Risk Premia in the Futures and Forward Markets

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INTRODUCTION

Two of the major paradigms of portfolio theory are the one-period Capital Asset Pricing Model (CAPM) and the intertemporal Consumption Capital Asset Pricing Model (CCAPM). Each has encountered empirical problems. The CAPM fails to explain many well-documented anomalies (e.g., the weekend effect, the January effect, the small firm effect), while the CCAPM is faced with strong empirical rejection from Hansen and Singleton (1982) in the stock market and Jagannathan (1985) in the futures market.[1]

Despite these shortcomings, the models continue to find favor in the investments literature. Recent articles using the CAPM to model futures market returns include Chang, Chen, and Chen (CCC) (1990); Elam and Vaught (1988); Baxter, Conine, and Tamarkin (BCT) (1985); and Carter, Rausser, and Schmitz (CRS) (1983). Unfortunately, in an intertemporal setting, such as a futures market, one-period models may fail to capture important intertemporal elements of risk in their definition of risk premium.

In the stock market, attempts have been made to adapt the one-period CAPM to a time varying framework [e.g., Ferson and Gibbons (1985)]. However, it would be more natural to use a multi-period model to generate time varying asset pricing equations. A simple approach is through the CCAPM. However, given the previous rejections, it must first be documented that some specification of this model has empirical support.

This article adapts the methodology of Huang (1988, 1989) to address problems in the empirical rejection of the CCAPM. This methodology relies on replacing the marginal rate of substitution with an index portfolio, avoiding the use of noise and infrequently reported consumption data. The index portfolio's return is identified by a multi-factor linearity assumption. Estimation is performed using the Generalized Method of Moments (GMM) [Hansen (1982); Hansen and Singleton (1982)]. Huang reports considerable success with this methodology in the foreign forward exchange markets.

This article extends Huang's methodology to more general settings and empirically estimates the model on the agricultural and foreign exchange futures markets. This

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[1]For examples of these anomalies, see Schwert (1983), Keim and Stambaugh (1984), Keim (1985), or many others.

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application is of interest for two reasons. First, it provides an alternative to the previously mentioned strategy of using a one-period CAPM—a method pioneered by Dusak (1973)—in empirical futures testing. Second, it provides a direct comparison with Jagannathan (1985) who tests the model using consumption data. Jagannathan identifies the CCAPM model with utility assumptions and tests corn, wheat, and soybean futures. His study rejected the model. This study does not reject the model.[2]

This article proceeds as follows. First, the general intertemporal utility maximization model is used to derive a pricing equilibrium in which the asset's conditional risk premium may be written as a simple linear function of the index's time varying risk premium. The empirically tractable version of this model requires an identifying assumption on the return to the index portfolio and a stationarity assumption on the asset's Beta, but allows testing with only financial data. The identifying assumption on the return of the index portfolio is that at time t its expected value is a linear function of observable pre-determined or exogenous instruments.

Empirically, the futures and forward premia are found to behave in accordance with the equilibrium model. The results appear stronger in the currency contracts than the agricultural markets. These results support the notion that the CCAPM is a useful, intuitive description of actual market behavior.

MARKET EQUILIBRIUM AND THE TIME VARYING RISK PREMIUM

The first order condition arising from the common intertemporal utility maximization model may be written as

$$p(t) = E_t\{m_{t+k}[p(t+k) + d(t+k)]\} \tag{1}$$

where: $p(t)$ is today's price; $p(t+k)$ is period $t+k$'s price; $d(t+k)$ is the cash dividend at time $t+k$; and m_{t+k} is the marginal rate of substitution between expected period $t+k$ and known period t consumption.

Letting $r(t, t+k)$ represent one plus the risk free rate between time t and $t+k$, eq. (1) may be reexpressed as

$$E_t[m_{t+k}P(t, t+k)] = 0 \tag{2}$$

where

$$P(t, t+k) = \{[p(t+k) + d(t+k)]/p(t)\} - r(t, t+k)$$

$P(t, t+k)$ represents the risk premium associated with the particular asset being considered.

Traditionally, eq. (2) is empirically identified with a constant relative risk aversion utility assumption [e.g., Hansen and Singleton (1982) in the stock market or Jagannathan (1985) in the futures market]. However, an alternative procedure relies on the discovery, used in the forward market by Huang (1989), that any portfolio, b, with an excess return structure given by

$$R_b(t, t+k) - R(t, t+k) = m_{t+k}/E_t[(m_{t+k})^2] \tag{3}$$

also will follow the dynamics of eq. (2) (Here, capital R indicates the risk free rate from t to $t+k$, as opposed to lower case r, which indicates one plus the risk free rate). This possibly non-unique portfolio is the one that may be used with eq. (2) as an index portfolio.

