THE WORLD PRICE OF FOREIGN
EXCHANGE RISK

Bernard Dumas
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ABSTRACT

We consider a world capital market in which the investor population is heterogenous.

Investors of different countries differ in the prices of goods at which they consume the income

from their investments.   In such a setting, the international CAPM incorporates rewards for

exchange rate risk, in addition to the traditional reward for market-covariance risk.   The aim of

the paper is to determine whether these additional risk premia empirically play a significant role

in the pricing of securities.   The test being conducted is a test of a conditional version of the

CAPM.   It builds on the recent empirical literature which points out that stock market returns

may, to some extent, be predicted on the basis of a number of instrumental variables, such as

interest rates and dividend yields.   All previous tests of the international CAPM with exchange-

risk premia have been tests of the unconditional version and have been inconclusive.

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Introduction

With the work of Harvey (1989, 1991), an opportunity has arisen to test the *international* asset pricing model in its *conditional* form, without having to pre-specify the behavior of second moments of rates of return.

In the CAPM of Solnik (1974), Sercu (1980), Stulz (1981) and Adler-Dumas (1983), exchange-rate risk is priced. The model contains risk premia which are based on the covariances of assets with exchange rates, in addition to the traditional premium based on the covariance with the market portfolio.[1] These new premia are present because of deviations from Purchasing-Power Parity. In consuming their capital income, investors of different countries have access to goods at prices which are unequal.[2] Therefore, they view differently the returns from the same assets. The Japanese grant a premium on assets which protect their real purchasing power; this is a different premium from the one granted by the U.S. investors. Hence, the two premia show up as separate terms in the aggregated model.

We call "international" a CAPM which contains additional terms to reward exchange-rate risk while we call "classic" a CAPM which does not contain such terms and in which there is only one risk premium based on the covariance of the asset return with the market portfolio.[3] The main goal of the present paper is to discriminate empirically between the two models and to test the null hypothesis that exchange-rate risk receives a zero price, against the international CAPM alternative.

Attempts have been made in the past at testing the international CAPM;

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[1] See Equation (14) in Adler-Dumas (1983).

[2] The comparison is done after conversion into a common currency unit, of course.

[3] The classic CAPM is sometimes applied to international data (as in Harvey (1991)) using the world market portfolio as a basis for pricing.

see Solnik (1974) and Stehle (1977). They were based on the unconditional version of the International CAPM. These attempts, which will be replicated below, have been inconclusive. Recently, Korajczyck and Viallet (1989) have performed tests of several versions of the unconditional classic CAPM. They tend to reject all of them.

It is natural to test the CAPM in its conditional form. It is bad enough that the econometrician does not know what investors know and, therefore, *must* deal with a somewhat integrated, partially faulty CAPM. One would not want to carry the defect further by ignoring the conditioning information which is obviously available to investors, such as interest rates, equity prices etc.. These must appear in empirical tests in the form of instrumental variables.

The next issue is how to test a conditional CAPM. Many methods have been proposed. Of necessity, they rely on extraneous assumptions concerning the behavior of the moments of the probability distribution of returns in relation to the instrumental variables, and/or on the behavior of the market prices of risk. The major distinction between methods is the assumption made regarding the behavior of second moments. In the latent variable approach,[4] second moments are assumed constant and market prices of risk (the latent variables in question) are related linearly to the instrumental variables.[5] Generalized ARCH-M methods[6] specify second moment behavior and assume that the market price of risk is constant. In Ferson and Harvey (1991a, b), as in Fama and

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[4]See Hansen and Hodrick (1983), Hodrick and Srivastava (1984).

[5]In the latent variable approach, conditional first moments need not be specified.

[6]For an application of the GARCH-M methodology to international data, see Engel and Rodrigues (1989), Hodrick (1987), Chan, Karolyi and Stulz (1992). Chan, Karolyi and Stulz conducted a conditional bivariate estimation of a GARCH-M model of two assets, a U.S. equity index and a foreign equity index. This was a conditional classic CAPM since no exchange-rate risk premium was modelled. They found some evidence of a risk premium based on the covariance risk with the international market portfolio.

MacBeth (1973), the second moments are obtained by a separate, first-pass estimation and then the model is tested. This last method relies on an assumption concerning the speed at which second moments vary.

The alternative is to restrict the behavior of the market prices of risk, as was done in the latent-variable approach. Recently, Harvey (1989) has proposed a method in which the prices of risk are assumed constant and then the second moments are free to move about in an unspecified way. Furthermore, for the special case in which the CAPM features only one risk premium, he has proposed a substitution which allows both the market price of risk and the second moments to evolve in an unspecified way. In Harvey (1991), the classic CAPM is applied to international data using that technique. Unfortunately, the technique is not generalizable to more than one risk premium and has the undesirable implication that the CAPM is forced to be exactly verified when applied to the *ex post* return on the market portolio.[7]

In the present paper, we intend to apply the approach of Harvey (1989), but restricting the market prices of risk to be linear functions of the instrumental variables, in a manner similar to the latent-variable approach.

The major shortcoming of any CAPM model is that the model does not specify the choice of instrumental variables. CAPMs are partial-equilibrium models reflecting the equilibrium in the financial market only. The link with underlying physical and monetary variables is left unspecified. General-equilibrium models would make that link explicit and would in this respect be preferable. However, existing general-equilibrium models of the international economy are extremely simplistic. It would probably be premature to undertake any empirical tests at this stage. Furthermore, most of the underlying physical variables of the economy are observed with measurement errors and

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[7]The market's pricing error -- h_{mt} in Harvey's notation, as defined by his Equation (5) with j = m -- is identically equal to zero.

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with, at best, quarterly frequency whereas the financial variables which we wish to explain are observed with greater frequencies. Hence, even if the model under test did specify the choice of underlying variables, these would have to be proxied by endogenous variables that are observed frequently, such as financial market variables. The search for proxies would be guided by the model and would, therefore, introduce a degree of arbitrariness smaller than that introduced by the arbitrary specification of instrumental variables in a CAPM. The methodological gain would be undeniable but the end result may turn out to be very similar. In Section 2, we discuss our choice of instrumental variables.

For consistency, a CAPM which is conditional should also be multiperiodic (or dynamic). It is inconsistent to assume that investors base their estimates of future returns on current information, and then to assume that these same investors will not anticipate that the information, at the next investment point in time, will have shifted. If they do anticipate information shifts, investors adjust their portfolio choice today in an attempt to hedge those shifts, thereby introducing in the CAPM more premia, which are based on the covariances of asset returns with changes in the instrumental variables. Hence, the theory leads to an equilibrium relation[8] which includes numerous risk premia linked to possible shifts in the information set. This is true equally in the classic and the international CAPMs. A test of a full-blown conditional, international and dynamic CAPM is beyond our computational capabilities at the present time. But, in the last section of this paper, we attempt to throw some light on the choice one faces. Which is more important? Taking into account exchange risk premia or dynamic hedging premia?

The paper is organized as follows. Section 1 lays out the model and the

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[8]See Merton (1973).

econometric method to be used. Section 2 describes the data and some summary statistics concerning them. In Section 3, we estimate the conditional version of the international CAPM by the Generalized Method of Moments and conclude that the model is not rejected by the data. Section 4 contains the main tests in which we compare the international and the classic, conditional CAPMs and test for the price of exchange risk. In Section 5, we examine the role of the conditioning, instrumental variables; in particular, we test the hypothesis of zero price of exchange risk in the unconditional, international CAPM. In Section 6, we perform some validation experiments, including out-of-sample experiments, and in Section 7 we test whether the world capital market -- made up of the stock and the foreign exchange markets -- is integrated. In section 8, we run a comparison between international and dynamic CAPMs.

1. Model and econometric strategy

1.1 The classic and international CAPMs with Time-Varying Moments

This study focuses on *conditional*, asset pricing restrictions of a static nature. There are $L + 1$ countries, a set of $m - n + L + 1$ assets -- other than the measurement-currency deposit, -- comprised of n equities or portfolios of equities, L non-measurement-currency currency deposits and the world portfolio of equities which is the mth and last asset. The non-measurement-currency deposits are singled out by observing the above order in the list; i.e., they are the $(n + 1)$st to $(n + L)$th assets.

The international Capital Asset Pricing model is Equation (14) in Adler and Dumas (1983):

$$E[r_{jt}|\Omega_{t-1}] - \sum_{i-1}^{L} \lambda_{i,t-1} \text{Cov}[r_{jt}, r_{n+i,t}|\Omega_{t-1}] + \lambda_{m,t-1} \text{Cov}[r_{jt}, r_{mt}|\Omega_{t-1}] \quad (1.1)$$

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where r_{jt} is the nominal return on asset or portfolio j, $j = 1...m$, from time $t - 1$ to t, in excess of the rate of interest of the currency in which returns are measured, r_{mt} is the excess return on the world market portfolio and Ω_{t-1} is the information set which investors use in choosing their portfolios. The time-varying coefficients $\lambda_{i,t-1}$, $i = 1...L$, are the *world prices of exchange rate risk*. The time-varying coefficient $\lambda_{m,t-1}$ is the world price of market risk.

