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Alternative Hypotheses on the Excess Return on Dollar Assets, 1980-84

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Summary

From late 1980 through 1984, dollar-denominated assets exhibited average annual returns 12 to 18 percent higher than those on similar assets denominated in other major currencies. From the point of view of efficient financial markets theory, this margin is puzzling because it suggests unexploited profit opportunities.

There are two explanations for this apparent puzzle: a high risk premium on dollar assets and a systematic discrepancy between actual and expected returns. The former explanation is not very convincing, because the alleged risk premium seems too large to be credible (compared, for example, with the historic risk premium of equities over government bonds). The paper therefore investigates the suggestion that large return differentials can be attributed to a systematic difference between expected and actual exchange rate changes. Exchange rate changes are emphasized because they were quantitatively the most important factor contributing to the return differentials.

The two hypotheses underlying this explanation are based on the idea that, for a prolonged period, there was a small but significant possibility of a large depreciation of the dollar. Since this depreciation did not take place, the actual values of exchange rate changes differed persistently from their expected values. The two models capable of generating such a situation are a "peso problem" model, in which the possibility of an important policy change is the source of the discrepancy between actual and expected exchange rate changes and a speculative bubble model, in which the exchange rate is temporarily driven away from its fundamental value by market expectations, but the possibility of a burst in the bubble and of a collapse to the fundamental value is also significant.

By contrast, the differentials in nominal interest rates do not exhibit a similar pattern. As can be seen from the bottom panel of Table 1 the interest rate differential in favor of dollar assets showed a very modest tendency to increase relative to the pound sterling and the Japanese yen, but not relative to the rest of the currencies. Even in those cases where there has been an increase in the interest rate differential, its magnitude is much smaller than the change observed in ex post returns. 1/ Therefore, the persistent appreciation of the U.S. dollar exchange rate was primarily responsible for the change in the pattern of the ex post return differential. In fact, during the last of the three periods considered, the dollar has risen, in effective terms, at an average rate of some 12 percent annually. The U.S. dollar exchange rate is also the major driving force of the short run variability of the excess return. A (sample moments) variance decomposition of the ex post excess returns shows that over 90 percent of the variance of the excess return is explained by the variance of the exchange rate.

To summarize the stylized facts, the data in Table 1 suggest two observations. First, there has been a substantial increase in the mean value of the ex post difference in returns in favor of U.S. dollar denominated assets, a process that started in the last months of 1980. Second, the increase in the excess return has been the result of the combination of relatively constant nominal interest rate differentials in favor of the dollar with a persistent appreciation of the dollar.

In order to find a theoretical justification for these observations, there are two main lines of reasoning that can be followed. The first is to assume that the ex post excess returns serve as unbiased estimates of the expected returns, which leads to the conclusion that there has been a considerable increase in the risk premium associated with dollar assets. 2/ The second is to consider that there has been a sustained divergence between the expected and the realized values of the returns, a fact that would be likely to arise when the probability distribution of the exchange rate is asymmetric.

1/ This behavior of the nominal interest differential may be sensitive to the dates and the measure of interest rates chosen. But, in any case, movements in interest rate differentials have been one order of magnitude smaller than exchange rate changes.

2/ A different, but related, explanation of recent exchange rate developments is the "safe haven" hypothesis, which explains the real appreciation of the dollar as the consequence of a change in perception about country risks (Dooley and Isard (1985)). However, in this context, the shift in asset demands would imply a lower rather than higher expected return on dollar assets, because this explanation implies a lower relative risk on U.S. dollar-denominated assets.

The plausibility of the first explanation--an increase in the risk premium as the main determinant--is questionable. Although the increase in the supply of U.S. dollar-denominated assets--which came mostly as a consequence of the large federal deficits over the last period--could provide some rationalization of a higher risk premium on those assets, a 10 to 18 percentage point increase in the risk premium seems to be excessively high. For example, the excess return of the stock market over treasury bills in the United States was, on average, about 6 percent for the period 1889 to 1978, as computed by Grossman and Shiller (1981). (Data presented by Mehra and Prescott (1985).) Also, the increase in the risk premium that results from a change in the relative asset supplies can be theoretically calculated on the basis of the capital asset price model. Frankel (1985b), using sample moments to estimate the variance-covariance matrix and assuming a value of two for the coefficient of risk aversion, calculated that a one percentage point increase in the share of U.S. government bonds in the portfolio of world asset-holders implies only an increase of 2 annual basis points in the yield differential favoring dollar assets. Then, given an estimated increase in the share of U.S. assets of between 10 and 15 percentage points since 1980, this factor could only account for less than 1 annual percentage point of excess return, which is less than one-tenth of the observed increase in return differentials. Although these computations probably underestimate the required changes in risk premia, they are still a very long distance away from increments of 10 to 18 percent. 1/

Therefore, this paper investigates the second explanation, that is, the hypothesis that there has been a systematic difference between the observed return differentials and their expected values. This situation would arise when the probability distribution of the exchange rate is assymetric and includes a small probability of a very large change in the value of the exchange rate. This change would be associated with an event such as a shift in policy regimes or a sudden change in expectations of market participants. If such event has a low probability of occurrence it is likely that it will not be observed during long sample periods but, if the implied change in the exchange rate is large enough, it will still have a considerable effect over the observed excess return.

There is also some casual evidence supporting the idea that the exchange rate was following a process of that type, particularly near the end of the sample period. For example, there seemed to be a widespread belief among economists that a large drop in the value of the

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1/ Several comments on Frankel's paper pointed out the implausibly low value of the risk premium that is predicted by these estimates (Brookings Papers on Economic Activity, 1985:I). The critical problem seems to be the values of the variance-covariance matrix, for which the sample moments might be a poor estimate if the processes are not stationary.

dollar was eventually inevitable, either because of the action of market forces or because of political decisions. This is evident, for example, from the Symposium on the Exchange Rate, BPEA (1985:1). Furthermore, in a communique issued after a meeting in September 1985, the five major industrial countries expressed the view that the dollar was above the value that corresponded to economic fundamentals and started to coordinate some policy actions aimed at bringing down its value. Anticipations of actions of this type, even if they fail to take place for some time, affect the return on financial assets, and could well have generated the high ex post excess return on dollar assets that was observed during the period under study.

There are two families of models that can explain a situation like the one described: a "peso-problem" model and a speculative bubble model. A peso-problem situation arises when a potential change in the current regime or policy stance has a significant influence over the expected value of the exchange rate, but this change does not take place over some relevant length of time. 1/ A speculative bubble is a situation in which the price of an asset follows a rational expectations path but diverges from the fundamental value of the asset, that is, from the intrinsic value of the asset according to economic considerations. Although both of these formulations would tend to influence the foreign exchange market in a similar way, the underlying driving forces are different. In the former case it is the anticipation of policy actions that is driving the market, while in the latter it is purely the mood or the whims of the economic agents. 2/

A number of authors have considered these types of alternative hypotheses as plausible explanations of the behavior of the dollar exchange rate, although without attempting to test them empirically. For example, Dornbusch (1982) considers the applicability of these families of models, and explains what he calls the "dollar problem". He sees the tightening of monetary policy in the United States since 1979 as a random event, in the sense that its continuation was regarded by the public as less than certain. Also, there are a number of empirical papers--Cumby and Obstfeld (1984), Hodrick and Srivastava (1984), and Fama (1984), for example--that mention the peso problem as a possible reason for the failure of tests of asset price equations, but that do not pursue the idea further.