[2]The estimation procedure of this study is carried out in a manner as comparable to Jagannathan as possible so that a comparison of the results with his is possible.

The combination of eqs. (2) and (3) yields

$$E_t[P(t,t+k)] = \beta(t,t+k)E_t[R_b(t,t+k) - R(t,t+k)] \tag{4}$$

where

$$\beta(t,t+k) = \text{cov}(P(t,t+k), R_b(t,t+k))/\text{var}(R_b(t,t+k))$$

This equation appears in Huang (1989), where the derivation is based on forward exchange equations. However, the model is more general than that. Many assets may be priced by the time varying risk premia model eq. (4) represents.

FUTURES AND FORWARD CONTRACTS

Equation (1) may be used to price futures contracts. The appropriate specification is

$$f(t,t+k) = E_t[m_{t+k}\pi(t,t+k)f(t+k,t+k)] \tag{5}$$

where: $f(t,t+k)$ is the futures price at time t; $\pi(t,t+k)$ is the product of one plus one day risk free interest rates, i.e., $r(t,t+1)r(t+1,t+2)\ldots r(t+k-1)r(t+k)$; and $f(t+k,t+k)$ is futures expiration price. Equation (5)[3] results from considering a portfolio of $r(t,t+1)$ in the futures market and $f(t,t+k)$ in the one-period bond market. The proceeds of this position are $r(t,t+1)f(t+1,t+k)$ which then is rolled over each day until expiration, leaving a terminal value of $\pi(t,t+k)f(t+k,t+k)$. Substituting the initial outlay of $f(t,t+k)$ and the terminal value in eq. (1) yields eq. (5).

The risk premium associated with the futures contract is written as

$$P_1(t,t+k) = \pi(t,t+k)f(t+k,t+k)/f(t,t+k) - r(t,t+k) \tag{6}$$

The futures risk premium has elements which capture both the final price risk and the reinvestment risk associated with marking to market, the former by the term $f(t+k,t+k)/f(t,t+k)$ and the latter through $\pi(t,t+k)$.

A forward contract may be priced as a futures contract for which marking to market occurs only once, at time $t+k$. This results in a forward market risk premium given by

$$P_2(t,t+k) = [r(t,t+k)(S(t+k) - F(t,t+k))/F(t,t+k)] \tag{7}$$

where $F(t,t+k)$ is the forward price at time t, and $S(t+k)$ is the spot price at time $t+k$. This model differs slightly from the ad hoc premium definition used by Huang.[4] Equation (7) may be obtained also by pricing forward contracts directly with eq. (1).

EMPIRICAL FORMATION OF THE PREMIUM

This study covers the period 1966 through 1988 for the agricultural commodities, using the March, May, July, and September contracts. The financial commodities cover the period 1972 through 1988, using the March, June, September, and December contracts.

Futures contract premia (defined by $P_1(t,t+k)$) require the variable $\pi(t,t+k)$, which is formed using weekly quotes from the Harris Bank Review.[5] The variable

[3]The reader is referred to Jagannathan(1985) for more detail.

[4]The definition in Huang is $[S(t+k) - F(t,t+k)]/S(t+k)$ which follows the equilibrium dynamics of eq. (1) but does not follow the dynamics implied by considering it as a futures contract which only marks to market once.

[5]The use of daily quotes which matches the marking to market intervals would have been optimal, but were not available. Weekly quotes, however, are a substantial improvement over the monthly quotes utilized in Jagannathan (1985).

Table I
INITIAL FACTORS CONSIDERED TO EXPLAIN FUTURES PREMIA

CONST—the constant vector (1)		
DMFS—		—German Marks
BPFS—future/spot price ratio		—British Pounds
SFFS—or forward/spot ratio		—Swiss Francs
SYFS—		—soybeans
CNFS—future/spot price ratio		—corn
WHFS—		—wheat
STDBP—historical standard deviation[a]		—British Pounds
STDDM—		—German Marks
STDSF—		—Swiss Francs
STDCC—		—cocoa
STDCN—historical standard deviation[a]		—corn
STDSY—		—soybeans
STDWH—		—wheat
D1—		
D2—dummies indicating contract expiration month		
D3—		
POL1—		—one
POL2—polynomial in time of order		—two
POL3—		—three
PI—historical π, $\pi(t-28,t)$[b]		
RATE—$r(t,t+k)$		
RINC—Monthly measure of average U.S. real income		

[a] Historical standard deviations are based on the previous 10 days futures settlement prices, or the previous 6 weeks forward contract prices.
[b] Historical π is calculated with weekly data.

