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Hedging Pressure Effects in Futures Markets

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ABSTRACT

We present a simple model implying that futures risk premia depend on both own-market and cross-market hedging pressures. Empirical evidence from 20 futures markets, divided into four groups (financial, agricultural, mineral, and currency) indicates that, after controlling for systematic risk, both the futures own hedging pressure and cross-hedging pressures from within the group significantly affect futures returns. These effects remain significant after controlling for a measure of price pressure. Finally, we show that hedging pressure also contains explanatory power for returns on the underlying asset, as predicted by the model.

FUTURES PRICES ARE KNOWN TO DEVIATE from expected future spot prices because of risk premia that traders expect to earn (or pay) when trading in futures markets. Futures risk premia are important because they affect the costs and benefits of hedging, as well as the diversification benefits that result from including futures in investment portfolios. Also, to the extent that economic agents make their production, storage, and consumption decisions by looking at futures prices as indicators of future spot prices, it is important to know the bias that exists in futures prices.

There is an ongoing debate about the determinants of futures risk premia. Futures risk premia are usually related to systematic risk, as in the work of Dusak (1973), Black (1976), and Jagannathan (1985), among others, and to net positions of hedgers in futures markets, which is known as hedging pressure. Hedging pressure results from risks that agents cannot, or do not want to trade because of market frictions such as transaction costs and information asymmetries. The use of hedging pressure as an explanation for the futures price bias dates back to Keynes (1930) and Hicks (1939), and has more recently been incorporated in models that allow both hedging pressure and systematic risk to affect futures prices (see, e.g., Stoll (1979) and Hirshleifer (1988, 1989)). Carter, Rausser, and Schmitz (1983) and Bessembinder (1992) provide empirical evidence for the combined role of the futures con-

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tracts own hedging pressures and systematic risk, as measured by the covariance between the futures returns and the market return and other economic aggregates.

In this paper we use a simple model in the spirit of Mayers (1976), Stoll (1979), and Hirshleifer (1988, 1989) in which agents face multiple sources of nonmarketable risks. The model implies that expected futures returns are determined by hedging pressure and by the covariance of the futures return with the market return. The distinguishing feature of the model used in this paper is that the futures risk premium is not only determined by its own hedging pressure, but also by hedging pressures from other markets, referred to as cross-hedging pressures.

We analyze the effect of hedging pressure variables on futures risk premia for 20 futures markets that are divided into four groups: financial futures, agricultural futures, mineral futures, and currency futures. The data set consists of semimonthly observations for the period from January 1986 to December 1994. For these markets, we find that both own-hedging pressure and cross-hedging pressure variables from within the futures own group are important in explaining futures returns.[1]

Taking into account that these results might also be explained by the traditional price pressure hypothesis—that a shock in demand or supply causes a temporary price change—we show that our findings are robust because (cross-) hedging pressure effects are still significantly present after controlling for price pressure effects. We measure price pressure as a change in hedging pressure. We also show that hedging pressure variables affect both the futures returns and the returns on the underlying values of the futures contracts. The finding of hedging pressure effects in spot returns, as well as in futures returns, is consistent with the predictions of the pricing model but not with the price pressure hypothesis.

The remainder of this paper is organized as follows. In Section I we present a simple model for futures returns. Section II describes the data, and in Sections III and IV an empirical analysis of hedging pressure effects is presented. This paper ends with a summary and some conclusions.

I. Modeling Futures Risk Premia

There is an extensive literature,[2] both theoretical and empirical, that relates futures risk premia to two determinants: systematic risk and hedging pressure. In mean-variance models, if all risks are perfectly marketable, or if all agents have free access to the available financial markets, agents can

[1] We also analyzed hedging pressure effects using the specification error bounds introduced by Hansen and Jagannathan (1997). This analysis showed that the inclusion of hedging pressure variables in the pricing model led to a significant decrease in the specification error bounds for the 20 futures markets that are analyzed. These results can be obtained from the authors upon request.

[2] See, for example, Stoll (1979), Hirshleifer (1988, 1989), Carter et al. (1983), and Bessembinder (1992).

freely diversify their portfolios and futures risk premia depend only on systematic risk—in other words, on the covariation between futures returns and the market return.