The model takes into account the fact that investors of different countries view returns differently; Equation (1.1) is the result of an aggregation over the several categories of investors. The covariances with exchange rates are present because of the optimal exchange-risk hedging behavior of the various investors. In truth, these should be covariances of rates of return on assets with changes in PPP (Purchasing-Power Parity) deviations between countries. However, in this study we consider a world restricted to countries in which local currency inflation risk (to a one-month horizon) has been negligible. We, therefore, identify PPP deviations changes with exchange rate changes.[9]

By contrast, the classic CAPM ignores investor diversity and assumes, in effect, that everyone in the world translates returns into consumption as do the residents of the reference currency country. Hence, no exchange-risk hedging premium appears. In the above notations, the restriction of the international CAPM to the classic CAPM is stated as:

$$\lambda_{i,t-1} = 0 \qquad i = 1...L, \forall t \qquad (1.2)$$

[9] Although each investor looks at returns from his own currency's point of view, it is immaterial in which currency units the model is written. This is because the theoretical model assumes the absence of money illusion (i.e., homogeneity of degree zero of the investors' utility functions in nominal wealth and local prices).

We now rewrite the international CAPM in the most parsimonious way that we can find. We introduce a new notation, M_t, referring to the marginal rate of substitution between nominal returns at date t and at date t-1 that is implied by the international CAPM. It is well known that the first-order condition of any portfolio choice problem may be written:

$$E[M_t r_{jt} \mid \Omega_{t-1}] = 0,$$

(1.3)

or, equivalently:

$$E[r_{jt} \mid \Omega_{t-1}] = Cov(r_{jt}, -M_t/E[M_t \mid \Omega_{t-1}] \mid \Omega_{t-1}). \qquad j = 1, \ldots. m. \quad (1.4)$$

Define u_t as the relative unanticipated component of the marginal rate of substitution:

$$u_t = 1 - M_t/E[M_t \mid \Omega_{t-1}],$$

(1.5)

with the obvious property that:

$$E[u_t \mid \Omega_{t-1}] = 0.$$

(1.6)

One may then rewrite (1.4) as:

$$E[r_{jt} \mid \Omega_{t-1}] = E[r_{jt} u_t \mid \Omega_{t-1}], \quad j = 1, \ldots. m.$$

(1.7)

Define h_{jt} as:

$$h_{jt} = r_{jt} - r_{jt} u_t, \quad j = 1, \ldots. m.$$

(1.8)

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h_{jt} is a disturbance that is unrelated to the information Ω_{t-1} under the null hypothesis that (1.7) holds. Indeed, (1.7) may be rewritten:

$$E[h_{jt}|\Omega_{t-1}] = 0, \qquad j = 1,\ldots.m. \qquad (1.9)$$

The international CAPM gives a special form to the marginal rate of substitution and to its unanticipated component. Let u_t be defined as:

$$u_t = \lambda_{0,t-1} + \sum_{i=1}^{L} \lambda_{i,t-1} r_{n+i,t} + \lambda_{m,t-1} r_{mt}. \qquad (1.10)$$

Then, under (1.6), Equations (1.1) and (1.9) are equivalent. In (1.10), $\lambda_{0',t-1}$ is whatever term is needed to bring about (1.6). The economic interpretation of Equation (1.10) is discussed below.

1.2 Econometric specification

In this subsection, we outline the empirical procedure that we are going to follow. We state two auxiliary assumptions that are needed. These will be discussed in subsection 1.3.

Assumption 1 of the empirical analysis: the information Ω_{t-1} is generated by a vector of instrumental variables Z_{t-1}.

Z_{t-1} is a row vector of ℓ predetermined instrumental variables which reflect everything that is known to the investor. We discuss in Section 2 below our choice of the Z variables; some of them will be variables endogenous to the financial market. The Zs in their limited number will not constitute a full description of the state of the real-world economy. Assumption 1 is a strong

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assumption which does not simply limit the information set of the econometrician; it limits the information set of the investors and, therefore, their strategy space.[10] Testing the CAPM under information set Ω_{t-1} or under the information set generated by Z_{t-1} is not testing two different implications of the same theory of investment. The two tests refer to two different theories of investor behavior.

Next, we specify the way in which the market prices, λ, move over time. In a general equilibrium setting these would probably be nonlinear functions of the exogenous variables describing the state of the economy. Nonetheless, we now assume that the variables, Z, can serve as proxies for the state variables and that there exists an exact linear relationship between the λs and the Zs:[11]

Assumption 2:

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\begin{aligned}
\lambda_{0,t-1} &= -Z_{t-1}\delta , \\
\lambda_{i,t-1} &= Z_{t-1}\phi_i , \qquad\qquad i = 1,\ldots L \\
\lambda_{m,t-1} &= Z_{t-1}\phi_m .
\end{aligned}
\qquad (1.11)
$$

Here the δs and ϕs are time-invariant vectors of weights. Later on, we interpret Assumption 2 in relation to the literature. But we first get on with the specification of the econometric model.

Given Assumption 2 and the definition (1.10) of u_t, we have:

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[10] By way of contrast, Hansen and Richard's (1987) theory of conditional vs unconditional portfolio efficiency deals with restrictions on the econometrician's (or the outside observer's) information set, keeping the investor's (or the fund manager's) information set the same.

[11] This specification has some similarities with the latent-variable approach of Hansen and Hodrick (1983) and Gibbons and Ferson (1985). The λs are the "latent variables".

$$u_t = - Z_{t-1} \delta + \sum_{i=1}^{L} Z_{t-1} \phi_i \, r_{n+i,t} + Z_{t-1} \phi_m \, r_{mt} \, , \qquad (1.12)$$

with u_t satisfying (1.6). Equation (1.12) serves to define u_t from now on.

We form the 1+m vector of residuals: $\epsilon_t = (u_t, h_t)$. Combining (1.6) and (1.9) under Assumption 1 yields: $E[\epsilon_t \mid Z_{t-1}] = 0$, which implies (but is by no means equivalent to) the unconditional condition:

$$E[\epsilon_t Z_{t-1}] = 0. \qquad (1.13)$$

The sample version of this last restriction is the moment condition:

$$Z'\epsilon = 0, \qquad (1.14)$$

where Z is a Txℓ matrix and ϵ a Tx(1+m) matrix, T being the number of observations over time. This a total of ℓx(1+m) moment conditions.

In order to run a test of the above specification, we choose a number m of assets which is large enough that the model imposes some overidentifying restrictions. We have ℓ parameters δ and ℓx(L+1) parameters ϕ; we choose L + 1 < m (more assets than countries) so that it is not possible to satisfy all the moment conditions exactly. We use Hansen's (1982) generalized method of moments (GMM) to minimize the average deviation from these moment conditions and thereby get the best estimates of the parameters δ and ϕ. The deviations in the various moment conditions are weighted by a weighting matrix, w, which is the inverse of a consistent estimate of the covariance matrix of sample moment conditions. Under the null hypothesis that (1.6) and (1.9) hold, the value of the resulting quadratic form is asymptotically distributed χ^2 with degrees of freedom equal to the number of orthogonality conditions minus the number of parameters. This being an asymptotic test, the number of observations plays no role in the determination of the degrees of freedom. Neither do distributional assumptions, provided that the conditions of the Central Limit Theorem are satisfied.

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As has been shown by Newey and West (1987a),[12] a similar statistic may be used to test the null hypothesis that some specific, additional restriction, or set of restrictions, binds the parameters. One computes the χ^2 statistic in the absence of restriction and then again under the added constraints imposed on the model, but this time using the weighting matrix w of the unconstrained model. The difference in the two χ^2 statistics so obtained is itself χ^2 distributed with as many degrees of freedom as there are new restrictions.

1.3 Discussion of the assumptions

Before we carry out our program of research, we now go back and interpret Assumption 2 (Equations (1.11)).

We are aided in the interpretation of the assumptions by the marginal rate of substitution M_t, which, in the language of Hansen and Jagannathan (1991), is the "pricing kernel" implied by the mean-variance theory of international asset pricing.

In line with Hansen and Jagannathan (1991), Equation (1.10) expresses the pricing kernel as a linear projection on a subspace of asset returns, namely the riskless return, the returns on the market portfolio and the returns on currencies.[13] The projection has time-varying coefficients λ. Assumption 2 (Equation (1.11)) specifies how those coefficients vary over time as a function of the instrumental (or state) variables.

Our specification differs somewhat from most implementations of the Hansen-Jagannathan projection. Equation (1.10) does not project the pricing kernel, M_t, itself. It projects the unanticipated part, u_t, of the kernel or,

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[12]See also Gallant and Jorgenson (1979), Eichenbaum, Hansen and Singleton (1988), Eichenbaum and Hansen (1990).