1/ The origin of the term refers to the Mexican situation of the 1970's, when the peso was permanently at a forward discount, despite a fixed exchange rate system that was in place for years. See Krasker (1980).

2/ Another possibility that has been suggested is that the large appreciation of the dollar was caused by an increase in the long-term interest differential. If the exchange rate of the dollar is expected to eventually return to its starting value, a 5 percentage point interest differential on 10-year securities requires a logarithmic initial appreciation of the exchange rate of 50 percent. However, this interpretation does not help to explain the large interest differential on short-term assets.

The plan of the paper is the following. Section II investigates the plausibility of the peso-problem explanation for the high ex post return on dollar assets. The strategy is to take standard models of asset pricing and to test whether the restrictions imposed by such models can be rejected in a way that conforms to the predictions of a peso-problem model. The evidence shows that variables that are indicators of expectations of potential policy actions are correlated with the observed values of the excess returns, which is consistent with the peso-problem explanation (although not exclusively). Section III discusses a speculative bubble model that is consistent with the behavior displayed by the variables during this period and performs some statistical tests of that specification. Again, the evidence is in general favorable, although some of the parameters are not significant; however, as in the former case, the tests performed do not rule out other interpretations of the data. Section IV draws some conclusions.

II. A "Peso-Problem" Model

This model describes a situation in which the returns on financial assets are heavily influenced by a potential change in the policy stance that would bring about a substantial depreciation of the exchange rate. Although the probability of such a policy shift occurring in any given month is low, the depreciation of the exchange rate that this policy shift would generate is considerable. Then, the observed high excess return on dollar assets is a consequence of the lack of occurrence of this policy change: if the change were to occur the dollar would depreciate and the excess return would be highly negative but, as long as the change does not occur, the excess return is persistently positive. From the point of view of the effects on the excess return, the exact nature of the policy change involved is unimportant. The only requirements are that it implies a substantial depreciation of the dollar and that the probability of its occurrence is low, as perceived by the market participants.

The econometric implications for the excess returns of this type of situation will first be obtained for a simple case, which is when domestic and foreign assets are perfect substitutes. Then, the same approach will be followed to perform the empirical tests on the basis of more sophisticated formulations of asset pricing models. The econometric implications of the model are obtained under the assumption that, during the sample, the policy change did not take place. This is somewhat different from the original approach followed by Krasker (1980), who focused in the speed of convergence of the estimators when the probability distribution of the residuals is asymmetric. That approach seems to be more appropriate for a situation in which the economy alternates between the two different regimes repeatedly, which is not what is suggested by the data in this case. Also, the econometric difficulties caused by this situation are not merely a small sample problem. This is because, by the very nature of the problem, the exchange rate will not in general have a stationary probability distribution. For example, if the policy regime changes are expected to be more than ephemeral, after an actual change in regime takes place, the probability of ocurrence of the two regimes must change, which means that the probability distribution function of the exchange rate process must also change. 1/

The simplest version of this family of models can be developed under the assumptions that there are two countries and two assets (one denominated in each currency), individuals are risk-neutral, and the prices of goods are non-stochastic. In such a world, under the usual assumptions about portfolio selection, all assets are perfect substitutes and the financial market equilibrium condition is that the expected nominal return on all assets be the same. Denoting by i the (continuously compounded) interest rate on the home currency assets, by i* the same variable referred to the foreign country, and by x the logarithm of the exchange rate (units of domestic currency per one unit of foreign currency), the excess return y is defined as:

$$(1) \quad y_{t+1} = i_t - i_t^* - x_{t+1} + x_t$$

Under rational expectations, the equalization of expected returns implies that the excess return must be unpredictable using any information known at the time that the asset prices are determined, or:

$$(2) \quad E(y_{t+1} | I_t) = 0$$

where $E(.|I_t)$ refers to the mathematical expectation conditional on the values of all relevant variables dated at time t or earlier.

These constraints on the conditional expectations of returns can be used directly to perform econometric tests of their validity. In particular, a testable proposition is that the excess returns should exhibit no correlation with any variable that is part of the information known to the agents at the time of determining the price of the asset. The failure of this property to hold implies that the market is not using all the available information to predict asset returns, and therefore the model specification can be rejected; however, the test does not discriminate which particular assumption fails to hold.

Now suppose that, at any time t, the system can find itself in either of two states, which are represented by the variable Ω. In the context of the described situation, Ω indicates the policy regime or stance

1/ More technically, the observations would be neither independent nor identically distributed.

vis-a-vis the exchange rate. If $\Omega = 1$, the stochastic model that determines the exchange rate is $x_t = \bar{e} + u_t$ with $E(u_t | I_{t-1}) = 0$, $Var(u_t) = \sigma_u^2$. If instead, $\Omega = 2$, the exchange rate follows a model $x_t = \bar{s} + u_t$. For it is assumed that the random term u_t is the same in both states (so that they differ only in the expected values of the exchange rate, $\bar{e}$ and $\bar{s}$) but the same qualitative properties would obtain under different distributional assumptions.

The probability of state 1 is $P(\Omega=1) = \Pi$. The same rational expectations equilibrium condition should still apply, that is, $E(y_{t+1} | It) = 0$. In order to satisfy it, the excess return will follow:

$$(3) \quad y_{t+1} = (\Pi\bar{e} + (1-\Pi)\bar{s}) - x_{t+1}$$

Suppose that during the sample period the system has been permanently in state 1. Then, an econometrician testing the properties of the excess return will face the fact that $E(y_{t+1} | I_t, \Omega=1)$ is equal to $(1-\Pi)(\bar{s} - \bar{e})$ instead of zero. This will lead him to the rejection of the model (or of the market efficiency assumption) even though that conclusion is obviously not warranted.

In order to test the applicability of the peso problem formulation the best alternative would be to develop a full general equilibrium model that would specify how the values of Π, $\bar{e}$ and $\bar{s}$ are determined as a function of the policy regime and other variables. However, this paper pursues a more modest goal here and will conduct a search for evidence that the behavior of the excess return has been roughly consistent with a model of the peso problem variety. As shown above, the excess return, instead of being unpredictable, would be a function of the differential value of the exchange rate under the two regimes and of the corresponding probabilities. However, neither Π nor $\bar{s}$ is observable and, in general, neither one will be constant over time. Furthermore, a glance at equation (3) reveals that it is not possible to identify both of them. But if there exist some variables Z that are correlated with them, they could be used as instruments or indicators of the unobservable variables. More specifically, the assumption is the following:

$$(4) \quad [(1-\Pi)(\bar{s}-\bar{e})]_{t+1} = Z_t\beta + \varepsilon_{t+1}$$

The above notation on the left hand side is meant to represent the probability of a change in regime at time t+1 times the difference between the expected values of the exchange rate under states 1 and 2 at t+1 (these values are no longer assumed to be constant). Using equation (3), equation (4) implies that the following regression could be estimated:

$$(5) \quad y_{t+1} = Z_t\beta + \varepsilon_{t+1}$$

The instruments Z must be correlated with the probability--as evaluated ex ante by market participants--of a regime change. Therefore, variables such as the appreciation of the dollar real exchange rate, the U.S. trade deficit, or indicators of the fiscal and monetary stances, could play that role. If the vector of coefficients β is nonzero the evidence would be consistent with the peso problem formulation. Such test would represent a rejection of the rational expectations conditions (equation (2)), because Z_t is obviously part of I_t, although the reasons for this rejection could be multiple. According to the peso problem explanation, it is not a failure of the theoretical structure of the model but instead it is a consequence of a particular random distribution of the exchange rate.