$r(t,t+k)$ is formed from the yield of the U.S. treasury bill which expires closest to time $t+k$.[6] These yields are gathered from the *Wall Street Journal.*

To minimize the effects of data imperfections, the interval lengths, $(t,t+k)$, are selected as the maximum which do not lead to overlapping. This is 8 weeks for the agricultural future premia and 12 weeks for the currency futures and forward contracts. All intervals are chosen to be such that $t+k$ is the expiration price of the asset. Estimation does not require the time intervals to be constructed in this manner but doing so creates intervals comparable to those of Jagannathan (1985). The futures settlement prices are from the Columbia Futures Center.

[6] $t+k$ is defined here as the last Friday on which the contract is traded.

A SIMPLE TEST FOR THE TIME-VARIATION AND EXPLANATORY FACTORS OF THE RISK PREMIA

A simple hypothesis of the time varying behavior in the futures premia is the linear specification,

$$P_1(t,t+k) = a_0 + a_1 Z_1(t) + \ldots + a_n Z_n(t) + \varepsilon_1(t,t+k) \tag{8}$$

The elements $Z_1(t), \ldots, Z_n(t)$ may be anything in the market participants' information set at time t. Assuming that the expected error, $\varepsilon(t,t+k)$, is zero, eq. (8) may be rewritten

$$H_0\colon E_t\begin{bmatrix}(P_1(t,t+k) - \mathbf{a}'\mathbf{Z})Z_1(t)\\ \cdots \\ (P_1(t,t+k) - \mathbf{a}'\mathbf{Z})Z_n(t)\end{bmatrix} = 0 \tag{9}$$

for any given commodity. This vector of equations may be estimated by GMM techniques.[7]

The linear model posited here is a reasonable specification. However, it is shown later that the CCAPM [eq. (4)] identified with an index portfolio is exactly eq. (8) with cross equation restrictions added to the a_i's. Therefore, it is useful to look for factors that explain the premia in an unrestricted sense, because it will add weight to the claim that the full test of the model has power.

The literature is replete with potential factors for explaining risk premia in the futures and forward contracts. It is expedient to use those factors which other authors have reported to be useful. Table I lists the factors chosen to explain the futures premia. The paragraphs following discuss the basis for their selection. Unfortunately, data for the most desirable factors are not available.[8]

The ratio $f(t,t+k)/S(t)$ is used by Jagannathan (1985) while $F(t,t+k)/S(t)$ is used by Hansen and Hodrick (1980) and Huang (1989) as instruments in GMM estimation. These spot premia are intended to capture the difference in the cost of carrying the commodity to time $t+k$ and the service flow of holding the inventory for the same period.

Seasonalities in the returns to commodity contracts have been documented by Cornett and Trevino (1989), Malick and Ward (1987), and Fama and French (1987).[9] Jagannathan implicitly acknowledged these factors by deseasonalizing the spot premium.

Cycles of a period longer than one year and other unspecified regularities in the data may be captured by polynomial approximation which are formed by adding t, t^2, t^3, etc. to the independent variable list. The theoretical basis for this procedure is the Weierstrauss Approximation Theorem Rudin (1987). Their use for econometric work is suggested by Jorgenson (1964).

Variance measures have been found to be important in hedging considerations. Peck (1975) demonstrates that the best hedge is a function of the standard deviation of the spot forecast, the future forecast, and the covariance of the spot and futures market prices for the commodity. The prevalence of many such models is the motivation for the choice of $\sigma_i(t-10,t)$, as a possible explanatory factor.[10]

[7]Actually, for this specification GMM may be performed using OLS regressions with White's (1980) covariance matrix.

[8]For example, average per capita consumption is not observable, and its proxies are only published quarterly. Similarly, instruments that track the true supply and demand for a commodity are not available or are reported only infrequently. Even open interest data is available only for recent contracts.

[9]Fama and French found seasonal patterns for agricultural, but not currency, futures.

Jagannathan chooses the lagged growth in real consumption as an instrument. This study substitutes a measure of real income. The use of real income is motivated by the nature of the intertemporal model. Also, Jagannathan uses lagged values of the $\pi(t, t+k)$ variable; specifically, $\pi(t-2, t)$, with 30-periods. This study uses $\pi(t-4, t)$ with 1-week periods.[11]

Not all of the factors in Table I are useful in explaining the variation. Therefore, a first regression equation involving all the factors is estimated for each commodity; then a second regression equation is estimated for each premium using only the factors that are significant at 15% for at least one commodity. Tables II, III, and IV report the regression results for the group of regressors selected.

