954	5.288	-3.821	5.487	-2.078	1.602
Maximum Value	-3.006	8.847	-3.173	8.269	-1.719	2.385
Median Value	-3.862	8.487	-3.741	7.929	-2.055	2.333

	Military Expenditure in Real Terms		Total Expenditure in Real Terms		Real GNP	
	$Z(t_\alpha)$	$Z(\phi_3)$	$Z(t_\alpha)$	$Z(\phi_3)$	$Z(t_\alpha)$	$Z(\phi_3)$
Minimum Value	-2.589	1.389	-1.329	1.417	-2.442	3.433
Maximum Value	-1.592	3.537	-1.065	1.717	-2.097	4.215
Median Value	-2.509	3.333	-1.229	1.598	-2.324	3.942

Critical Values, $Z(t_\alpha)$; 10%: -3.12; 5%: -3.41; 2.5%: -3.66; 1%: -3.96

Critical Values, $Z(\phi_3)$; 10%: 5.34; 5%: 6.26; 2.5%: 7.16; 1%: 8.27

Table 2: Testing for Cointegration

Dependent Variable: Real Exchange Rate

Independent Variable:

	Augmented Dickey-Fuller
Real Military Expenditure	1.399
Real Total Government Expenditure	2.233
Real GNP	2.271
Real Military Expenditure and Real GNP	4.162
Real Total Government Expenditure and Real GNP	2.861
Real Military Expenditure and Real Total Government Expenditure	3.509
Real Military Expenditure, Real Total Government Expenditure and Real GNP	4.431

Critical Values (Phillips-Ouliaris, 1987)

	Significance Level	
n	0.050	0.025
1	3.3454	3.5861
2	3.7696	4.4055
3	4.1375	4.4079

n is the number of variables included in the right hand side of the cointegrating regression.

Table 3: Cointegrating Regression and Error Correction Mechanism

Cointegrating Regression

Dependent Variable: Real Exchange Rate

Independent Variables:

	Estimated Coefficient	Standard Error
Constant	3.1412	0.1978
rmil	0.017	0.0013
rgnp	-0.0009	0.00005

Error Correction Mechanism

Dependent variable: change in the real exchange rate

Independent variables:

	Estimated Coefficient	Standard Error		Estimated Coefficient	Standard Error
$\hat{\mu}_{t-1}$	-0.1021	0.0364	$\Delta(rgnp)_{t-3}$	-0.0003	0.0005
$\Delta(rmil)_{t-1}$	-0.0009	0.0029	$\Delta(rgnp)_{t-4}$	0.0001	0.0004
$\Delta(rmil)_{t-2}$	0.0002	0.0031	$\Delta(reexch)_{t-1}$	0.3989	0.0883
$\Delta(rmil)_{t-3}$	0.0085	0.0029	$\Delta(reexch)_{t-2}$	0.0144	0.0908
$\Delta(rmil)_{t-4}$	-0.0073	0.0027	$\Delta(reexch)_{t-3}$	0.0757	0.0918
$\Delta(rgnp)_{t-1}$	0.0004	0.0004	$\Delta(reexch)_{t-4}$	0.0599	0.0950
$\Delta(rgnp)_{t-2}$	-0.0005	0.0005	$R^2 = 0.238$	D.W. = 2.006	

rmil: real military expenditure
rgnp: real gnp
$\hat{\mu}$: estimated error from the cointegrating regression