The tests conducted here are based on the two most popular asset pricing models. These are the consumption-based asset price model, which has been used in the international finance context by, for example, Hansen and Hodrick (1983), and the traditional or static capital asset pricing model, which has been applied and tested in the international finance case by, for example, Frankel (1982). The strategy is the following: our null hypothesis will be that the corresponding equilibrium asset price model holds in "pure" form, that is, with the usual assumption that the exchange rate has a stationary probability distribution. The alternative hypothesis will be that a peso problem situation exists and that some instruments Z_t, that satisfy the requirements explained above, are available. As above, the test that the coefficients of those variables are nonzero will serve as indirect evidence in favor of the validity of the alternative formulation of the exchange rate process.

1. The consumption-based model

This model is based on the optimal time path of consumption and portfolio selection that an individual chooses in a dynamic stochastic environment. From the point of view of asset prices, the main implication is that the equilibrium returns on each of the different assets should be perfectly correlated with the marginal utility of consumption enjoyed by any consumer-investor in this economy. See Merton (1973) or Breeden (1979). (A derivation is presented in Appendix I.)

A particularly convenient version of this model for empirical purposes is obtained under two assumptions: one, that the utility function belongs in the class of constant relative risk aversion, and two, that the logarithm of the marginal utility of consumption, the logarithms of the returns on the different assets, and the logarithms of the other relevant variables follow a joint Gaussian vector autoregression process. Under this specification, one implication of the theory is that the expected value of the difference in the logs of any two nominal returns (which has been defined above as the excess return) should equal a constant that is determined by the variance of the returns and the covariances between returns and marginal utility (See Appendix I.) 1/ Applying a standard rational expectations argument, it follows that the sample observations can be represented in the following way:

$$(6) \quad y_t^j = k^j + \eta_t$$

where y^j represents the ex post excess return of dollar assets over the foreign asset j. Furthermore, η has the property that $E(\eta_t | I_{t-1}) = 0$, where I_{t-1} indicates a set that contains past values of the relevant variables, and $Var(\eta_t) = \sigma_\eta^2$.

Turning to the alternative hypothesis, the assumption is that there are two possible states of the economy, related to different policy regimes. During some span of time the economy found itself continuously under one regime but the probability of a change of regime was not insignificant. There exists a set of instruments Z_t which are correlated with the probability of a regime change and with the magnitude of the depreciation that would follow. Then, as shown in Appendix I:

$$E(\eta_{t+1} | I_t, \Omega_{t+1}=1) = Z_t \beta.$$

Since October 1980 is tentatively considered the starting date for this situation, this suggests running the following regression for each return differential favoring dollar-denominated assets:

$$(7) \quad y_{t+1} = k + D_t Z_t \beta + \mu_{t+1}$$

where $D_t = 0$ before October 1980, and

$= 1$ since October 1980.

As before, since the Z variables are in the information set they should not help predict the excess return under the null hypothesis. The test that the β coefficients are nonzero, although formally only rejecting the model in this version, also provides evidence in favor of a peso problem specification. 2/

1/ Note that this model implies that the risk premium is constant.

2/ It should be noted that the fact that the coefficients β are different from zero could also be consistent with other alternative hypotheses. For example, it could be argued that the variables Z are acting as predictors of a time-varying risk premium. However, as argued in Section I, the risk premium explanation does not appear to be sufficient to justify the magnitude of the return differentials.

2. Empirical results

The main difficulty in the empirical estimation of equation (7) is the selection of appropriate instruments for the unobservable variables involved in the equation. Potential candidates are variables that somehow measure the degree of "overvaluation" of the U.S. dollar because the higher the "overvaluation" of the U.S. dollar, the more likely that the authorities will shift the policy stance and, trivially, the larger the devaluation that would take place if such policy change is enacted. The variables that provided the best empirical results were the real exchange rate of the dollar and the U.S. trade deficit. The other variables that were considered as candidates were the interest rate differential and the U.S. budget deficit.

The selection of the nominal interest rates also involves some complication. It would be preferable to use the nominal return on assets that are completely default-free, so that the exchange rate could be considered to be the only source of uncertainty. A standard procedure (for example in Mishkin (1984)) is to use Eurocurrency deposit rates, under the assumption that the differences in expected rates of return are not affected by the default risk, since it is identical for deposits of different currency denominations. This reasoning is not, however, entirely correct. The difference in expected returns is not affected by the default risk only when the latter--in addition to being the same for all assets--is uncorrelated with variations in the exchange rate. 1/ That is not likely to be the case if changes in exchange rates have some impact on the financial position of banks operating in the eurocurrency market. This situation could arise either directly, when the net asset position of banks is not perfectly balanced in every currency, or indirectly through the effect that sharp changes in exchange rates may have over the solvency of the borrowers in this market. However, it is assumed that the default risk in the Eurocurrency market is of sufficiently small magnitude to be safely ignored. Furthermore, given the predominance of exchange rate changes in the determination of the actual excess returns, it is unlikely that small differences in the measures of interest rates would bring about a substantial difference in the empirical results.

1/ To see this, consider the following example. Let α be the random variable that indicates the proportion of a deposit that is recovered (α will equal one in normal times and will be less than one in the event of bank failure). Then, $\alpha(1+i)$ is the final value of a dollar denominated asset, and $\alpha(1+i^*)\hat{x}$ the yield of a, say, mark denominated deposit, where $\hat{x}$ indicates the rate of depreciation. The expected return differential will be $(1+i)E(\alpha) - (1+i^*)E(\alpha\hat{x})$. Then, if for example $Cov(\alpha,x) > 0$, the difference in expected returns will tilt in favor of mark-denominated deposits.

The results of estimating equation (7) by ordinary least squares are presented in Table 2. The sample period runs from June 1974 to March 1985. Five excess returns were examined independently: the return of U.S. dollar deposits versus mark, French franc, pound, yen and Swiss franc deposits. The interest rate variable is the thirty-day Eurocurrency deposit rate. Lagged values of the real exchange rate of the dollar (based on normalized labor costs) and the ratio of the U.S. trade deficit to GNP were used as indicators of the "overvaluation" of the dollar. Although these two variables had significant coefficients when included alone, there was a considerable loss of significance when both were included simultaneously, probably as a consequence of their high collinearity.