This two-step process is used because the test statistics are based on asymptotic distribution theory. The number of observations here is not exceptionally large, so there is the possibility that having many factors which are mainly noise would influence the results considerably. However, the results reported in Tables II–IV are not the result of "data mining," since these factors also are significant in the first step. The second step is added to obtain a more accurate assessment of the factors likely to be influencing factors to the premia.[12]

For currency futures, the significant factors are CONST, DMFS, BPFS, STDSF, and STDBP. The significant factors for the agricultural commodities are CONST, D1, D2, D3, POL1, POL2, POL3, SYFS, CNFS, WHFS, STDCN, and STDSY. In general, the factors in the currency regressions seem to perform better than those in the agricultural estimations. This is plausible if future exchange rates can be forecast with more certainty

Table II
REGRESSIONS OF CURRENCY FUTURES PREMIA ON EXPLANATORY FACTORS (SIGNIFICANCE LEVEL IN PARENTHESIS)

	Currency		
Instruments	**German Mark**	**Swiss Franc**	**British Pound**
CONST	1.74 (1%)	2.30 (1%)	1.56 (7%)
BPFS	−2.24 (5%)	−3.05 (1%)	−0.17
DMFS	0.50	0.76	−1.40 (9%)
STDSF	0.04 (1%)	0.08 (0%)	0.08 (0%)
STDBP	−0.06 (0%)	−0.09 (0%)	−0.09 (0%)
R^2(GM) = 15%			
R^2(SF) = 28%			
R^2(BP) = 10%			

Sample period (1972:7 − 1988:12).
Number of observations = 66.

[10]The intent is not to say that, if this variance estimate is significant in the estimation, then hedging behavior plays an important role. This test is incapable of making that determination. The intent is to give a reason to suspect they might be important factors. To actually determine how these factors are used by agents would require knowledge of their utility functions.

[11]This factor is meant primarily to exploit any autocorrelation in the premia. It is not based on an economic rationale. It is included here mainly to honor precedent.

[12]The pruning does nothing to alter the fact that each commodity does have factors to which it responds, and this is all that is required to proceed with the equilibrium test of the CCAPM model. Ideally, all factors both significant and insignificant would be employed but the power of the test would be greatly diminished.

Table III
REGRESSIONS OF AGRICULTURAL FUTURES PREMIA ON EXPLANATORY FACTORS (SIGNIFICANCE LEVEL IN PARENTHESIS)

	Commodity			
Instruments	Corn	Cocoa	Soybeans	Wheat
CONST	0.61	0.96 (2%)	0.60 (8%)	0.12
CNFS	−0.54	−0.74 (5%)	−0.25	0.08
WHFS	−0.04	−0.16 (10%)	−0.15 (8%)	−0.06
SYFS	−0.13	−0.11	−0.24 (6%)	−0.17
STDCN	0.00	−0.03	−0.08 (0%)	0.01
STDSY	0.02	0.02	0.04 (11%)	−0.00
D1	0.07 (13%)	−0.01	−0.01	−0.06 (15%)
D2	0.09 (7%)	−0.04	0.02	−0.05
D3	0.11 (6%)	0.02	−0.00	−0.02
POL1	0.00	0.02 (3%)	0.02 (0%)	0.01 (11%)
POL2	−0.01	−0.03 (7%)	−0.05 (0%)	−0.02 (10%)
POL3	0.01	0.02	0.04 (0%)	0.02 (11%)
$R^2(\text{CN}) = 17\%$				
$R^2(\text{CC}) = 25\%$				
$R^2(\text{SY}) = 25\%$				
$R^2(\text{WH}) = 28\%$				

Sample period (1966:7 − 1988:12).
Number of observations = 84.

TABLE IV
REGRESSIONS OF FORWARD PREMIA ON EXPLANATORY FACTORS (SIGNIFICANCE LEVELS IN PARENTHESES)

	Currencies		
Instruments	British Pound	German Mark	Swiss Franc
CONST	3.41 (0%)	3.41 (6%)	1.72
BPFS	−0.92 (0%)	−1.90 (2%)	−0.94
DMFS	−0.64	−3.98 (6%)	−2.89 (10%)
SFFS	0.14	2.53 (6%)	2.14 (10%)
STDBP	−0.01 (0%)	−0.00	−0.01
STDDM	0.01 (0%)	−0.01	−0.00
STDSF	−0.01 (10%)	0.16	−0.01
$R^2(\text{BP}) = 22\%$			
$R^2(\text{GM}) = 13\%$			
$R^2(\text{SF}) = 10\%$			

Sample period (1967:3 − 1988:12).
Number of observations = 87.

than future commodity prices. This would be the case if any, or all, of the factors of production, demand, or storage costs, are more difficult to estimate (or observe) for agricultural commodities. The results for the forward currencies are also encouraging, and the significance levels are very high.

These tables indicate that time varying behavior in the premia can be documented. This implies that one-period models may be inadequate, or at least incomplete, and that there is reason to continue modeling futures and forward contracts in an intertemporal setting.