To show the nature of models containing both systematic risk and hedging pressure, suppose that there are K assets available in which agents can invest, as well as L futures markets. The net returns on the K assets are denoted by the K-dimensional vector $\mathbf{r}_{A,t+1}$, where the ith element of $\mathbf{r}_{A,t+1}$ is given by $(P_{i,t+1} - P_{i,t})/P_{i,t}$. The returns on the L futures contracts are denoted by $\mathbf{r}_{F,t+1}$, where the ith element of $\mathbf{r}_{F,t+1}$ is given by $(F_{i,t+1} - F_{i,t})/F_{i,t}$.[3] Apart from these marketable securities, the end-of-period wealth of an agent may be affected by S nonmarketable positions, the returns on which are given by the S-dimensional vector $\mathbf{r}_{S,t+1}$. These nonmarketable positions may serve as the underlying value of the futures contracts and can also coincide with some of the K assets in $\mathbf{r}_{A,t+1}$. However, it is also possible that the nonmarketable positions are different assets or other risky positions. The returns on the nonmarketable positions are defined in the same way as asset returns. The portfolio return of agent j, r_{t+1}^{j}, is given by

$$r_{t+1}^{j} = \mathbf{w}_A^{j\prime}\mathbf{r}_{A,t+1} + \mathbf{w}_F^{j\prime}\mathbf{r}_{F,t+1} + \mathbf{q}_t^{j\prime}\mathbf{r}_{S,t+1}, \tag{1}$$

where $\mathbf{w}_A^{j}$ is the vector of portfolio weights in the K assets, $\mathbf{w}_F^{j}$ the positions in the L futures contracts, and $\mathbf{q}_t^{j}$ the sizes of the S nonmarketable positions faced by agent j at time t. The asset weights, futures positions, and nonmarketable positions are all expressed as a fraction of wealth invested in financial markets. Throughout the analysis we will make the assumption that $q_{s,t}^{j}$, the sth element of $\mathbf{q}_t^{j}$, is known at the beginning of the period. If $r_{s,t+1}$ refers to the return on a nonmarketable commodity, this assumption implies that we assume there is no quantity risk.[4]

If the wealth of agent j invested in assets is denoted by Y_t^{j}, the aggregate nonmarketable position $q_{s,t}^{m}$ is given by

$$q_{s,t}^{m} = \frac{\sum_{j=1}^{N} Y_t^{j} q_{s,t}^{j}}{\sum_{j=1}^{N} Y_t^{j}}, \tag{2}$$

where N is the number of agents. Thus, $q_{s,t}^{m}$ is the wealth-weighted average nonmarketable risk, which we will further refer to as the *aggregate nonmarketable risk*. For simplicity it is assumed that variances and covariances

[3] Notice that because of the zero-investment nature of futures contracts, the term "futures return" is actually a misnomer.

[4] This is not very restrictive within the framework considered here however, since we can always adjust the definition of $r_{s,t+1}$ to allow for quantity risk.

do not vary over time. Assuming that the portfolio problem for every agent j only depends on the mean and variance of his portfolio return r^j_{t+1}, it can be shown (see Appendix A) that the expected asset and futures returns satisfy

$$E_t[\mathbf{r}_{A,t+1}] - \eta\boldsymbol{\iota} = \boldsymbol{\beta}_A E_t[r^m_{t+1} - \eta] + \sum_{s=1}^{S} \boldsymbol{\theta}_{A,s} q^m_{s,t}, \tag{3a}$$

$$E_t[\mathbf{r}_{F,t+1}] = \boldsymbol{\beta}_F E_t[r^m_{t+1} - \eta] + \sum_{s=1}^{S} \boldsymbol{\theta}_{F,s} q^m_{s,t}, \tag{3b}$$

where $\boldsymbol{\iota}$ is a vector of ones, η is the Lagrange multiplier for the restriction that the weights in $\mathbf{w}_A$ sum to one, and β_i has the familiar beta-interpretation, $\beta_i = Cov[r_{i,t+1}, r^m_{t+1}]/Var[r^m_{t+1}]$, and where $\theta_{i,s}$ is given by

$$\theta_{i,s} = \gamma^m\{Cov[r_{i,t+1}, r_{s,t+1}] - \beta_i Cov[r^m_{t+1}, r_{s,t+1}]\}, \tag{4}$$

with γ^m the market risk aversion parameter. Notice that $\theta_{i,s}$ can be either positive or negative, depending on the sign and magnitude of the covariances in equation (4). However, for the futures own hedging pressure (i.e., when the nonmarketable position s is the underlying value of futures contract i), $\theta_{i,s}$ is likely to be positive, because in that case the first covariance is positive and typically much larger than the product of the second covariance and β_i. Also note that the model in equations (3a) and (3b) implies that the aggregate nonmarketable risk fraction $q^m_{s,t}$ affects the expected returns of futures, as well as assets. This latter result is similar to the CAPM with nontraded assets as discussed in Mayers (1976). The result that aggregate positions in nonmarketable risks affect the expected returns in futures and asset markets is the well-known hedging pressure effect.