The results are supportive of the peso-problem hypothesis, except for the case of the excess returns over yen-denominated assets. In all but that case, the coefficients of the indicator variables are significant at least at the 5 percent level. Since the right-hand side variables are all part of the information set, their significance constitutes a clear rejection of the model in its pure form, that is, when the exchange rate is generated by a covariance-stationary process. Also, all the coefficients have the expected sign and their values are not unreasonable. When the real exchange rate is used as the indicator variable, the results imply that that a 10 percent real appreciation of the US dollar increases the return differential in favor of dollar assets by an annual rate of approximately 1.7 to 2.0 percent. 1/ When the trade account is used, the coefficients imply that an increase in the commercial deficit of $40 billion causes the excess return on dollar assets to increase by 6 to 8 percentage points relative most other currencies (but only less than one percentage point relative to the Swiss franc). 2/

Almost every empirical study on returns on assets of different currency denomination has found evidence of heteroskedasticity, even when different specifications, sample periods, and data were used (compare for example, Hsieh (1984), Cumby and Obstfeld (1984), and Hodrick and Srivastava (1984)). Apart from the estimation and testing biases that arise, this fact is also a signal of misspecification of the model being estimated. In particular, it constitutes a violation of the covariance stationarity assumption. Therefore, a test of the homoskedasticy assumption was performed. This test is basically the extension to time series regressions of White's (1980) procedure that has been applied by most of the previous studies. Except for one of the regressions of the excess return over pound sterling, where

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1/ These values result from multiplying the coefficients reported in Table 3 by the mean of the right-hand side variable (1.3) and by 12 (to annualize it).

2/ In this case, the coefficients directly give the value of the change because the explanatory variable is the trade deficit at monthly rates as a percentage of GNP at annual rate.

Table 2. Test of the Consumption-Beta Model, One-Month Euro-Currency Returns

	Constant	Z	DW	F 1/	SE	Test 2/
(Z1 = Real effective exchange rate based on labor costs) 3/						
Deutsche mark	-0.12 (0.37)	1.09* (0.44)	2.17	6.04	3.20	0.24
French franc	-0.28 (0.36)	1.10* (0.44)	2.16	6.36	3.14	1.21
Pound sterling	-0.26 (0.37)	1.13* (0.44)	1.84	6.61	3.18	6.28
Japanese yen	0.18 (0.38)	0.42 (0.45)	1.82	0.86	3.26	1.12
Swiss franc	-0.26 (0.43)	1.27* (0.52)	1.95	5.94	3.76	0.36
(Z2 = Ratio of U.S.trade deficit to GNP in corresponding quarter)						
Deutsche mark	0.08 (0.34)	6.58* (2.83)	2.14	5.41	3.16	1.51
French franc	-0.04 (0.33)	6.15* (2.77)	2.11	4.94	3.09	1.79
Pound sterling	-0.14 (0.31)	8.87** (2.60)	1.96	11.67	2.90	5.59
Japanese yen	0.26 (0.35)	2.47 (2.93)	1.81	0.71	3.27	1.92
Swiss franc	-0.02 (0.40)	0.73* (3.34)	1.91	4.85	3.72	1.78

1/ Test of the significance of all coefficients. Critical value (5 percent) is 3.0.
2/ Test of the null hypothesis of homoskedasticity, distributed as Chi Square with two degrees of freedom.
3/ IFS line 65UMC110, interpolated using nominal exchange rates as benchmarks to get monthly data.

Note: Dependent variable = excess return over each currency. Standard errors in parentheses. Sample : June 1974 to February 1985.
** = Significant at the 1 percent level.
* = Significant at the 5 percent level.

it is marginally significant at 5 percent, heteroskedasticity is amply rejected. This is a clear support for the alternative specification, and may provide an explanation of why other studies have systematically encountered heteroskedasticity.

Given that many previous studies have focused on the return on 90-day deposits, and considering that that might be a more relevant decision period than the 30-day term used above, the same regressions were run using data on (overlapping) three-month ex post returns. Applying OLS the results are very similar, in fact with an improvement in the significance of the coefficients. These results are reported in Table 3. However, the OLS estimates of the standard errors are inconsistent in this case. The problem that arises here is that, since the interval between observations is shorter than the term of the deposits, some autocorrelation will be present in the residuals because they represent, at least partly, prediction errors. Consider the prediction error that is discovered at time t. *It will affect the return differential* on deposits made at t-3 and due at t, but also on deposits made at t-2 and t-1 that mature at t+1 and t+2. This means that the residuals will tend to follow a second order moving average process. Standard corrections, such as generalized least squares, are not useful in this case and would in fact render the estimates of the regression coefficients inconsistent too. The reason is that the regressors are not exogenous but merely predetermined, and the transformation of variables that the GLS procedure involves would induce correlation between the transformed right hand side variables and the transformed residuals.

A solution to this problem is presented by Cumby, Huizinga, and Obstfeld (1983). It consists of a two-step procedure. The first step is to estimate the coefficients by some consistent method (OLS in our case since all the right-hand side variables are predetermined); the second step is to use the fitted residuals to obtain an estimate of their variance-covariance matrix, imposing the serial correlation structure that is known to exist. This estimate of the variance-covariance matrix is used to carry out the hypothesis testing. The results of applying this procedure, also presented in Table 3, are not so favourable to the alternative hypothesis. The significance of the coefficients disappears in all cases. 1/ This fact is puzzling, since the behavior of the one-month and the three-month excess returns look remarkably similar to the naked eye. Furthermore, if the estimation is carried out using nonoverlapping data (a procedure that is in principle inferior because it disregards some information) the results are basically similar to those obtained by applying OLS, as can be seen from Table 4. Therefore, it is the procedure followed to correct the variance-covariance matrix, rather than the data, that is responsible for the lack of

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1/ Another estimation was done using the variance-covariance matrix suggested by Hansen and Hodrick (1980), which is consistent but not heteroskedasticty-resistant. The results did not differ significantly.

Table 3: Test of the Consumption-Beta Model
Three-Month Eurocurrency Returns

	Constant	Z	DW	SE	Test 1/
(Z1 = Real effective exchange rate based on labor costs)					
Deutsche mark	-0.10	1.14	0.75	1.72	0.10
	(0.20) 2/	(0.24)			
	(3.68) 3/	(4.18)			
French franc	-0.25	1.14	0.69	1.68	0.08
	(0.19)	(0.24)			
	(3.46)	(4.32)			
Pound sterling	0.29	1.37	0.74	1.74	0.14
	(0.20)	(0.25)			
	(3.84)	(4.17)			
Japanese yen	0.12	0.50	0.54	1.94	0.03
	(0.22)	(0.27)			
	(4.80)	(5.22)			
Swiss franc	-0.26	1.32	0.62	2.22	0.08
	(0.25)	(0.31)			
	(5.32)	(5.61)			
(Z2 = Ratio of U.S.trade deficit to GNP in corresponding quarter)					
Deutsche mark	0.10	5.73	0.74	1.78	0.12
	(0.19)	(1.60)			
	(3.64)	(21.6)			
French franc	0.02	4.77	0.65	1.76	0.07
	(0.19)	(1.59)			
	(3.64)	(21.8)			
Pound sterling	-0.08	7.41	0.76	1.8	0.24
	(0.19)	(1.62)			
	(3.75)	(20.1)			
Japanese yen	0.26	1.8	0.53	1.96	0.02
	(0.21)	(1.76)			
	(4.43)	(28.0)			
Swiss franc	-0.03	6.92	0.62	2.27	0.12
	(0.24)	(2.04)			
	(5.04)	(27.2)			

1/ Test of significance of all coefficents, based on the consistent variance-covariance matrix, distributed as Chi Square with 2 degrees of freedom. Critical value (5 percent) is 5.99.
2/ OLS standard errors.
3/ Standard errors based on a consistent estimate of MA2 variance-covariance matrix.

Note: Dependent variable = Excess return over each currency. Standard errors in parentheses. Sample: June 1974 to February 1985.