[13]Nonlinear pricing kernels are applied to international returns by Bansal, Hsieh and Viswanathan (1992).

equivalently, the kernel scaled down by its conditional expected value, which is left unspecified. Theoretically, that conditional expected value is equal to one over one plus the dollar rate of interest. By scaling the pricing kernel, we in effect cancel the requirement that the model should explain the level of the dollar rate at each point in time. We allow model estimation and testing to focus exclusively on the explanation of rates of return relative to the dollar rate.

Correspondingly, Assumption 2 concerns the coefficients of the projection of the scaled kernel. If these coefficients are linear functions of the instrumental variables, the coefficients of the projection of the straight kernel, M_t, would not generally be linear functions. In fact, in our formulation these latter coefficients are left incompletely specified on purpose.[14]

2. Data and preliminary statistics

We consider the monthly excess return on equity and currency holdings measured in a common currency, the U.S. dollar. The excess return on an equity market is the return on that market (cum dividend) translated into dollars, minus the dollar one-month nominally risk-free rate. The return on a currency holding is the one-month interest rate[15] of that currency compounded by the exchange rate variation relative to the U.S. dollar, minus the dollar one-month risk-free rate.

In this study, we take four countries into account: Germany, the United

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[14]Adding the theoretical requirement concerning the level of the dollar rate would allow us to say that the straight projection coefficients are linear functions of the instrumental variables divided by one plus the dollar rate. Since the dollar rate will be included among the instrumental variables, the straight coefficients would then be nonlinear functions of the instrumental variables.

[15]These are Euro-currency interest rates provided by Lombard Odier.

Kingdom, Japan and the United States. More precisely, we consider eight assets in addition to the U.S. dollar deposit: the equity index of each country,[16] a Deutschemark deposit, a Pound Sterling deposit, a Yen deposit and the world index of equities. In the CAPM, we include only three exchange risk premia -- as many as we have exchange rates in this world. There are missing risk premia in the CAPM since French investors in reality also play a role in the determination of the prices of German equities. These missing terms in the CAPM do not affect the consistency of our estimation since the moment conditions are that the hs are uncorrelated with the instrumental variables and not with the terms of the equation, as would be the case in OLS. The limited number of terms considered in the CAPM does not invalidate our test of the CAPM condition (1.14).

The number of instrumental variables is limited by the econometric methodology. Their choice is a sensitive question both from a conceptual and from an empirical point of view. Conceptually, the CAPM theory fails to specify the list of instrumental variables; if it did, not one of them could be omitted in a proper test of the conditional CAPM. Empirically speaking, we verify in Section 5 below that the choice of instrumental variables does make a difference to the results.

Our specification borrows from the work of others, done in unrelated contexts and on different data.[17] The dividend yield, the average bond yield and the short-term interest rate provide some prediction of equity returns.[18]

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[16]These are Morgan Stanley country indexes and the Morgan Stanley world index. See Harvey (1991) for an appraisal of these indexes.

[17]Hence, we are somewhat guilty of "data snooping" but not of "data mining".

[18]See Fama and French (1988), Breen, Glosten and Jagannathan (1989), Ferson and Harvey (1991), Harvey (1991) or Solnik (1993), among others. Other variables, such as the default spread, have been shown to have some predictive power.

We also know that equity returns in January seem larger than during other months. Harvey (1991) has shown that U.S. instruments have some power in predicting equity returns in foreign markets. The short-term interest-rate differential (equivalent to the forward premium) has been shown to help predict time variation in currency return.[19]

Our list includes six instrumental variables: a constant, the excess rate of return on the world index lagged one month, a January dummy,[20] the U.S. bond yield,[21] the dividend yield on the U.S. index and the one-month rate of interest on a Eurodollar deposit. This choice of instruments allows for a direct comparison with published tests of the classic CAPM applied to international data (e.g., Harvey (1991)).

There is a legitimate concern that some of these instrumental variables may not be stationary, thereby violating the assumptions of the Generalized Method of Moments. This may be the case for the dividend yield, the bond yield and the short-term rate of interest. To alleviate this problem, we do two things. First, in the empirical implementation the dividend yield and the bond yield are replaced by their difference with the short-term rate. Second, in Section 6 below we compare the results obtained with the level of the short-term rate used as an instrument to the results obtained after first differencing the rate of interest. We verify that the results are not changed.

The prediction of non U.S. returns would have been aided by the inclusion of non U.S. interest rates in the set of instrumental variables. But we have not included them. Including all the rates would have expanded the set beyond

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[19] See Cumby and Obstfeld (1984), Kaminsky and Peruga (1990), Giovannini and Jorion (1989), Bekaert and Hodrick (1992) and others.

[20] In Japan, the fiscal year ends in March. There may be a case for introducing an April dummy variable.

[21] The index of bond yields is constructed by Lombard Odier; for a description, see Solnik (1993).

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our computational capabilities. Including for each asset return the own rate
of interest only would have rendered heterogenous the set of instruments,
thereby raising thorny conceptual issues concerning the choice of
orthogonality conditions.

TABLE 1 GOES HERE

Table 1 contains some preliminary statistics on the rates of return and
the instrumental variables. Available index level data cover the period
January 1970 to December 1991 which is a 264 data point series. However, we
work with rates of return and we need to lag the rate of return on the world
index by one month in the instrumental-variable set; that leaves 262
observations spanning March 1970 to December 1991. Among instrumental
variables, the U.S. bond yield, the U.S. dividend yield (both of them measured
in excess of the Eurodollar rate) and the Eurodollar rate are fairly strongly
correlated and all three are somewhat correlated with the lagged world equity
return. In Table 1, as in all tables of this paper, excess rates of return on
assets are coded as 0.01 for a 1% rate of return per month. The instrumental
variables that are yields or rates of return (except for the lagged world
index rate of return) are coded as 1 for 1% per year. Similar conventions on
units have been used in the earlier literature.

Table 1 also contains OLS regressions of the various assets' returns on
the instruments, in order to gauge the instruments' predictive ability. R^2s
are small but a number of coefficients are significant. In all equations the
coefficient of the eurodollar rate is significant and negative. Admittedly, we
are dealing with excess returns, which increases the size of that coefficient
by one. Even without that, these would remain significant. The U.S. dividend
yield plays a significant role in predicting U.S. stock returns.

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The January dummy and the U.S. bond yield play a significant role in predicting Deutschemark returns. The January dummy plays a similar role in the case of the Japanese Yen. Whereas other researchers have amply documented day-of-the-week effects in foreign exchange rates, we are not aware of independent findings of month-of-the-year effects in currencies.

In comparing the R^2s of the regressions of the various assets on the common U.S. instrument set, we may appraise the extent to which it is legitimate to use these U.S. instruments rather than own-country instruments. The point to notice in Table 1 is that the R^2s of the regressions for non U.S. assets exhibit no tendency of being lower than the R^2 of U.S. equity. Foster and Smith (1992) have pointed out that the set of instruments of one country may appear to help predict another country's rate of return even though it is the wrong set of predictive variables, simply as a result of the correlation between the two countries' asset rates of returns. However, in calibrated simulations they indicate that, if such were the case, the spurious R^2 would be about 50 to 60% lower than that of the own-country prediction regression.[22] We see no such pattern in Table 1.

3. Estimating the conditional, international CAPM with GMM

TABLE 2 GOES HERE

The first order of business is to determine whether the international CAPM, which we have formulated, is viable. Table 2 contains the result of estimating the conditional, international CAPM on the data and the instrumental variables which we have described. The table displays the

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[22]See their Table 5.

estimates of the delta and the phi coefficients, which represent the way the market prices of risk vary over time. Several have strong t statistics.[23] The x^2 test of the overidentifying restrictions created by the CAPM has a P-value equal to 0.2276. Hence:

Statement #1: The conditional version of the international, static CAPM is not rejected by the data.

In Sections 4 and 7 below, we test several hypotheses in the context of this model and we compare it to other models.

4. Estimating the conditional, classic CAPM and testing the hypothesis that exchange rate risk receives a zero price in the conditional, international CAPM

In this section, we reach the main results of this paper concerning the relative desirability of the classic vs. international, conditional CAPMs and we show the significance of exchange risk pricing.

TABLE 3 GOES HERE

First, we estimate the conditional, classic CAPM, i.e. not including the risk premia on exchange-rate covariance risk. The result is displayed in Table 3. The P-value is: 0.0052. Hence:

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[23] In reading the tables, recall that excess rates of return on assets are coded as 0.01 for a 1% rate of return per month. The instrumental variables that are yields or rates of return (except for the lagged world market rate of return) are coded as 1 for 1% per year.

Statement #2: The conditional version of the classic, static CAPM applied to international data is rejected.