In empirical work (see, e.g., Carter et al. (1983) and Bessembinder (1992)), futures risk premia are usually related to market risk and the futures own hedging pressure. According to equation (3b) however, the futures risk premium is not only determined by its own hedging pressure, but also by *cross*-hedging pressures. As noted by Anderson and Danthine (1981), cross hedging may arise because the cash and the futures returns are not perfectly correlated (because of basis risk) or because agents may be concerned about hedging cash positions for which no futures contracts are traded. The remainder of the paper investigates the empirical relevance of these cross-hedging pressure effects.

II. Data Description

We analyze a data set consisting of semimonthly observations of 20 futures contracts over the period from January 1986 to December 1994. These futures contracts are divided into four categories, each containing five futures contracts: financial (S&P 500, Value-Line, T-bond, T-bill, Eurodollar), agricultural (wheat, corn, soybeans, live cattle, world sugar), mineral (gold, silver, platinum, crude oil, heating oil), and currency futures (Deutsche mark, British pound, Japanese yen, Canadian dollar, Swiss franc). The composition of the data set is comparable to the one studied by Bessembinder (1992, 1993). Details about the delivery months and the markets in which the futures contracts are traded can be found in Appendix B. We also have observations on the positions of large traders in each of the futures contracts as reported by the Commodity Futures Trading Commission (CFTC). The S&P 500 Index is used as a proxy for the market index. All data are obtained from the Futures Industry Institute (FII) Data Center.

Continuous series of futures returns are created for each futures contract, for both the first and the second nearest-to-maturity contracts. These return series are created by using a rollover strategy. For instance, for the nearest-to-maturity series a position is taken in the nearest-to-maturity contract until the delivery month, at which time the position changes to the following contract, which then becomes the nearest-to-maturity contract. To avoid the effect of the October 1987 crash, the returns in that month are excluded from the data set. This procedure results in a total of 40 series of 190 semimonthly returns.

Summary statistics for the nearest-to-maturity series for all futures contracts are presented in Table I. These summary statistics roughly confirm some well-known stylized facts about futures returns. For instance, mean returns on agricultural and mineral futures are comparable in (absolute) size with the mean returns on financial and currency futures. Standard deviations for agricultural and mineral futures returns are somewhat larger than for financial futures. Except for the index futures, the t-values reported in Table I show that for most contracts the average futures return is not significantly different from zero. Bessembinder (1992, 1993) uses a sample period that only partially overlaps with our sample period and reports similar statistics for these four categories of futures contracts.

The last two columns of Table I present the unconditional beta of each futures contract relative to the S&P 500 Index, together with the associated t-values, which are based on heteroskedasticity-consistent standard errors. We only find betas that are significantly different from zero for financial futures and for gold and silver futures. These betas indicate that most commodity and currency futures in our sample do not have systematic risk, which confirms the results found by Dusak (1973), Carter et al. (1983), and Bessembinder (1992).

Finally, Table I also reports the average correlations of each futures contract with the underlying assets in the four groups. For all futures contracts in our data set but two, the prices of the assets underlying the futures contracts are also provided by the FII. The exceptions are the underlying values for the T-bond and the T-bill futures. Since the underlying value of the T-bond futures is a hypothetical (unobserved) T-bond, we use the Datastream Long

Table I

Summary Statistics for Futures Returns

Returns are calculated from semimonthly data for the period January 1986 to December 1994, excluding observations for October 1987. Mean returns and standard deviations are annualized (×24) and are in percentages. The reported correlations are the average correlation of the futures contract with the underlying values in each group. $\hat{\beta}$ is the slope coefficient from a regression of the futures returns on the S&P 500 returns. The t-values for $\hat{\beta}$ are based on heteroskedasticity consistent standard errors.