Table 4. Three-Month Eurocurrency Returns. Non-Overlapping Data

	Constant	Z	DW	F 1/	SE	Test 2/
(Z1 = Real effective exchange rate based on labor costs) 3/						
Deutsche mark	-0.05 (0.37)	1.08* (0.45)	2.04	5.84	1.79	0.24
French franc	-0.16 (0.37)	1.02* (0.45)	1.96	5.28	1.78	1.21
Pound sterling	-0.27 (0.36)	1.18* (0.43)	1.64	7.48	3.18	6.28
Japanese yen	0.03 (0.40)	0.55 (0.48)	1.66	1.34	1.91	1.12
Swiss franc	-0.09 (0.47)	1.17* (0.56)	2.00	4.31	2.25	0.36
(Z2 = Ratio of U.S. trade deficit to GNP in corresponding quarter)						
Deutsche mark	0.12 (0.34)	7.32* (3.42)	1.97	4.58	1.82	1.51
French franc	2.62 (0.35)	6.38 (3.42)	1.83	3.48	1.82	1.79
Pound sterling	0.05 (0.35)	5.69 (3.43)	1.52	2.75	1.82	5.59
Japanese yen	0.20 (0.37)	2.37 (3.65)	1.65	0.42	1.94	1.92
Swiss franc	0.08 (0.43)	7.98 (4.28)	2.00	3.47	2.27	1.78

1/ Test of the significance of all coefficients. Critical value (5 percent) is 3.0.

2/ Test of the null hypothesis of homoskedasticity, distributed as Chi Square with two degrees of freedom.

3/ IFS line 65UMC110, interpolated using nominal exchange rates as benchmarks to get monthly data.

Note: Dependent variable = excess return over each currency. Standard errors in parentheses. Sample: June 1984 to February 1985.

** : Significant at the 1 percent level.

* : Significant at the 5 percent level.

significance. A possible explanation may come from analyzing the error term in equation (7). Since our indicator variables do not provide an optimal forecast of the unobservable probability of a regime change, the residuals in this regression will not be only the pure prediction error. It is a situation similar to the case of omitted variables. Then, if these "omitted variables" have a strong serial correlation, the variance-covariance matrix will, as a result, appear somehow "inflated".

To summarize, it is clear that--with the exception of the yen--the "pure" form of the intertemporal models of asset prices can be rejected. Furthermore, the finding that the higher the degree of "overvaluation" of the dollar, the higher the excess return on dollar assets, is an indication that a peso-problem type of exchange rate expectations may be at least part of the explanation of the observed excess returns.

3. The capital-asset pricing model

The capital-asset pricing model (CAPM) is certainly the most popular model of asset pricing in the finance literature. It is a static or one-period model that is based on the asset demands of savers that behave as mean-variance optimizers. Mean-variance optimization can be considered a local approximation to the more general assumption of expected utility maximization. Although the assumptions on which the CAPM is based seem to be more restrictive than the intertemporal model considered above, this is compensated by the simplicity and intuitive appeal of its predictions. In addition, if the random process generating the returns is time-separable in a well defined sense, or if the utility of the agents is logarithmic, the intertemporal problem collapses to the static one (Merton (1982)). Furthermore, the empirical implementation of the CAPM requires fewer additional assumptions, which is perhaps a reason why Mankiw and Shapiro (1984) found that it does a better job in explaining a cross-section of returns than the consumption-beta model. In the international finance context, an additional attractive feature of this model is that it provides a microeconomic foundation for the asset market approach to the exchange rate.

A useful formulation for empirical applications is the one proposed by Kouri (1977) and Dornbusch (1983), which focuses on asset demands. These turn out to be proportional to the expected rates of return, with the factor of proportionality involving the variances and covariances of all the returns. The derivation is shown in Appendix 1. This implies that the excess returns will satisfy:

(8) $E(y_{t+1}) = \alpha + w_t \delta$

where w_t is a vector containing the shares of the different assets in the aggregate portfolio. The coefficients δ are functions of the variance-covariance matrix of the returns, but they will be assumed to be constant, as is necessary in order to obtain an estimable form.

The approach will be entirely parallel to the one followed with the intertemporal model. It is assumed that the probability distribution of the exchange rate depends, as above, on which of the two possible policy regimes is governing the economy. For any period during which the system is in state 1, equation (3) implies that the excess returns will satisfy the following equation:

$$(9) \quad y_{t+1} - E(y_{t+1}|I_t) = ((1-\Pi)(\bar{s} - \bar{e}))_{t+1} + u_{t+1}$$

where, in this case, $E(y_{t+1}|I_t)$ is given by equation (8). If, as before, there exist instruments Z_t for the first term in the right hand side of equation (9), the following regression can be run:

$$(10) \quad y_{t+1} = \alpha + w_{t+1}\delta + D_t Z_t \beta + u_{t+1}$$

where D_t is the dummy variable that equals one from October 1980 onward. 1/ Once again, a rejection of the hypothesis that $\beta = 0$, will constitute a rejection of the static CAPM in a way that is suggestive of a peso-problem type of situation.

4. Empirical results

The most serious data problem in this case is to select and measure the securities to be included in the aggregate portfolio. The standard procedure, followed here, is to consider only the outstanding stock of government bonds, in the spirit of most empirical work related to the asset market approach to the exchange rate. 2/ The specific procedure followed to construct those stocks is detailed in Appendix II. The ex post real interest rates were computed using an inflation rate measured as a weighted average of CPI's, with the weights determined by the size of the respective GNP's. Only the 30-day returns were used.

1/ Note that, although the regression based on the consumption-beta model--equation (7)--seems to be nested into (10), it can be seen that this is not the case when all the restrictions implied by the models are considered. For example, as shown in Appendix I, the coefficients α and δ in (10) are a function of covariances between asset returns, and of the variance-covariance matrix of the residuals u, while the constant term k in (7) is a function of the covariances of asset returns with consumption. (These restrictions were not tested in this paper.)

2/ The practice is based on the assumption that government bonds are outside assets. However, based on finance theory, the correlations with all the traded securities are relevant and, for example, stocks and private bonds should also be part of the model.

The results, displayed in Table 5, indicate that when the real exchange rate is used as the indicator variable, the null hypothesis--the "pure" form of this model--is rejected in all cases but Japan. For that country, the entire equation does not seem to fit very well either, since the value of the F test of significance of all coefficients is about one, whereas the critical value (5 percent) is 2.1. The U.S. trade deficit did not provide successful results in this model, and it is not reported. The point estimates of the share coefficients seem to be roughly in line with previous studies that have used different samples and definitions of asset quantities. The estimated coefficients imply that a 10 percent increase in the real exchange rate causes an increase of about 4 to 8 points in the yield differential (see footnote (1), page 20 for the derivation of these values).

The importance of this model in this context is that it contains an explicit formulation of the risk premium explanation. That is, the increase in the outstanding stock of dollar securities associated with the U.S. federal deficit is included as an explanatory variable in this specification. Nevertheless, there is still evidence that variables measuring the degree of "overvaluation" of the dollar are able to explain, to some extent, the behavior of the excess return on dollar assets.