This estimation is close to Harvey's (1991) but for the addition of currencies in the list of assets.[24]

In this article, we are interested in determining whether exchange risk is priced. Considering how sharp the rejection is and in view of the earlier acceptance of the international CAPM, we should have no doubt that exchange risk is priced in the international financial market. Nevertheless, a proper test is needed.

TABLE 4 GOES HERE

Since the classic and the international CAPMs are nested, we can treat the classic as the null hypothesis and the international as alternative hypothesis, in testing for the significance of exchange rate pricing. The null is that every element of the ϕ_i vectors is zero (see restriction (1.2) and Assumption 2, Equation (1.11)). Following the Newey-West (1987a) prescription, we estimate the classic, conditional CAPM, holding the weighting matrix at its value estimated under the international, conditional CAPM. Table 4 shows the result. The χ^2 constrained by the null is: 83.8436 which is much higher than the unrestricted χ^2 which had been found for the international CAPM (28.8039); the P-value of the null hypothesis is: 10^{-5}.

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[24]Harvey (1991) used the default spread on bonds as an additional instrumental variables and did not include the dollar short interest rate as a separate instrument. He had a forecasting equation for each asset return, not just for the Marginal Rate of Substitution, as we do here (Assumption 2, Equation 1.12) with parsimony in mind.

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Statement #3: The hypothesis of zero price on exchange rate risk [$\phi_i = 0$; i = 1..L] in the conditional version of the international CAPM is rejected.

It is useful to determine which asset(s) of our list cause the classic CAPM to be rejected, while the international one is not. We seek an answer to this question by decomposing the χ^2 statistic into components, each one of which represents the contribution of one asset. A perfect decomposition of this statistic is not possible because the covariances in the moment conditions applied to two different assets are not generally equal to zero. A partial response to the question is obtained by approximating the covariance matrix of moment conditions by the elements that belong to its diagonal blocks, each block corresponding to one asset.[25]

TABLE 5 GOES HERE

Table 5 shows the decompositions of various χ^2 based on neglecting the elements outside the diagonal blocks. The last two lines of each column serve as a check that the χ^2 so reconstructed is very close to the statistic measured originally. The first column of Table 5 contains the decomposition of the χ^2 statistic which served to test the overidentifying restrictions of the classic CAPM (supporting Statement #2); the second column contains the decomposition of the χ^2 of the international CAPM (Statement #1) and the third column pertains to the χ^2 difference of the test of significance of exchange

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[25] It would be possible more formally to rerun the estimation, removing one asset each time and then testing whether the set of moment conditions corresponding to each asset holds, as suggested by Newey and West (1987a), Eichenbaum, Hansen and Singleton (1988, appendix C) and Gallant (1987). The procedure we use here is a summary procedure and is based on the same concept as the formal test. After identifying the asset which causes rejection, we do run a formal test (see below).

risk premia (Statement #3). It is apparent that the rejection of the classic CAPM as well as the rejection of the classic CAPM null are due primarly to the Deutschemark deposit, and secondarily to the Japanese Yen deposit.

As a confirmation of this role of the Deustchemark, we also run a formal test in the manner of Newey and West (1987a), Eichenbaum, Hansen and Singleton (1988, appendix C) and Gallant (1987). To do that, we remove the Deutschemark from the list of assets and reestimate the parameters holding the weighing matrix at its value estimated under the full set of assets, removing from the inverse weight matrix the rows and columns corresponding to the Deutschemark moment conditions. The drop in the objective function value is χ^2 distributed with as many degrees of freedom as there are instrumental variables. The reduced χ^2 is found to be equal to: 48.372, while the χ^2 under the full list of assets for the classic CAPM was 69.119 (Table 3). The p-value of the null hypothesis that the Deutschemark fits the classic CAPM is equal to 0.002.

Table 5 also shows that the international CAPM, while not being rejected overall, seems to explain the German and British markets somewhat less well than does the classic CAPM. The two models have similar performances for other securities. The international CAPM predicts the marginal rate of substitution somewhat less well than does the classic CAPM.

Much interest in recent years has been focused on the question of knowing what moves risk premia in financial markets. Is the movement in risk premia mostly the result of the time-varying nature of risk or of the time-varying nature of the market reward per unit of risk? The latent variable approach, for instance, was based on the premise that the risk coefficients (the betas) are constants while the market reward does all the work. The work of Ferson and Harvey (1991a, 1991b) is specifically geared at separating the effects of the two variations. In the present model, we have allowed both quantities to vary; the risk varies in a fashion which is unspecified; the rewards to risk

$(\lambda_i s, \lambda_m)$ vary according to Assumption 2. We are therefore in a position to throw some light on this debate.[26]

We test the hypotheses that λ_m, and then the $\lambda_i s$, are time-invariant. The results are displayed in Table 4. The P-value of the nulls of time invariance are of the order of 10^{-6} and 10^{-7}:

Statement #4: The hypothesis that the price of market risk is time-invariant in the conditional version of the international CAPM is rejected. The hypothesis that the market prices of foreign exchange risks are time-invariant is also rejected.

The significance of foreign exchange risk premia in the international CAPM could be an artifact linked to the large outstanding amount of government bonds which have nominal denominations in various currencies.[27] These bonds are in investors' portfolios and should, perhaps, have been included in the market portfolio but have not been.[28] It is at least conceivable that the foreign-exchange risk premia, that we measured empirically, are just proxies for the missing bond returns. We now test this possibility. For lack of a reliable theory indicating what share government bonds should receive in the market portfolio, we make the auxiliary assumption that the shares of those bonds in the market portfolio are constant. This joint hypothesis implies that there exist constants γ_i such that:

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[26] But we cannot quantify the relative importance of the two types of variations since we have left the second moments unspecified.

[27] We are grateful to Ingrid Werner for this observation.

[28] Under the principle of Ricardian equivalence they should not be, because government bonds, considered as an asset in investors' portfolios, are offset by future taxes that investors will have to pay to allow the government to pay off the bonds. But it is not clear to what extent this principle holds in practise.

$$\lambda_{i,t-1} = \gamma_i \, \lambda_{m,t-1}, \qquad \text{for all } t, \qquad (4.1)$$

or, equivalently:

$$\phi_i = \gamma_i \, \phi_m. \qquad (4.2)$$

γ_i is the share of bond i in the market portfolio divided by one minus the share of all bonds (i.e., the share of equities). The overidentifying restrictions of the international CAPM, with restriction (4.2) added, were tested and rejected with a $\chi^2 = 65.2233$ and 39 degrees of freedom leading to a p-value equal to 0.053. The null hypothesis (4.2) was tested against the unrestricted international CAPM. The results are shown in Table 4. The p-value is of the order of 10^{-5}.

Statement #5: The foreign-exchange risk premia that we have identified cannot be interpreted as proxies for missing bonds in the market portfolio.

While we have been able to conclude that exchange risk premia are statistically significant, the technique used here does not allow an estimation of the relative sizes of the various risk premia. It is indeed possible to compare the sizes of the various market prices of risk. A glance at Table 2 shows that the coefficients of the λ_is (market prices of exchange risk) are of the same order of magnitude as those of λ_m. However, risk premia are equal to market prices of risk times the *ex ante* measures of risk (covariances with exchange rates and with the market portfolio). Unfortunately, *ex ante* measures of risk are not available in our estimation. As has been mentioned, the econometric method used here (see Section 1) has

the property that it does not require the specification of the behavior of second moments. The flip side of that coin is that we cannot indicate the size of risk premia.

5. The role of conditioning information

TABLES 6 AND 7 GO HERE

One extreme way of measuring the impact of conditioning information is to do away with it and to estimate the unconditional forms of the two contending CAPMs. We do this by setting $Z = 1$. The results of these two separate estimations are displayed in Tables 6 and 7. The classic and the international CAPMs imply estimated constant relative risk aversions equal to 1.7032 and 1.1334 respectively. The P-values found are 0.1606 for the classic, unconditional CAPM and 0.049 for the international, unconditional CAPM:

Statement #6: In their unconditional versions, the international CAPM is marginally rejected while the classic CAPM is not rejected.

By way of comparison, recall (Statement 1) that we have not rejected the international CAPM, conditioned on our choice of instrumental variables, while we have rejected the classic CAPM conditioned on the same information set (Statement 2). Conditioning information plays a crucial role in discriminating between the two models.

Since the classic and the international CAPMs are nested, we can again use the dclassic CAPM as null hypothesis and the international CAPM as alternative, to test the significance of exchange rate pricing. We do this test in the context of the unconditional CAPMs in order to replicate earlier empirical attempts. We fit the classic, unconditional CAPM using the

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covariance matrix of moment conditions obtained from the international, unconditional CAPM estimation. The result of this hypothesis test appears in Table 4. The P-value for the hypothesis of zero exchange risk pricing is: 0.74.