IDENTIFICATION OF THE EQUILIBRIUM MODEL

The intertemporal model of the premia's behavior cannot be estimated without an identifying assumption on the return of the index portfolio, $R_b(t, t + k)$. The assumption adopted here is that the return of the index portfolio is linearly related to known instrumental variables [following Huang (1989)]. Specifically,

$$R_b(t, t + k) - R(t, t + k) = \Sigma_n a_n Z_n(t) + \varepsilon(t, t + k) \tag{10}$$

where $Z_n(t)$ is at least weakly exogenous and $\varepsilon(t, t + k)$ is a forecast error. **Z(t)** is the vector of elements in the information set that is used to predict the returns on $R_b(t, t + k)$. Furthermore, the dimension of the parameter space must be reduced by assuming $\beta(t, t + k) = \beta$. This stationarity assumption does not rule out time varying risk premia, but it is inconsistent with time varying conditional covariances and variances.

Substituting assumption (10) and $\beta(t, t + k) = \beta$ into eq. (4) yields,

$$P_{\#}(t, t + k) = \beta \Sigma \alpha_n Z_n(t) + e_{\#}(t, t + k) \tag{11}$$

with

$$E[e_{\#}(t, t + k) e_{\#}(t, t + k - i)] = f(., t) \tag{12}$$

$$E[e_{\#}(t, t + k) Z_j(t)] = 0 \tag{13}$$

$f(., t)$ is a function of the information available at time t. It is equal to zero if $i > k$ and $\varepsilon(t, t + k) = 0$. The effect of this set of restrictions is to assume that the risk premium of an asset may be broken into two components. The first is a constant effect associated with the particular asset's sensitivity to movements in the return of the index portfolio. This is represented by β. The second effect is the level of the return on the index portfolio, for which a proxy is used. That proxy is the level of the instruments, the $Z_n(t)$'s, multiplied by the index portfolio's sensitivity to these factors, given by the α_n's.

Any empirical test of this model will, of course, be a join t test of the CCAPM and the identifying assumption on the index portfolio. This is similar to the tests of Jagannathan and of Hansen and Singleton which are joint tests of the CCAPM and a specific utility function. It should be noted also that an exhaustive specification of the $Z_n(t)$'s is not necessary for consistency.

ESTIMATION OF THE MODEL

GMM techniques allow estimation of eq. (13) on a vector of commodities without assumptions on the distribution from which $e(t, t + k)$ is drawn. For the futures contracts, the initial model estimated is written as

$$H_0 : \begin{bmatrix} [P_{cc}(t,t+k) - \beta_{cc}\Sigma\alpha_n Z_n(t)]Z_1(t) \\ \cdots \\ [P_{wh}(t,t+k) - \beta_{wh}\Sigma\alpha_n Z_n(t)]Z_1(t) \\ \cdots \\ \cdots \\ [P_{cc}(t,t+k) - \beta_{cc}\Sigma\alpha_n Z_n(t)]Z_n(t) \\ \cdots \\ [P_{wh}(t,t+k) - \beta_{wh}\Sigma\alpha_n Z_n(t)]Z_n(t) \end{bmatrix} = e(t,t+k) \tag{14}$$

The symbols *cc*, *cr*, *sy*, and *wh* stand for cocoa, corn, soybeans, and wheat. A similar specification applies to the British Pound, Swiss Franc, and German Mark, for each of the futures and forward markets.

The primary reason for writing currencies and agricultural contracts as separate vectors is that the two groups of futures contract do not expire at the same dates. This makes it very difficult to find a range of $(t, t + k)$ of reasonable length where none of the contracts are expiring.[13] In addition to their role in identifying the index's return, the $Z(t)$'s are used as instruments in the regression. This is possible since a Kronecker product of n Euler conditions with a vector of q instruments will result in a new vector of Euler conditions which is nq in length. For this study the natural choice for $Z(t)$ is the same as those factors identified earlier as having explanatory power in describing the variation in the premia.

The parameter estimates β', α' are chosen as

$$\boldsymbol{\beta}',\boldsymbol{\alpha}' = \text{argmin}(\Sigma_t e'\Sigma W_t e) \tag{15}$$

W is a weighting matrix computed as a function of the parameter estimates in the manner described in Hansen (1982) and Hansen and Singleton (1982). For this study convergence of the W estimator is considered to have been achieved when no element of W changes by more than .5% in an iterative step.

One of the β's is normalized to one, requiring estimation of $q + n - 1$ parameters. This leaves $(q - 1)(n - 1)$ overidentifying restrictions. The minimization is performed using Powell's method, which does not require the use of gradient procedures.[14]

The goodness of fit for this model may be tested by noting that, evaluated at $\boldsymbol{\beta}', \boldsymbol{\alpha}'$, the number of observations multiplied by $\Sigma_t e' W \Sigma_t e$ is distributed chi-square with degrees of freedom equal to $(q - 1)(n - 1)$. The power of this test is directly related to the significance of the α_n's.