III. A Speculative Bubble Model

The price of an asset is in a speculative bubble equilibrium when it follows a rational expectations path that diverges from the fundamental value of the asset. This means that the expectations of the market participants are "correct" (that is, they are equal to the mathematical expectation of the asset price), but they are not equal to the fundamental value of the asset (that is, to its intrinsic economic value). In the case of the exchange rate, the fundamental value seems a bit harder to define than in that of a real asset, since the fundamental value of the currencies involved is itself less precise a concept. Since currencies lack consumption value, their market value necessarily depends on the expectation that they will be accepted as means of payments by other agents in the future. However, it is still possible to define the fundamental value of the exchange rate, for example as the one that corresponds to the equilibrium path that converges to a steady state.

Are rational bubbles a possible equilibrium in foreign exchange markets? Based on the literature, 1/ the answer seems to be in the affirmative, if a reasonable description of the foreign exchange market could be one in which finite-lived agents trade a perpetual asset, the supply of which is determined by outside forces. Also, given that assessments of the fundamental

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1/ See Blanchard and Watson (1982) and Tirole (1985) on the possibility of rational bubbles.

Table 5. Test of the CAPM Model: $Y = \alpha + W\delta + Z\beta + U$ 1/

	α	δ_1	δ_2	δ_3	δ_4	δ_5	β	DW	F 2/
Deutsche mark	-1.8	-209.5**	-30.3	55.8	419.4**	288.3	-5.77**	2.10	3.69
	(6.2)	(65.9)	(55.4)	(32.9)	(117.6)	(342.2)	(1.7)		
French franc	-1.6	-197.8**	-41.2	64.1*	415.2**	135.9	-6.07**	2.14	4.22
	(6.0)	(63.7)	(53.5)	(31.8)	(113.7)	(330.8)	(1.6)		
Pound sterling	-6.3	-143.4*	51.4	28.7	278.8*	495.1	-4.27**	2.15	3.55
	(5.8)	(62.1)	(52.2)	(31.0)	(110.8)	322.5)	(1.6)		
Japanese yen	7.8	-60.1	-68.9	-14.1	191.9	-129.0	-2.96	1.80	0.99
	(6.8)	(72.1)	(60.6)	(36.0)	(128.7)	(374.6)	(1.8)		
Swiss franc	-3.3	-263.0**	-68.6	105.5**	576.6**	216.9	-8.37**	1.91	5.59
	(6.9)	(74.2)	(62.4)	(37.1)	(132.4)	(385.5)	(1.9)		

1/ The dependent variable is the difference in monthly ex post real interest rates (each currency minus the dollar). A weighted average of CPI's was used as deflator. The explanatory variables W are a constant and the portfolio share of each currency-denominated bond in the following order: Deutsche mark, French franc, pound sterling, Japanese yen, and Swiss franc. Z is the dollar real exchange rate lagged one period.

2/ Test of the significance of all coefficients. Critical value (5 percent) is 2.1.

Note: Standard errors in parentheses. Sample: June 1974 to September 1984.

** : Significant at the 1 percent level.

* : Significant at the 5 percent level.

value of the exchange rate seem to be quite "noisy", misperceptions or self-fulfilling prophecies might be likely in these markets. However, the question of the general equilibrium implications of a bubble on the exchange rate is a more difficult one, since all the repercussions on the rest of the economy should be considered.

To account for the observed behavior of the excess return on dollar assets of recent years, the exchange value of the dollar could be thought as having been on a bubble path (along which its value was appreciating) for most recent years; however, there was always a small probability that the dollar would crash and suffer a large depreciation that would restore the fundamental equilibrium. This would produce persistently positive excess returns on dollar assets even under equalization of ex ante returns. However, the duration of the period with high positive excess returns may be too long to be explained by a single episode (over four years); this suggests that the model might perhaps apply only to a subset of the sample considered.

Despite the different underlying forces that drive the process of appreciation of the exchange rate, there are some formal similarities between the speculative bubble model and the peso problem models. Both models could explain persistent differences in the ex post returns on assets of different currency denomination and a sustained appreciation of the exchange rate. In addition, the statistical results reported in the previous section do not necessarily rule out the speculative bubble hypothesis. Consider for example a situation in which the exchange rate is being driven entirely by speculative forces; all the same, the more overvalued the dollar becomes, the larger the depreciation necessary to bring it back to the fundamental level. Then, under a speculative bubble equilibrium, excess returns would also tend to show some correlation with the degree of overvaluation of the dollar.

The model will be developed under the assumption that the assets are perfect substitutes. This is certainly not the best assumption but it will suffice to explore the explanatory power of this approach for the behavior of excess returns. There are two possible states of the world: under state one ($\Omega = 1$) the exchange rate is on the bubble path, and under state two ($\Omega = 2$) the exchange rate is on its fundamental path. Changing slightly the notation, e_t will denote the bubble exchange rate and s_t will denote the fundamental exchange rate. The probability of occurrence of a bubble state is constant over time, and is denoted as π. From equations (1) and (2), and assuming that the economy is on a bubble equilibrium at time t, it follows that:

$$(11)\quad F_t = \Pi E(e_{t+1}) + (1-\Pi)E(s_{t+1}) - e_t$$

where $F_t = i_t - i_t^*$. Equation (11) can be solved forward to obtain the equilibrium value of the bubble exchange rate:

$$(12)\ e_t = \sum_{k=0}^{\infty} \Pi^k\ E\left((1-\Pi)s_{t+k+1} - F_{t+k} | I_t\right)$$

In equation (12), e_t is the only value that satisfies the dynamic rational expectations relation (11) and that does not start off on an explosive or implosive path. However, it is not the only rational expectations solution (see, for example, Shiller (1978)), and it does not conform very well to stylized facts that were described earlier. This is because, if F is expected to remain roughly constant (as it has been), and so is the fundamental exchange rate s (as is assumed to be approximately true) then the bubble exchange rate e will also be roughly constant, which openly contradicts the behavior of the dollar in the last five years. A definite, marked trend in e requires that either F or s display a similar trend. Therefore, other solutions to equation (11) will be considered, which are of the form:

$$(13)\ e_t = \sum_{k=0}^{\infty} \Pi^k\ E\left((1-\Pi)s_{t+k+1} - F_{t+k} | I_t\right) + A\Pi^{-t}$$

where A is an arbitrary constant that should be negative in the case of the dollar in recent years. It can be checked that equation (13) is a solution by using it to substitute for e_t and e_{t+1} in equation (11). This type of solution implies that the bubble exchange rate is following an explosive path, that is, as $t\to\infty$, $e_t\to 0$. However, in the long run, the bubble will burst with probability one. This is because the probability of a crash at or before time T is given by $\sum_{k=0}^{T} \Pi^k(1-\Pi)$ which $\to 1$ as $T \to \infty$. This means that, despite the fact that the price of foreign exchange is moving toward a value of 0, the chances of actually getting close to that value are insignificant. In fact, the expected duration of this bubble is only $1/(1-\Pi)$. 1/ Then, this model can serve at least as a local approximation to the exchange rate process, although it would cease to be a sensible one if the bubble were to last for an unexpectedly long time.