Statement #7: The hypothesis that exchange rate risk is not priced [H_o: $\lambda_i = 0$; $i = 1..L$] in the *unconditional* version of the international, static CAPM is not rejected.

This is the sense in which earlier empirical attempts based on the unconditional CAPMs were inconclusive.

In view of the result of Hansen and Richard (1987) -- that unconditionally efficient portfolios are also conditionally efficient, -- there is an apparent contradiction between our Statement #6 and our Statement #2, as far as the classic CAPM is concerned. Indeed, Statement #6 says that the market portfolio may be considered unconditionally efficient whereas Statement #2 says that it is not conditionally efficient. Did we wrongly reject the classic CAPM in Statement #2?

The classic CAPM is a first-order condition applied to the market portfolio. The appropriate form of a first-order condition depends on the space of strategies being considered. No statement of efficiency of a portfolio should be made without specifying the space of strategies within which that portfolio is efficient.

Hansen and Richard's result must be understood *ceteris paribus*. Their result means that a portfolio which is unconditionally efficient within a space of strategies is also conditionally efficient within that *same space* of strategies. The restriction that we have tested under the name "conditional (classic) CAPM" is a moment condition which is implied by the first-order

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condition of conditional efficiency, in the vast space of strategies that depend, in an unspecified fashion, on the lagged information variables, Z. The moment condition that we have tested under the name "unconditional (classic) CAPM" is the first-order condition of unconditional efficiency in the space of strategies with constant portfolio weights (Z - 1). Hansen and Richard's result does not apply to that comparison.[29]

In effect, the special case Z - 1, under which statements #6 and 7 were obtained, not only restricts the conditioning information of the econometrician; it also restricts the investors' information and, therefore, their space of strategies.

6. Discussion of validity

In this section, we evaluate the robustness of our results.[30] We are particularly concerned that some of the assumptions of the GMM method may not be satisfied. Chief among those is the finite size of our sample while the χ^2 tests are asymptotic (subsection 6.1). Other possible violations of GMM assumptions may arise from non stationarity of the variables (rates of return and instrumental variables) and from serial dependence in the sample moments. We look at these two aspects in subsections 6.2 and 6.4. In addition, we want

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[29]To illustrate the role played by the strategy space in deriving first-order conditions, consider the problem of writing the unconditional efficiency of a portfolio policy among the strategies with portfolio weights which are linear in the information variables, Z. In the notations of Section 1 above, the first-order conditions of that problem would be:

$$E[h_j Z_k] - 0, \text{ for all } j \text{ and } k.$$

These conditions are, in fact, identical to the particular implication of conditional efficiency that we have selected to express the conditional CAPM (Equation (1.14)). They do not resemble the condition that we have called the "unconditional CAPM".

[30]We already know that they are sensitive to the choice of conditioning information.

to check whether our results depend on the currency unit in which returns have been measured (subsection 6.3).

6.1. Finite sample size

Given the relative parsimony of our econometric specification (subsection 1.2), the finite-sample problem may not be as acute in the present application as it may be in others. With 8 assets, 6 instrumental variables, 30 parameters and 262 months of observations, the total number of numerical items to be estimated, equal to the number of parameters plus the elements of the weight matrix, is:

$$30 + 54 \times 55/2 - 1515,$$

while the total number of datapoints concerning asset returns and instruments is equal to:

$$262 \times (8 + 6) - 3668.$$

The adjustment for finite sample size suggested by Ferson and Foerster (1991) implies that estimated variances of estimates should be multiplied by: $3668/(3668 - 1515) - 1.70$, or that the standard errors should be increased (and the t statistics should be reduced) by 30% only.

Monte Carlo experiments are the traditional answer to the question of finite sample size.[31] They require that one simulate the stochastic processes for all the variables of the model. Their stochastic processes must, therefore, either be known from theory -- which they are not in our case -- or be estimated prior to obtaining the sampling distributions on the coefficients of the CAPM. Hence, Monte Carlo experiments themselves would be questionable.

Instead of simulating the variables, data may be obtained from out-of-sample observations. Indeed, the ultimate test of the validity of a model is

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[31] See Ferson and Foerster (1991).

its ability to help in forecasting. In sample, raw statistical estimates from an OLS regression provide the best possible fit; the overidentifying restrictions of a model only deteriorate the fit. Out of sample, however, a theoretical model can beat OLS. Unfortunately, splitting our sample of 262 observations into two subsamples proved perilous because each subsample was small.[32] χ^2 statistics computed out of sample were excessively large. It does not seem possible at this point to validate the use of asymptotic statistics by such out-of-sample tests.

6.2 Stationarity

The only potential problem of non stationarity concerns the Eurodollar rate of interest. Other variables, such as the dividend yield and the bond yield, have been introduced as spreads relative to the Eurodollar rate. They are unlikely to be non stationary.

In order to allay possible concerns with this issue, we redid the critical estimation and test using as instrumental variable not the level of the Eurodollar rate but its first difference. The χ^2 for the overidentifying restrictions of the international CAPM was equal to 22.7302 which produced a p-value equal to: 0.5358. The χ^2 for the overidentifying restrictions of the classic CAPM was equal to: 59.228 and produced a p-value equal to: 0.04. The χ^2 for the test of significance of the foreign-exchange risk premia, equal to 66.6093 lead to a p-value of 1.7×10^{-7}. Hence, the results contained in Statements #1, 2 and 3 are not overturned.

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[32]For instance, subsamples of equal sizes contain 3668/2 = 1834 datapoints. This number is to be compared to the number, 1515, of numerical elements to be estimated.

6.3 Measurement currency

While the theoretical CAPMs themselves are invariant to the choice of the measurement currency, auxiliary Assumption #2 regrettably is not so invariant. To ascertain the potential damage, we performed again the estimation of the two CAPMs and the tests of significance, using the Deutschemark, instead of the U.S. dollar, as the unit in terms of which nominal rates of return were measured. The χ^2 for the overidentifying restrictions of the international CAPM, equal to 28.686, produced a p-value equal to: 0.2322. The χ^2 for the overidentifying restrictions of the classic CAPM, equal to 71.115, produced a p-value equal to: 0.0033. The χ^2 for the test of significance of the foreign-exchange risk premia, equal to 68.314, lead to a p-value of 10^{-7}. The results contained in Statements #1, 2 and 3 stand.

6.4 Serial dependence in the vector of sample moments

Autocorrelation in the vector of sample moments may affect the consistency of the variance-covariance matrix of that vector. Newey and West (1987b) have proposed a weighting scheme for covariance smoothing. However, the number of terms to be included in the scheme remains arbitrary. We have conducted experiments to determine the impact of covariance smoothing, depending on the number of months included in the scheme, on the test of overidentifying restrictions of the international CAPM:

Number of months	χ^2	p-value
0	28.8039	0.2276
1	24.2535	0.4472
2	21.3757	0.6165
3	20.4972	0.6682
4	19.0099	0.7515.

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The test result is not overturned.

7. <u>Testing for segmentation</u>

We have already accepted jointly all the overidentifying restrictions of the international conditional CAPM. It may be superfluous to test one of them in isolation. Nevertheless, we observe that the conditional, classic CAPM is rejected, in large part as a result of the introduction of currencies in the list of assets (see Section 4). One may therefore raise the question of knowing whether currencies are priced differently from equity securities, i.e. whether the foreign exchange market is segmented from the stock market.

In testing for segmentation, we cannot allow each asset to have a different ϕ matrix, as the model would then be underidentified. Instead, we group assets into categories. There are many possible groupings. In line with the above observation, we recognize two groups or markets: equities and currencies. We estimate a conditional version of the international, static CAPM in which we relax the CAPM restriction that the ϕs are the same for both asset categories. Then we test the hypothesis of equality of the ϕs between the two categories. We only allow the prices of exchange rate risk to differ.

TABLES 8 AND 9 GO HERE

In Tables 8 and 9, we display the χ^2 value for the relaxed international CAPM and the ϕ parameters. The two tables correspond to two versions of the estimation. The definition (1.12) of the residual of the marginal rate of substitution forecast, u_t, involves the parameters ϕ. The two versions of the estimation differ according to which set of parameters ϕ is used in the definition: those of the foreign-exchange market or those of the equity

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market. The results are not sensitive to the choice of specification.

In each block of parameter estimates of Tables 8 and 9, the first two parameters are the exchange-risk ϕs measured in the equity market, the middle parameter is the element of the vector ϕ_m and the last two paramaters are the exchange-risk ϕs of the foreign exchange market. There is some similarity between the exchange-risk ϕs of the two markets. A formal comparative test is obtained by estimating the standard form of the international, conditional CAPM, with ϕs restricted to being equal in the two financial markets, but using the weighting matrix of the relaxed model. The calculations for the corresponding Newey-West test are in Table 4. The P-value is 0.5845 or 0.7601 depending on the version of the test. Hence:

Statement #8: In the international, conditional CAPM, the hypothesis of integration of the international stock and foreign exchange markets is not rejected.