EMPIRICAL RESULTS

Table V reports estimates of (15) for the currency futures contracts. Table VI reports results for the agricultural futures contracts. The reader is cautioned to remember that these beta estimates are relative to the Swiss Franc, whose beta is standardized to one. The reader is cautioned against misinterpreting the alpha estimates because they relate to an unobservable index portfolio, not to any particular premium. Their importance is in demonstrating that the test has power. Should these coefficients be insignificant it would

[13]Another important reason is that the information variables, **Z(t)**, are used as instruments, yet each type of premium responds to different elements in the agent's information set. Although all of these could be incorporated into a single **Z(t)** vector, this would introduce noise which could be troublesome in finite samples.

[14]The use of a non-gradient method of minimization is computationally burdensome. However, in this situation, it seems to provide superior stability over those that require the use of the gradient.

Table V

RESULTS OF THE GMM-ILVM TEST FOR CURRENCY FUTURES CONTRACTS

Coefficient of:	Parameter Estimate	z-value	Statistical Significance
Alphas			
CONST	16.39397	3.008	1%
BPFS	−19.73761	−2.823	1%
DMFS	3.38788	0.505	
STDSF	0.59000	4.802	1%
STDBP	−0.61275	−4.878	1%
Betas			
SF	1.45533	10.243	1%
BP	0.38788	2.396	5%
Chi-Square (8 d.f.) = 11.03982			

Number of observations = 66.

Sample period (1972:7–1988:12).

The convergence criteria for the weighting matrix require that no element have a variation of more than 0.5% from the previous iteration. Estimates are obtained using Powell's Method of direct search optimization.

Table VI

RESULTS OF THE GMM-ILVM TEST FOR AGRICULTURAL FUTURES CONTRACTS

Coefficient of:	Parameter Estimate	z-value	Statistical Significance
Alphas			
CONST	−0.72307	−0.581	
CNFS	1.29148	1.035	
WHFS	−0.14611	−0.966	
SYFS	−0.46871	−1.651	
STDCN	−0.13463	−1.947	6%
STDSY	0.12841	2.272	5%
D1	0.22198	1.786	10%
D2	0.37922	2.403	5%
D3	0.09125	0.848	
POL1	−0.00613	−0.491	
POL2	−0.00027	−0.553	
POL3	−0.00000	−0.501	
Betas			
Corn	−1.94191	−2.333	5%
Soybeans	0.09187	0.304	
Wheat	0.59517	2.064	5%
Chi-Square (33 d.f.) = 27.45288			

Number of observations = 84.

Sample period (1967:7–1988:12).

The convergence criteria for the weighting matrix is that no element have a variation of more than 0.5% from the previous iteration. Estimates are obtained using Powell's Method of direct search optimization.

be difficult to claim the overall test of the model has any content. The chi-square of the currency futures contract for this model is 11 (8 degrees of freedom). This is significant only at about 21%, so the model is not rejected. The alphas, however, are significant at the 5% or 1% level for all factors except DMFS.

In Table VI, the chi-square for the agricultural commodities is 27.5 (33 degrees of freedom). This is significant at greater than 50%, though results for the agricultural factors are not as powerful as for the currencies. Of the 12 instruments used 4 have coefficients significant at 10%.[15]

The results of Table VI are the most significant of this article. For agricultural commodities, when the identification strategy is changed, the exact opposite conclusion from Jagannathan is obtained as to the suitability of the CCAPM to model futures contracts.[16]

In the forward market the instruments are CONST, BPFS, DMFS, SFFS, STDBP, STDDM, and STDSF. The interval $(t, t+k)$ is 3 months. This is a greater number of instruments than has been used in previous studies. Also, as discussed previously, the definition of $P_2(t, t+k)$ is new.

In Table VII, the model is not rejected at 10%, though the chi-square is still large enough to reject at 20%. This is not in complete agreement with Huang (1989), who found strong support for the model at 3-month maturities. However, in both cases the model is not rejected.

Table VII
RESULTS OF THE GMM–ILVM TEST FOR FORWARD CURRENCY CONTRACTS

	Parameter Estimates		
Coefficient of:	**Parameter Estimate**	**z-value**	**Statistical Significance**
Alphas			
CONST	2.63026	2.6506	1%
BPFS	−2.47146	−4.4598	1%
DMFS	0.57333	0.6125	
SFFS	−0.75408	−0.9953	
STDBP	−0.01077	−5.2567	1%
STDDM	0.01504	2.7967	1%
STDSF	−0.00940	−2.1286	5%
Betas			
British Pound	0.33572	1.6852	10%
German Mark	0.03986	0.1999	
Chi-Square (13 d.f.) = 17.86284			

Number of observations = 87.