1. Empirical results

In order to proceed to the empirical estimation, it is necessary to solve the infinite sums in the right-hand side of equation (13). This is achieved by specifying what kind of processes the fundamental exchange rate and the interest rate differential follow. For the fundamental exchange rate, it is *assumed that it remained constant during the sample* period. For the interest rate differential, it is assumed that it follows a univariate ARIMA process. Following Box-Jenkins identification procedures, an AR(2) specification was chosen for the interest rate differential (an ARMA(1,1) also seemed to fit the data well). Under these

1/ This model was first developed (in a different context) by Blanchard (1979).

assumptions, applying techniques developed in Hansen and Sargent (1980) that involve the use of the Wiener-Kolmogorov prediction formula, the following system is obtained:

$$(14)\ e_t = \bar{s} - \theta_1 F_t - \theta_2 F_{t-1} + A\Pi^{-t} + \varepsilon_{1t}$$

$$(15)\ F_t = \Psi_1 F_{t-1} + \Psi_2 F_{t-2} + \varepsilon_{2t}$$

with the following cross-equation restrictions:

$$(16)\ \theta_1 = 1/(1-\Psi_1\Pi-\Psi_2\Pi^2),$$

$$(17)\ \theta_2 = \Psi_2\Pi\theta_1.$$

There are two interesting tests that can be performed on this system. One is the significance of the term $A\Pi^{-t}$, which represents a test of the existence of an explosive bubble. The other one is the set of cross-equation restrictions (16) and (17), which represents a test of rationality in the formation of expectations on future interest rate differentials. A feature that may be problematic in a solution such as equation (13) is that it implies that the exchange rate will appreciate at an increasing rate, even with a constant nominal interest differential. This can be seen by noting that, in the case of a constant F, $E(e_t - e_{t-1}|I_{t-1}) = A(1-\Pi)\Pi^{-t}$. However, this acceleration in the process derives from the general structure of the problem and not from any particular assumption made here. As the dollar becomes more overvalued, the loss in case of a crash in the bubble becomes bigger; therefore the expected rate of appreciation under the bubble state must be increasing too. This is the main reason why this type of bubble is not well suited to explain a long-lasting episode.

The results, which are presented in Table 6, are in general favorable to the model. Only the case of the dollar/deutsche mark rate was considered. Since the model is nonlinear in both the variables and the parameters (even in its unrestricted form), a minimum distance method of estimation was utilized. 1/ Given the plausibility of bubbles of shorter duration, three nested sample periods were considered: (a) from January 1983 to February 1985, (b) from November 1981 to February 1985, and (c) from November 1980 to February 1985. The coefficients of the model are jointly highly significant, and the key parameters have the correct sign and their values are generally in line with prior beliefs. Moreover, the results do not differ considerably for the different sample periods.

The first hypothesis--the significance of the explosive bubble term--stands well in the data. The values of likelihood ratio tests of the exclusion of the term $A\Pi^{-t}$ are reported in the penultimate column of Table 6. The tests easily reject such exclusion. However, the t-statistics

1/ The MINDIS routine of the RAL system.

Table 6. A Speculative Bubble Model

Estimation of:

(14) $e_t = s - \theta_1 F_t - \theta_2 F_{t-1} + A\Pi^{-t} + \varepsilon_{1t}$

(15) $F_t = \Psi_1 F_{t-1} + \Psi_2 F_{t-2} + \varepsilon_{2t}$

	Ψ_1	Ψ_2	$\bar{s}$	θ_1	θ_2	A	Π	Test 1/	Test 2/
				Sample: January 1983 to February 1985					
Unrestricted	1.07	-0.27	-0.81	21.9	-18.4	-0.019	0.95	65.2	
	(0.18)	(0.18)	(0.08)	(9.96)	(9.97)	(0.027)	(0.02)		
Restricted	1.06	-0.25	-0.78			-0.031	0.95		6.8
	(0.17)	(0.17)	(0.08)			(0.034)	(0.02)		
				Sample: November 1981 to February 1985					
Unrestricted	0.89	-0.20	-0.79	12.1	-10.5	-0.028	0.95	99.3	
	(0.15)	(0.16)	(0.04)	(6.08)	(6.11)	(0.017)	(0.01)		
Restricted	0.88	-0.20	-0.78			-0.031	0.95		0.4
	(0.15)	(0.16)	(0.04)			(0.018)	(0.01)		
				Sample: December 1980 to February 1985					
Unrestricted	0.83	-0.33	-0.69	2.5	1.55	-0.092	0.97	108.6	
	(0.12)	(0.12)	(0.06)	(3/)	(3.77)	(0.050)	(0.01)		
Restricted	0.83	-0.33	-0.69			-0.09	0.97		0.6
	(0.12)	(0.12)	(0.06)			(0.05)	(0.01)		

1/ Likelihood ratio test of the joint significance of A and Π. Distributed as Chi Square. Critical values are: 5 percent 5.99, and 1 percent 9.21.

2/ Likelihood ratio test of the parameter cross-equation restrictions (equations (16) and (17) in the text). Distributed as Chi Square. Critical values are the same as for the first test.

3/ This parameter value was restricted in order to obtain convergence.

for A itself are only marginally significant, although those of Π are highly significant. The values of Π range between 0.94 and 0.97, which implies a probability of crash of between 3 and 6 percent for each month. As the sample period considered is longer, the estimates of Π become higher; the reason is that for a bubble of longer durability a lower probability of crash is required. The estimates also imply that if the bubble had crashed at any point in the sample, the dollar/mark exchange rate would have collapsed to a value that ranges between DM 2.0 and DM 2.3 according to the sample period considered. That value is the fundamental exchange rate implied by the estimates.

The second hypothesis--the cross-equation parameter restrictions--is also accepted. A likelihood ratio test statistic of the functional relationships between the parameters (16) and (17) is reported in the last column of Table 6. The restrictions cannot be rejected at the 5 percent level (although in one case they would be rejected at the 1 percent level). The implication of this hypothesis is that expectations of interest rate differentials are formed rationally, considering the autoregressive process followed by interest rate differentials. However, this result should be taken with more caution because some of the coefficients involved are not statistically significant; in such case restrictions among their values are less meaningful.

Overall, these results are almost entirely consistent with the model and suggest that this approach might be valuable; a possible extension would be to apply this kind of model to shorter episodes and data of higher frequency. A final qualification should be repeated here. The success of the estimation of this model does not necessarily preclude alternative explanations of the exchange rate process. For example, the explosive bubble term could be a proxy for any omitted variable, for instance a marked increase in the risk premium.

IV. Conclusions

In reality, a complete explanation of the high excess return of dollar assets during the period 1980-84 might require a combination of different reasons. Some increase in risk premium may have occurred, and some of the observations might have been an unanticipated sequence of new information favoring a dollar appreciation. In addition, the two alternative hypotheses considered in this paper--the peso problem and the speculative bubble models--were shown to be consistent with the data.

The observed correlation between excess returns and some proposed measures of the degree of "overvaluation" of the dollar provides the basis for a formal rejection of the theoretical asset pricing models in their "pure" form, and is suggestive that the dollar was suffering some sort of peso problem. In addition, this type of hypothesis may help explain the frequent rejections of "pure" asset price models and the evidence of heteroskedasticity that is reported in most empirical applications. However, the correlation mentioned above does not seem to hold in the case of the excess return on dollar-denominated assets over yen-denominated assets.

The speculative bubble model that was postulated showed some empirical success. The relevant statistical tests were favorable and the coefficients had the correct signs and plausible values. However, this hypothesis presents a major shortcoming in that it predicts an increasing rate of appreciation. This makes it somewhat inappropriate for a prolonged period of appreciation. Nevertheless, it is an appealing model that might be best suited for runs of shorter duration.