8. International vs dynamic CAPMs

We pointed out in the introduction that a conditional, static CAPM is internally inconsistent. If it is conditional, it should be multiperiodic since investors anticipate the future variations of the instrumental variables and hedge them over their lifetime. Indeed, recent research in international financial markets has made it a priority to use dynamic models. These come in two classes. The first class contains so-called "consumption CAPMs" as in Breeden (1979), Lucas (1978, 1982); these are Euler conditions based on one investor's consumption stream; they are valid equally in the domestic or international context; their empirical test requires the measurement of

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consumption.[33] The second class is based on the world market portfolio as in Merton (1973).[34] Since CAPMs of this second class are obtained by aggregation, the composition of the world population of investors here again makes a difference.

The test of a full conditional, international, dynamic Merton-CAPM would require an extremely large number of assets as otherwise the model is not overidentified. We are not in a position to run a test with enough assets. But we can run a "horse race" between the two types of models in order to determine which should be our first priority: the introduction of hedging risk premia as in the dynamic, classic CAPM or the introduction of exchange risk premia as in the static, international CAPM.

TABLE 10 GOES HERE

Table 10 contains the results of applying to international data a dynamic model in which all the independent, stochastic instrumental variables,[35] with a one-period lead, are also priced risk factors. The P-value is found to be: 0.3450.

Statement #9: The dynamic, classic CAPM is not rejected by our international data.

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[33]However, in the latent-variable method [Hansen and Hodrick (1983), Gibbons and Ferson (1985), Hodrick and Srivastava (1984)], the assumption that each security's measure of risk is constant obviates the need to observe consumption. See, however, Wheatley's (1989) critique.

[34]See Ferson and Harvey (1991a, b).

[35]I.e., all of them except the constant and the January dummy which are not stochastic, and the rate of return on the world market index which is colinear with the market factor. That leaves: the U.S. bond yield, the U.S. dividend yield and the Eurodollar interest rate.

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The "horse race" is not conclusive. The conditional, international CAPM and the dynamic CAPM are both accepted by the data.

Finally, we perform a test to verify the significance of intertemporal hedging premia in the dynamic CAPM. This involves re-estimating the conditional, static CAPM, using the weighting matrix of the dynamic model. The resulting χ^2 is equal to: 26.1627. Calculations for this test appear in Table 4. The P-value is: 0.0057.

Statement #10: The hypothesis of zero prices on intertemporal hedging risks in the dynamic CAPM is rejected by our international data.

We have no evidence to conclude in favor of either model.

Conclusion

Based on a sample of securities which included equities and currencies, our results show that foreign-exchange risk premia are a significant component of securities rates of return in the international financial market, and that the international CAPM dominates the classic CAPM.

The parsimonious econometric specification that we use here has undoubtedly helped in reaching this unequivocal conclusion. The parsimony was achieved in two ways. First, the estimation technique used made it possible to test the various CAPMs without specifying the behavior of the second moments of rates of return. Second, by relying on the concept of kernel estimation, we also obviated the need to estimate the behavior of the first moments of rates of return. Only the behavior of the investors' marginal rate of substituation had to be estimated.

The parsimony in the specification increases the power of the tests by

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reducing the number of parameters which have to be estimated. However, it makes it impossible to answer two interesting questions. Because the second moments are not specified, it is not possible to determine how large the foreign exchange risk premia are relative to the classic reward for market covariance risk.

Because the first moments have not been specified, it is not possible to measure how much each asset deviates from a CAPM. Nevertheless, we were able to determine which assets cause the classic CAPM to be rejected in our sample. We found that foreign exchange risk premia are needed chiefly in order to explain rates of return on currencies. Once these risk premia are included in the CAPM, no evidence of segmentation between currency markets and stock markets has been found.

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Table 1 Summary statistics

number of obs= 262.00000 [March 1970 - December 1991]

Excess returns

	MEAN/month	STD DEV/month
German equity	0.0050726679	0.062362157
U.K. equity	0.0065975649	0.077541166
Japanese equity	0.0090457824	0.065944529
U.S. equity	0.0024764962	0.046825699
Deutschemark	0.0017136374	0.034912228
British Pound	0.0017428969	0.031856602
Japanese Yen	0.0027198626	0.033234643
World equity	0.0031789237	0.043619171

Instruments

	MEAN	STDEV	PAIRWISE CORRELATIONS				
Cst	1.00000	0.00000					
$r_m(-1)$	0.0361454	0.521389	1.0	0.093	0.27	0.26	-0.25
JanD	0.0801527	0.272049	0.093	1.0	-0.013	0.0025	0.00038
USbony-E$	0.154504	2.13435	0.27	-0.013	1.0	0.78	-0.74
USDivy-E$	-4.70187	2.68230	0.26	0.0025	0.78	1.0	-0.97
Euro$	8.90630	3.27651	-0.25	0.00038	-0.74	-0.97	1.0

OLS WITH HET-MA-CONSISTENT STD ERRORS, NUMBER OF MA TERMS=   0.00000

German equity

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	-0.000500044	0.0172819	-0.0289346	0.0186013
$r_m(-1)$	0.00320124	0.00923349	0.346699	0.00760901
JanD	-0.00930024	0.0127758	-0.727958	0.0140009
USbon-E$	0.00251177	0.00272403	0.922079	0.00286999
USDiv-E$	0.00758596	0.00537947	1.41017	0.00589303
Euro$	0.0046577	0.0041725	1.11629	0.0044989

Rsquared is   0.0366406

- -
residual auto correlations
(rho1˜rho2˜rho3˜rho4˜rho8˜rho12˜rho24˜rho36)

-0.018	-0.028	0.071	0.052	-0.015	-0.067	0.031	0.054

Table 1 continued (1)

<u>U.K. equity</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	-0.0241160	0.0192274	-1.25425	0.0225987
$r_m(-1)$	0.00149542	0.0102895	0.145335	0.00924421
JanD	0.0457431	0.0272173	1.68066	0.0170097
USbon-E$	.000393302	0.00370134	0.106259	0.00348676
USDiv-E$	0.0215969	0.00744184	2.90210	0.00715947
Euro$	0.014426	0.0051522	2.79987	0.0054658

Rsquared is   0.0802930
----
residual auto correlations
(rho1~rho2~rho3~rho4~rho8~rho12~rho24~rho36)
    0.033   -0.12   0.035   0.023   -0.022   -0.054   0.035   -0.065

<u>Japanese equity</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	0.0235762	0.0192123	1.22715	0.0195348
$r_m(-1)$	0.0105354	0.0102990	1.02295	0.00799090
JanD	0.00524982	0.0109185	0.480818	0.0147036
USbon-E$	0.00187947	0.00277557	0.677149	0.00301403
USDiv-E$	0.00312446	0.00564541	0.553451	0.00618880
Euro$	-0.00010460	0.0044475	-0.0235194	0.0047247

Rsquared is   0.0498163
----
residual auto correlations
(rho1~rho2~rho3~rho4~rho8~rho12~rho24~rho36)
    -0.029   -0.027   0.041   0.040   0.070   0.063   -0.018   0.079

<u>U.S. equity</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	-0.0222053	0.0134187	-1.65480	0.0136891
$r_m(-1)$	-3.74043E-05	0.00641996	-0.00582625	0.00559963
JanD	0.0191409	0.0125185	1.52901	0.0103036
USbon-E$	0.00144035	0.00231997	0.620850	0.00211209
USDiv-E$	0.0135140	0.00499992	2.70284	0.00433681
Euro$	0.0097086	0.0036650	2.64896	0.0033109

Rsquared is   0.0746112
----
residual auto correlations
(rho1~rho2~rho3~rho4~rho8~rho12~rho24~rho36)
    0.015   -0.052   0.013   0.0084   0.019   0.039   -0.030   -0.096

Table 1 continued (2)

<u>Deutschemark</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	0.0276441	0.00996991	2.77275	0.0101463
$r_m(-1)$	-0.0111683	0.00405834	-2.75194	0.00415043
JanD	-0.0149178	0.00746202	-1.99916	0.00763696
USbon-E$	0.00115600	0.00153799	-0.751631	0.00156547
USDiv-E$	0.00150231	0.00314975	0.476963	0.00321443
Euro$	-0.0019187	0.0024410	-0.786037	0.0024540

Rsquared is   0.0854548
----
residual auto correlations
(rho1ˉrho2ˉrho3ˉrho4ˉrho8ˉrho12ˉrho24ˉrho36)
    0.048   0.069   -0.022   -0.0095   -0.016   -0.014   -0.012   0.062

<u>British Pound</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	0.0166959	0.00788918	2.11631	0.00950770
$r_m(-1)$	-0.00587173	0.00392309	-1.49671	0.00388921
JanD	-0.00176166	0.00626974	-0.280978	0.00715631
USbon-E$	-0.00153343	0.00147796	-1.03753	0.00146695
USDiv-E$	0.00280898	0.00286324	0.981050	0.00301212
Euro$	-0.00012971	0.0020446	-0.0634376	0.0022996