Sample period (1967:3–1988:12).

The convergence criteria for the weighting matrix requires that no element have a variation of more than 0.5% from the previous iteration. Estimates are obtained using Powell's Method of direct search optimization.

[15]To further investigate the behavior of the agricultural commodities, pairwise tests are performed also for each possible commodity pair. None of the pairwise models perform substantially differently from the overall model reported here.

[16]The estimations are performed also using only the instruments that Jagannathan used, and the null hypothesis is not rejected.

DESCRIPTIONS OF EMPIRICALLY OBSERVED PREMIA

Descriptive statistics of the futures and forward premia are given in Tables VIII and IX. An integral part of the futures premium definition is the ratio of the future spot price to the current futures price. Abstracting from a term premium (i.e., ignoring the possibility $\pi(t,t+k) \neq r(t,t+k)$), this ratio determines whether the risk premium is positive or negative.

Normal backwardation coincides with $f(t+k,t+k) > f(t,t+k)$. The premium to holding a futures contract in this case is positive. Table VIII illustrates that this is true for the average risk premium of all agricultural commodities tested. Of course, the premium definition is ex ante in nature, and the observations are ex post. However, rational expectations assumes that these two values are, on average, coincident.

Table VIII
DESCRIPTIVE STATISTICS OF THE FUTURES PREMIA
(PREMIA ARE FORMED WITH $(t,t+k)$, OF 8 WEEKS)

Premium	Mean	σ	Skew	Kurt	Min	Max
DM	−0.004	0.04	0.543	3.128	−0.084	0.120
SF	−0.003	0.05	0.525	3.321	−0.115	0.125
BP	−0.003	0.04	0.077	2.854	−0.086	0.106
CN	0.018	0.13	2.623	13.721	−0.197	0.710
CC	0.026	0.15	0.937	4.114	−0.241	0.491
WH	0.017	0.11	1.349	6.534	−0.200	0.484
SY	0.021	0.14	1.331	10.524	−0.386	0.712

Correlations

	DM	SF	BP
DM	1.000		
SF	0.872	1.000	
BP	0.670	0.609	1.000

	CN	CC	SY	WH
CN	1.000			
CC	0.284	1.000		
SY	0.517	0.345	1.000	
WH	0.437	0.029	0.186	1.000

BP—British Pound
DM—German Mark
SF—Swiss Franc
CN—Corn
CC—Cocoa
SY—Soybeans
WH—Wheat
$(\cdot) \equiv (t,t+k)$

$P(\cdot) \equiv$ the futures premium

$P(\cdot) = \pi(\cdot)[f(t+k,t+k)/f(\cdot)] - r(\cdot)$
$\pi(\cdot) \equiv$ product of 1 plus one day rates

$f(x,y) \equiv$ futures contract written at time x expiring at time y
$r(\cdot) \equiv$ one plus the risk free rate

Number of obs. = 66 for currencies, 84 for crops.
Time period is 1972:7 to 1988:12 for currencies, 1966:7 to 1988:12 for crops.

The results above fit well with the traditional theory that hedgers tend to be farmers who wish to assume the short side of the futures contract while speculators tend to bear this risk by taking the long side of the futures positions. In return, the hedgers pay an "insurance" premium to the speculators.

Contango coincides with $f(t + k, t + k) \leq f(t, t + k)$. The risk premium will be negative to agents who hold a long position. Table VIII indicates that this situation occurs for all currency contracts tested. An explanation consistent with this argument is to assume that hedgers are net long, since they are using the futures markets to guarantee the price of future import goods. Speculators are then net short and the hedgers buy insurance from speculators. The forward market results of Table IX show that this behavior is also true in the forward currency markets. Since a term premium is not a possibility for the forward contracts, this also supports the notion that the signs in the futures premia are indicative of normal backwardation and contango.

CONCLUSIONS AND FUTURE RESEARCH

This article demonstrates that intertemporal modeling of futures and forward risk premia with the CCAPM is likely to be superior to single period modeling, provided the model is identified with an index portfolio. This is important because it contradicts the conclusions of Jagannathan (1985) about using the CCAPM in the futures market.