Asset Pricing Models

1. The consumption-based model

The intertemporal capital asset pricing model is based on the optimal decisions of an agent that chooses a path of consumption and asset demands from a menu of securities that offer uncertain returns. These choices can be represented as the solution to the following problem:

$$(1)\quad J(W_t) = \max u(c_t) + \beta E_t[J(W_{t+1})]$$

$$\text{s.t. } W_{t+1} = [W_t - c_t + \Psi_t][R^1_{t+1} + \textstyle\sum_{j=2}^{n} w^j(R^j_{t+1} - R^1_{t+1})]$$

where W represents nonhuman wealth, R^j $(j=1,\ldots,n)$ is the random variable that equals one plus the rate of return on asset j, Ψ is nonstochastic labor income and w^j $(j=2,\ldots,n)$ is the share of asset j in the agent's portfolio. Note that the condition that the sum of w^j equals one has been imposed, but some of the w's may be negative (short-selling of the asset). (The notation applied here is slightly different from the one in the text, but this should not cause problems.)

The solution to this problem gives the following first-order necessary condition:

$$(2)\quad u_c'(c_t) = \beta E_t[u_c'(c_{t+1})R^j_t]$$

for $j=1,\ldots,n$. Letting $S_{t+1} = \beta u_c'(c_{t+1})/u_c'(c_t)$, this equation can be written as:

$$(3)\quad E_t[S_{t+1}R^j_t] = 1$$

In order to obtain an estimable form, the model must be complemented by some statistical assumptions. The following ones closely resemble Hansen and Singleton (1983). Let $R_t = [R^1_t, R^2_t, \ldots, R^n_t]$. Let $h_t = \ln[S_t, R_t, Z_t]'$, where Z_t are other economic variables that have some significant relationship with consumption and asset returns (in our applications, these were the real exchange rate and the trade deficit). Then, it is assumed that:

$$(4)\quad h_t = A_0 + A(L)h_{t-1} + U_t$$

where A(L) is a matrix polinomial in the lag operator and U is multivariate normal $(0, \Sigma)$. Consider the set $I^h_t = [h_t, h_{t-1}, \ldots]$. Conditional on I^h_t, the distribution of $\ln S_{t+1} + \ln R_{t+1}$ is Normal (μ^j_t, σ^{j2}). μ^{jt} is a function of the past values of h and σ^{j2} is constant. By the properties of the lognormal distribution, it follows that:

(5) $E[S_{t+1}R^j_{t+1}|I^H_t] = \exp(\mu^j_t + (1/2)\ \sigma^{j2})$

Given that I^h_t is a subset of I_t, by the law of iterated expectations, $E[S_{t+1}R^j_{t+1}|I^h_t] = 1$. Then:

(6) $\mu_{t-1} = -1/2\sigma^{j2}$

which means that:

(7) $E[\ln S_{t+1} + \ln R^j_{t+1}|I^h{}_t] = -1/2\sigma^{j2}$

Then, for two returns i and j:

(8) $E[\ln R^j_{t+1} - \ln R^i_{t+1}|I^h_t] = 1/2(\sigma^{i2} - \sigma^{j2})$

What implies:

(9) $\ln R^j_{t+1} - \ln R^i_{t+1} = y^i_{t+1} = k^{ij} + \eta_{t+1}$

with $E(\eta_{t+1}|I^h_t) = 0$. The first equality follows from the fact that the difference in the logs of the real returns is equal to the difference in the logs of the nominal returns. It can be seen that these distributional assumptions produce a constant risk premium.

Turning to the alternative hypothesis, under state one, the exchange rate has an expected value: $E(x|\Omega=1) = \bar{s}$ and under state two, $E(x|\Omega=2) = \bar{e}$. Recalling that $y^i_{t+1} = i_t - i^*_t - (x_{t+1} - x_t)$, it can be seen that:

(10) $E[y^i_{t+1}|I^h_t, \Omega_{t+1}=1] = k^i + (1-\Pi)_{t+1}(\bar{e}_{t+1} - \bar{s}_{t+1}) = Z_t\beta$

which is the basis for the tests carried out in the paper.

2. The static capital asset pricing model

The static capital asset pricing model determines the equilibrium returns that would prevail if the market were made up of savers who try to maximize the expected utility they derive from the value of their wealth. A useful approximation is to consider that the agents maximize a function of the mean and the variance of wealth. (The approximation is exact if utility is quadratic or the returns have a normal distribution). The basic setup (identical to Frankel (1983), for example) is:

$$\text{Max} \quad F\left(E_t(W_{t+1};V_t(W_{t+1})\right)$$

$$\text{s.t.}\ W_{t+1} = W_t(1 + R^1_{t+1} + w^1_t y_{t+1})$$

where W represents the value of (nonhuman) wealth, E_t and V_t are the conditional first and second moments, R^1 is one plus the real rate of return on asset one, $y = [R^2-R^1,\ldots,R^n-R^1]'$ and w is the vector of shares of assets 2 through n in the agents portfolio. As before, the shares are constrained to add up to one, but they can be negative.

A first order condition for this optimization is:

$$(11)\quad F_1'W_tE_t(y_{t+1}) + F_2'W_t^2\,\lfloor 2\Sigma w_t + 2\text{cov}(y_{t+1},R^1_{t+1})\rfloor = 0$$

where F_1' and F_2' indicate the derivatives of the utility function with respect to its first and second argument and Σ is the variance-covariance matrix of the excess returns y. Approximating the coefficient of risk aversion, ρ, by $-2WF_2/F_1$, equation (11) implies:

$$(12)\quad E_t(y_{t+1}) = K + \rho\Sigma w_t$$

which is the null hypothesis of this model. Now consider that there are two possible states of the world. Under state one, the excess returns follow the random process $y_{t+1} = \bar{y}^1_t + u_{t+1}$, and in state two they satisfy: $y_{t+1} = \bar{y}^2_t + u_{t+1}$. Then, $E_t(y_{t+1}) = \Pi\bar{y}^1_t + (1-\Pi)\bar{y}^2_t$ where Π is the probability of state 1. It follows that, in state one, the ex post excess returns will be given by:

$$(13)\quad y_{t+1} = E_t(y_{t+1}) + (1-\Pi)(\bar{y}^2_t - \bar{y}^1_t) + u_{t+1}$$

Substituting the expected value of the excess returns from equation (12), the alternative hypothesis of this model that is tested in the paper is obtained.

Computation of the Aggregate Portfolio Composition

The outstanding stocks of bonds issued by the different governments were computed applying the following methodology:

United States: IFS lines 88 minus 88a minus 88ad;

Germany: IFS lines 88 minus 12a;

France: IFS lines 88b minus 12a;

United Kingdom: the flow of budget deficit was cumulated over a starting value of PS 57.8 billion at end 1972. The deficit was estimated as IFS lines 84a minus 84aa minus 84ab plus 85ac plus 85ad. Since only quarterly data is available, interpolation was used to obtain monthly figures.

Japan: Bank of Japan monthly statistics, Table 79, column corresponding to "National Governments Debts" held by "Other holders or Lenders."

Switzerland: The flow of budget deficit was cumulated over a starting vlaue of SF 9.6 billion at end 1972. The deficit measure was IFS line 84a.

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