Rsquared is   0.0355085
----
residual auto correlations
(rho1ˉrho2ˉrho3ˉrho4ˉrho8ˉrho12ˉrho24ˉrho36)
    0.090   0.067   -0.019   0.029   -0.048   -0.010   0.014   0.019

<u>Japanese Yen</u>

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	0.0178674	0.00924367	1.93293	0.00978246
$r_m(-1)$	-0.00268856	0.00418139	-0.642982	0.00400160
JanD	-0.0112784	0.00621528	-1.81462	0.00736312
USbon-E$	0.000873910	0.00148191	0.589718	0.00150934
USDiv-E$	0.00120969	0.00349170	0.346448	0.00309917
Euro$	-0.00096488	0.0026206	-0.368185	0.0023660

Rsquared is   0.0618756
----
residual auto correlations
(rho1ˉrho2ˉrho3ˉrho4ˉrho8ˉrho12ˉrho24ˉrho36)
    0.043   0.0016   0.036   0.050   -0.0059   0.051   -0.086   -0.025

Table 1 continued (3)
World equity

Coeff	Value	NW Std Err	T-stat	OLS Std Err
Cst	-0.0127904	0.0127695	-1.00163	0.0126632
$r_m(-1)$	0.00300301	0.00576226	0.521152	0.00517998
JanD	0.0173971	0.0104891	1.65858	0.00953138
USbon-E$	0.00145192	0.00204164	0.711153	0.00195380
USDiv-E$	0.0116415	0.00406912	2.86093	0.00401179
Euro$	0.0077449	0.0030994	2.49888	0.0030627

Rsquared is   0.0874106

----

residual auto correlations
(rho1~rho2~rho3~rho4~rho8~rho12~rho24~rho36)
   0.0048   -0.074   0.030   -0.0047   0.0064   0.038   -0.0061   -0.056

Table 2 Estimation of the conditional, international CAPM
number of observation= 262.00000; number of factors= 4.0000000

Coeff	Value	Std Err	T-stat
deltas			
Cst	0.1003	0.2603	0.3854
$r_m(-1)$	-0.0991	1.3946	-0.0711
JanD	1.3406	0.5416	2.4752
USbon-E$	-0.0358	0.0384	-0.9319
USDiv-E$	-0.0197	0.0863	-0.2281
Euro$	0.0195	0.0645	0.3016
phis			
Constants			
$/DM	22.4735	14.7214	1.5266
$/Pound	19.3737	23.3126	0.8310
$/Yen	18.2531	18.0832	1.0094
Wldmkt	-18.5363	7.6691	-2.4170
$r_m(-1)$			
$/DM	-371.3151	113.5849	-3.2691
$/Pound	180.1012	90.2006	1.9967
$/Yen	100.6250	77.2074	1.3033
Wldmkt	31.6038	31.4958	1.0034
January dummy			
$/DM	-60.4603	18.9181	-3.1959
$/Pound	40.6945	22.2498	1.8290
$/Yen	0.8343	25.5178	0.0327
Wldmkt	22.8588	8.6047	2.6566
U.S. bond yield - Eurodollar rate			
$/DM	-1.7018	3.8414	-0.4430
$/Pound	-7.9977	4.0051	-1.9969
$/Yen	3.4880	2.7192	1.2827
Wldmkt	1.9627	1.1707	1.6765
U.S. dividend yield - Eurodollar rate			
$/DM	0.4544	4.9157	0.0924
$/Pound	5.6074	4.7711	1.1753
$/Yen	-3.7700	3.6377	-1.0364
Wldmkt	10.1277	2.2334	4.5346
Eurodollar			
$/DM	-1.6611	3.3473	-0.4962
$/Pound	0.5133	4.1589	0.1234
$/Yen	-3.6828	3.0457	-1.2092
Wldmkt	7.6852	1.7015	4.5168

no. of iterations: 2; weighing matrix updated: 15 times
Chi-square : 28.803934; RIGHT TAIL P-value : 0.227597
Degrees of freedom : 24.000000

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Table 3
Estimation of the conditional, classic CAPM
nbre observation= 262.00000
nbre facteurs= 1.0000000

Coeff	Value	Std Err	T-stat
deltas (vector δ)			
Cst	-0.0637	0.1042	-0.6108
$r_m(-1)$	0.5866	0.5408	1.0847
JanD	0.1264	0.1221	1.0347
USbon-E$	-0.0425	0.0180	-2.3625
USDiv-E$	0.1090	0.0536	2.0345
Euro$	0.0792	0.0385	2.0603
phis (vector ϕ_m)			
Cst	-9.6176	5.8744	-1.6372
$r_m(-1)$	24.6887	24.9418	0.9899
JanD	0.0802	2.8527	0.0281
USbon-E$	0.0442	0.8240	0.0536
USDiv-E$	11.1430	1.8205	6.1207
Euro$	7.5439	1.3841	5.4504

no. of iterations: 4.000000
weighing matrix updated   7.000000 times
Chi-square :   69.118881
RIGHT TAIL P-value :   0.005252
Degrees of freedom :   42.000000

Table 4 Hypotheses tests

Statement n^o	Null hypothesis	Alternative (unrestricted model)	χ^2 difference [Newey-West(1987) D statistic]	degrees of freedom	P-value
3	$\phi_i = 0$; i = 1,2,3	International conditional CAPM	83.8436 - <u>28.8039</u> 55.0397	18	10^{-5}
4	λ_m time in-variant	"	66.9043 - <u>28.8039</u> 38.1002	5	3×10^{-7}
	λ_i time in-variant i = 1,2,3	"	80.9286 - <u>28.8039</u> 52.1247	15	5×10^{-6}
5	$\phi_i = \gamma_i \phi_m$ i = 1,2,3	"	78.1137 - <u>28.8038</u> 49.3098	15	10^{-5}
7	$\lambda_i = 0$; i = 1,2,3	International unconditional CAPM	10.7996 - <u>9.5413</u> 1.2583	3	0.7398
8	$\phi_j^e = \phi_j^{FX}$ i = 1,2,3 Integration	International conditional CAPM allowing different ϕs	24.8049 - <u>8.6921</u> 16.1128	18	0.5845
8	$\phi_j^e = \phi_j^{FX}$ i = 1,2,3 Integration	International conditional CAPM allowing different ϕs	21.1877 - <u>7.6729</u> 13.5148	18	0.7601
10	ϕs of prices of intertemporal risk are zero	Classic, dynamic CAPM	62.8816 - <u>26.1627</u> 36.7189	18	0.0057

Table 5

Analysis of chi squares

Table 5 shows the decompositions of various χ^2 based on neglecting the elements outside the diagonal blocks. The last two lines of each column serve as a check that the χ^2 so reconstructed is very close to the statistic measured originally. The first column of Table 5 contains the decomposition of the χ^2 statistic which served to test the overidentifying restrictions of the classic CAPM (supporting Statement #2); the second column contains the decomposition of the χ^2 of the international CAPM (Statement #1) and the third column pertains to the χ^2 difference of the test of significance of exchange risk premia (Statement #3).

	χ^2 of classic CAPM	χ^2 of inter- national CAPM	χ^2 of signifi- cance test
Marginal Rate	0.94731513	2.6531193	2.9077518
German equ.	2.2855163	5.5851848	5.8583204
U.K. equity	3.8707528	6.7506702	4.3948730
Japanese equ	5.4527897	2.0164275	2.7480713
US equity	1.6330651	0.93544680	0.68853614
Deutschemark	25.754764	0.79414429	20.520073
British Pound	6.5737112	1.5584333	7.8175743
Japanese Yen	13.842784	0.81542201	9.5830724
World mkt	1.7038594	1.8075721	0.99721894

Sum (reconstructed χ^2):

	62.064558	22.916420	55.515491

Actual χ^2 (from tables 2, 3 and 4)

	69.1188	28.8039	55.039700

Table 6

Estimation of the unconditional, classic CAPM

number of observation= 262.00000
number of factors= 1.0000000

Coeff	Value	Std Err	T-stat
$\delta - \lambda_0$	0.0055	0.0092	0.5921
$\phi_m - \lambda_m$	1.7032	1.4661	1.1617

no. of iterations: 2.000000
weighing matrix updated   4.000000 times
Chi-square :   10.527019
RIGHT TAIL P-value :   0.160622
Degrees of freedom :   7.000000

Table 7
Estimation of the unconditional, international CAPM

number of observation= 262.00000
number of factors= 4.0000000

Coeff	Value	Std Err	T-stat
$\delta - \lambda_0$	0.0099	0.0121	0.8156
$\phi s - \lambda s$			
$/DM	-0.3607	2.6090	-0.1383
$/Pound	0.3417	2.6257	0.1301
$/Yen	2.2238	2.4499	0.9077
Wldmkt	1.1334	1.5366	0.7376

no. of iterations: 2.000000
weighing matrix updated   4.000000 times
Chi-square :   9.541291
RIGHT TAIL P-value :   0.048906
Degrees of freedom :   4.000000

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Table 8: Estimation of the international, segmented CAPM (version 1)
number of observation= 262; number of factors= 4.