Additionally, this article supports the conclusions of Huang (1989) for the forward market. Beyond this, the model works with currency contrast as well as with agricultural contracts. This broad support indicates the problems with the CCAPM are related to poor

Table IX
DESCRIPTIVE STATISTICS OF THE FORWARD PREMIA

Premium	Mean	σ	Skew	Kurt	Min	Max
BP	−0.001	0.05	−0.159	3.156	−0.139	0.133
DM	−0.020	0.06	0.626	4.696	−0.124	0.265
SF	−0.069	0.07	0.729	3.291	−0.112	0.217

Correlations

	BP	DM	SF
BP	1.000		
DM	0.592	1.000	
SF	0.568	0.877	1.000

BP—British Pound Forward Premium
DM—German Mark Forward Premium
SF—Swiss Franc Forward Premium

Premia are formed with $(t, t + k)$ of 13 weeks
$P(t, t + k) = r(t, t + k)[S(t + k) - F(t, t + k)]/F(t, t + k)$
$P(t, t + k) \equiv$ the premium from $(t, t + k)$
$S(t + k) \equiv$ the spot commodity price at time $t + k$
$F(t, t + k) \equiv$ the price at time t of the futures contract
$r(t, t + k) \equiv$ one plus the risk free rate for period $(t, t + k)$

Based on 87 observations, 1967:3 to 1988:12.

consumption data or to restrictive utility assumptions which lead to the use of this data, and not the model itself.[15]

For pricing the returns to futures and forward contracts, this article demonstrates that a better alternative than one-period modeling exists. This model includes more features of futures markets, and performs quite well.

Finally, the derivation of this article's methodology demonstrates that the CCAPM model in conjunction with instrumental variables is easily applied to most markets. This implies that this methodology should have wide application in other markets as well.

Bibliography

Baxter, J., Conine, T., Jr., and Tamarkin, M. (1985): "On Commodity Market Risk Premiums: Additional Evidence," *The Journal of Futures Markets,* 5:121–125.

Carter, C., Rausser, G., and Schmitz, A. (1983): "Efficient Asset Portfolios and the Theory of Normal Backwardation," *Journal of Political Economy,* 91:319–331.

Chang, E., Chen, C., and Chen, S.-N, (1990): "Risk and Return in Copper, Platinum, and Silver Futures," *The Journal of Futures Markets,* 10:29–39.

Cornett, M., and Trevino, R. (1989): "Monthly Return Patterns on Commodity Futures Contracts," unpublished working paper, Southern Methodist University.

Dusak, K. (1973): "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums," *Journal of Political Economy,* 81:1387–1406.

Elam, E., and Vaught, D. (1988): "Risk and Return in Cattle and Hog Futures," *The Journal of Futures Markets,* 8:79–87.

Fama, E., and French, K. (1987): "Commodity Futures Prices: Some Evidence on Forecast Power, and Theory of Storage," *Journal of Business,* 60:55–73.

Ferson, W., and Gibbons, M. (1985): "Testing Asset Pricing Models with Changing Expectations and an Unobservable Market Portfolio," *Journal of Financial Economics,* 14:217–236.

Hansen, L. P. (1982): "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica,* 50:1029–1054.

Hansen, L. P., and Hodrick, R. (1980): "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy,* 88:828–853.

Hansen, L. P., and Singleton, K. (1982): "Generalized Instrumental Variable Estimation of Nonlinear Rational Expectations Models," *Econometrica,* 50:1269–1287.

Huang, R. (1988): "Tests of the Conditional Capital Asset Pricing Model with Changing Expectations," unpublished working paper, Vanderbilt University.

Huang, R. (1989): "An Analysis of Intertemporal Pricing for Forward Foreign Exchange Contracts," *Journal of Finance,* 44:183–194.

Jagannathan, R. (1985): "An Investigation of Commodity Futures Prices Using the Consumption-Based Intertemporal Capital Asset Pricing Model," *Journal of Finance,* 40:175–191.

Jorgenson, D. (1964): "Minimum Variance, Linear, Unbiased Seasonal Adjustment of Economic Time Series," *Journal of The American Statistical Association,* 59:681–724.

Keim, D. (1985): "Dividend Yields and Stock Returns: Implications of Abnormal January Returns," *Journal of Financial Economics,* 14:473–490.

[15]It has been argued often that either GMM methodologies or the ILVM modeling assumption may make these tests powerless to reject any hypothesis. This is not true. Jagannathan (1985) using GMM, rejected his model, and Huang (1989), using ILVM, rejects his model for 1-month forward contract.

Keim, D., and Stambaugh, R. (1984): "A Further Investigation of the Weekend Effect in Stock Returns," *Journal of Finance,* 39:819–835.

Malick, W., and Ward, R. (1987): "Stock Effects and Seasonality in the FCOJ Futures Basis," *The Journal of Futures Markets,* 7:156–167.

Peck, A. (1977): "Hedging and Income Stability: Concepts, Implications, and Example," in *Selected Writings on Futures Markets, Volume II,* A. Peck (ed.), Chicago: Board of Trade.

Rudin, W. (1987): *Real and Complex Analysis,* New York: McGraw-Hill.

Schwert, G. W. (1983): "Size and Returns, and Other Empirical Regularities," *Journal of Financial Economics,* 12:3–12.

White, H. (1980): "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test of Heteroskedasticity," *Econometrica,* 48:817–838.