Coeff	Value	Std Err	T-stat
<u>deltas</u>			
Cst	0.5091	0.3803	1.3388
$r_m(-1)$	-1.6740	2.1991	-0.7612
JanD	2.0263	1.2965	1.5629
USbon-E$	-0.1315	0.0644	-2.0431
USDiv-E$	-0.0046	0.1444	-0.0315
Euro$	-0.0278	0.1022	-0.2722
<u>phis</u>			
Constants			
$/DM	36.1297	42.0897	0.8584
$/Pound	-52.4139	48.0699	-1.0904
$/Yen	47.8305	43.6819	1.0950
Wldmkt	-21.2685	12.4932	-1.7024
$/DM	33.6442	14.5566	2.3113
$/Pound	-6.1650	23.1124	-0.2667
$/Yen	20.0105	19.2246	1.0409
$r_m(-1)$			
$/DM	-55.9196	279.6538	-0.2000
$/Pound	-166.8245	217.1752	-0.7682
$/Yen	270.0335	151.9910	1.7766
Wldmkt	-3.5697	52.1261	-0.0685
$/DM	-292.9597	120.4788	-2.4316
$/Pound	93.0163	88.9139	1.0461
$/Yen	138.2928	85.6744	1.6142
January dummy			
$/DM	-42.2269	65.0947	-0.6487
$/Pound	130.0524	62.2055	2.0907
$/Yen	-96.1994	72.5506	-1.3260
Wldmkt	41.7203	20.9126	1.9950
$/DM	-80.0846	36.9177	-2.1693
$/Pound	48.1513	38.5100	1.2504
$/Yen	10.4337	30.2642	0.3448
U.S. bond yield - Eurodollar rate			
$/DM	-1.9061	9.5978	-0.1986
$/Pound	1.5393	9.4907	0.1622
$/Yen	-1.5786	6.1936	-0.2549
Wldmkt	3.3095	2.1104	1.5682
$/DM	-3.9312	3.7230	-1.0559
$/Pound	-2.8167	3.3779	-0.8339
$/Yen	3.1289	3.0251	1.0343

U.S. dividend yield - Eurodollar rate
$/DM	-8.6394	11.0765	-0.7800
$/Pound	14.9430	12.0680	1.2382
$/Yen	-6.4283	7.4563	-0.8621
Wldmkt	9.2373	3.5354	2.6128
$/DM	-1.2091	5.2098	-0.2321
$/Pound	5.8209	5.7021	1.0208
$/Yen	-4.3609	4.0271	-1.0829

Eurodollar
$/DM	-8.3218	7.9750	-1.0435
$/Pound	13.4831	9.0065	1.4970
$/Yen	-7.9602	6.8058	-1.1696
Wldmkt	7.3253	2.2320	3.2820
$/DM	-3.9594	3.5773	-1.1068
$/Pound	3.7924	4.7503	0.7983
$/Yen	-4.1970	3.2781	-1.2803

no. of iterations: 2; weighing matrix updated: 19 times
Chi-square :   8.692101; RIGHT TAIL P-value :   0.191649
Degrees of freedom :   6.000000

Table 9: Estimation of the segmented, international CAPM (version 2)
number of observation= 262.00000; number of factors= 4.0000000

Coeff	Value	Std Err	T-stat
deltas			
Cst	0.2140	0.2634	0.8124
$r_m(-1)$	-0.6637	1.4620	-0.4539
JanD	1.3386	0.7237	1.8498
USbon-E$	-0.0449	0.0413	-1.0869
USDiv-E$	-0.0378	0.0870	-0.4346
Euro$	-0.0086	0.0663	-0.1293
phis			
Constants			
$/DM	29.2287	42.9409	0.6807
$/Pound	-51.9689	48.8381	-1.0641
$/Yen	60.9716	44.2389	1.3782
Wldmkt	-20.8490	12.1863	-1.7109
$/DM	33.0655	14.4696	2.2852
$/Pound	-5.4704	22.5615	-0.2425
$/Yen	21.3601	19.0982	1.1184
$r_m(-1)$			
$/DM	-202.3558	288.8460	-0.7006
$/Pound	-53.2066	236.8282	-0.2247
$/Yen	276.6722	151.3733	1.8277
Wldmkt	-10.4136	51.7077	-0.2014
$/DM	-320.2574	120.1331	-2.6659
$/Pound	104.1593	91.9665	1.1326
$/Yen	161.4160	85.0993	1.8968
January dummy			
$/DM	-17.1532	58.2276	-0.2946
$/Pound	108.4984	48.1470	2.2535
$/Yen	-111.7707	76.8188	-1.4550
Wldmkt	31.4578	13.9482	2.2553
$/DM	-61.2028	25.2392	-2.4249
$/Pound	35.3119	27.4238	1.2876
$/Yen	5.0272	26.5950	0.1890
U.S. bond yield - Eurodollar rate			
$/DM	3.1298	11.0338	0.2837
$/Pound	-1.5927	10.4763	-0.1520
$/Yen	-3.4142	6.2584	-0.5455
Wldmkt	3.4879	1.8967	1.8389
$/DM	-3.6437	3.8856	-0.9377
$/Pound	-2.5355	3.3989	-0.7460
$/Yen	2.7431	3.0982	0.8854

```
U.S. dividend yield - Eurodollar rate
   $/DM       -9.6946    10.8343    -0.8948
   $/Pound    17.2742    11.6383     1.4842
   $/Yen      -5.8251     7.2185    -0.8070
   Wldmkt      7.7501     3.9244     1.9749
   $/DM       -0.9425     4.8740    -0.1934
   $/Pound     5.4475     5.0615     1.0763
   $/Yen      -3.6385     3.9955    -0.9106

Eurodollar
   $/DM       -7.7742     7.6121    -1.0213
   $/Pound    14.4699     8.3437     1.7342
   $/Yen      -8.9216     6.7563    -1.3205
   Wldmkt      6.5321     2.3685     2.7579
   $/DM       -3.8402     3.3305    -1.1530
   $/Pound     3.4585     4.3464     0.7957
   $/Yen      -3.8658     3.1596    -1.2235

no. of iterations:        2; weighing matrix updated: 21 times
Chi-square :        7.672877; RIGHT TAIL P-value :        0.263062
Degrees of freedom :        6.000000
```

Table 10
Estimation of the dynamic, classic CAPM
number of observations= 262; number of factors= 4

Coeff	Value	Std Err	T-stat
deltas			
Cst	0.5707	0.6156	0.9271
$r_m(-1)$	-1.1738	3.5331	-0.3322
JanD	-0.0929	0.5821	-0.1597
USbon-E$	0.1251	0.0842	1.4861
USDiv-E$	-0.2665	0.1970	-1.3531
Euro$	-0.2026	0.1655	-1.2242

phis			
Constants			
Wldmkt	-1.6416	5.0725	-0.3236
instr.#1	-23.3693	7.5118	-3.1110
instr #2	-207.8525	70.3929	-2.9527
instr #3	-74.2577	28.5741	-2.5988
$r_m(-1)$			
Wldmkt	-2.2503	12.5635	-0.1791
instr.#1	3.4945	18.0170	0.1940
instr #2	9.9653	226.9270	0.0439
instr #3	114.3082	84.5685	1.3517
January dummy			
Wldmkt	2.4259	1.9730	1.2296
instr.#1	-1.2790	6.7022	-0.1908
instr #2	-20.0728	65.0969	-0.3084
instr #3	-18.4000	29.9821	-0.6137
U.S. bond yield - Eurodollar rate			
Wldmkt	1.2404	0.6894	1.7993
instr.#1	2.2638	0.8486	2.6676
instr #2	32.7672	11.4101	2.8718
instr #3	11.9770	4.9997	2.3955
U.S. dividend yield - Eurodollar rate			
Wldmkt	-3.4455	1.8682	-1.8443
instr.#1	1.7900	1.6597	1.0786
instr #2	-21.9552	23.3186	-0.9415
instr #3	2.0741	9.6356	0.2153
Eurodollar			
Wldmkt	-1.9863	1.3934	-1.4255
instr.#1	3.4080	1.4876	2.2909
instr #2	8.0341	16.0956	0.4991
instr #3	9.3667	7.1165	1.3162

no. of iterations: 2; weighing matrix updated: 12 times
Chi-square :   26.162706; RIGHT TAIL P-value :   0.344961
Degrees of freedom :   24.000000