				Average Correlations					
	Avg.	t (avg.)	Std Dev.	Fin	Agr	Min	Cur	$\hat{\beta}$	$t(\hat{\beta})$
Financial									
S&P 500	11.10	(2.30)	13.70	0.573	0.092	−0.139	0.056	1.028	(77.94)
Value Line	12.10	(2.30)	14.98	0.525	0.003	−0.135	0.017	1.025	(21.10)
T-bond	7.03	(1.93)	10.34	0.423	0.015	−0.004	0.021	0.377	(6.40)
T-bill	0.21	(0.49)	1.23	0.113	−0.100	−0.115	0.057	0.015	(1.92)
Eurodollar	0.72	(1.71)	1.20	0.473	0.029	−0.097	0.012	0.031	(4.89)
Agricultural									
Wheat	5.54	(0.78)	20.09	0.015	0.250	0.057	−0.005	0.101	(0.83)
Corn	−4.38	(−0.56)	22.39	0.075	0.387	0.142	−0.004	−0.020	(−0.16)
Soybeans	0.31	(0.04)	20.34	0.082	0.450	0.080	−0.018	−0.116	(−1.03)
Live cattle	14.22	(3.45)	11.72	−0.025	0.089	−0.091	−0.001	0.061	(0.86)
World sugar	5.10	(0.36)	40.53	−0.052	0.327	−0.046	−0.020	0.103	(0.49)
Mineral									
Gold	−4.07	(−0.86)	13.51	−0.100	0.060	0.557	0.069	−0.258	(−2.84)
Silver	−5.81	(−0.67)	24.83	−0.103	−0.029	0.440	0.084	−0.234	(−1.68)
Platinum	−0.98	(−0.13)	21.97	−0.060	0.078	0.464	0.063	−0.014	(−0.09)
Crude oil	5.24	(0.58)	25.77	0.003	0.109	0.455	0.032	−0.436	(−1.53)
Heating oil	16.45	(1.28)	36.44	−0.074	−0.033	0.389	0.094	−0.199	(−0.74)
Currency									
Deutsche mark	4.70	(1.14)	12.12	−0.016	−0.021	0.096	0.661	−0.014	(−0.18)
British pound	4.52	(1.15)	11.95	−0.049	−0.146	−0.027	0.621	−0.043	(−0.68)
Japanese yen	6.61	(1.57)	11.95	0.037	−0.042	0.125	0.577	−0.016	(−0.24)
Canadian dollar	3.45	(2.16)	4.55	0.081	0.008	0.032	0.217	0.036	(1.35)
Swiss franc	3.80	(0.84)	12.92	0.134	0.006	0.062	0.655	−0.076	(−1.03)

Term Government Bond Index as the underlying asset of the T-bond futures. For the T-bill futures we use returns on a three-month T-bill to approximate the return on the underlying value.

The average correlations with the underlying values show that the futures returns are highly correlated with the spot returns within each group, but not across groups. Except for T-bill, live cattle, and Canadian dollar futures, the average correlations within each group are always at least 0.25. On the other hand, the average correlations across the four groups are much smaller, never exceeding 0.15 in absolute value. Combined with the fact that most futures contracts outside the financial groups have $\hat{\beta}$'s close to zero, it follows from equation (4) that cross-hedging pressure effects can be expected within each futures group, but not between the groups.

In the analysis below, risk premia are related to hedging pressure variables. Positions of large traders in futures markets as reported by the CFTC are used to construct proxies for the hedging pressures. Since large traders have to report to the CFTC whether they take a position in a futures market for hedging or for speculative reasons,[5] these reports can be used to construct a variable that measures whether hedgers have a net long or short position in a futures market. For each futures contract *s* we create a variable $\hat{q}^m_{s,t}$ that is based on reported positions of hedgers for each futures market *s*:

$$\hat{q}^m_{s,t} = \frac{\textit{number of short hedge positions} - \textit{number of long hedge positions}}{\textit{total number of hedge positions}}, \quad (5)$$

where the positions are measured by the number of contracts in market *s*. Given that $\hat{q}^m_{s,t}$ is constructed from positions that by definition arise from hedge demand, it seems reasonable that this variable will proxy for the aggregate nonmarketable risks.

Summary statistics for the hedging pressure proxies are reported in Table II. Notice that there is quite a lot of variation in hedging pressure. Substantial variation in hedging pressure exists for particular futures contracts, as measured by the individual standard deviations. Besides that, the cross-sectional differences between the hedging pressures, as shown by the differences in average hedging pressure, appear to be quite large as well. When introducing the term "normal backwardation," Keynes (1930) conjectured that it is "normal" for producers of agricultural commodities to be the dominant group of hedgers in these markets and to be on the short side of the futures markets. The statistics in Table II however, suggest that in most markets hedgers as a group can be either on the long or on the short side of the market.

[5] Actually, the groups of traders are referred to as *commercial traders* and *noncommercial traders*, but this comes down to a distinction between hedgers and speculators (see also Bessembinder (1992)).

Table II

Summary Statistics for Hedging Pressures

The hedging pressure variable is defined as

$$\frac{(number\ of\ short\ hedge\ positions - number\ of\ long\ hedge\ positions)}{(total\ number\ of\ hedge\ positions)}.$$

Hedging pressures are calculated from semimonthly data for the period January 1986 to December 1994, excluding observations for October 1987. Mean returns and standard deviations are in percentages. $\hat{\theta}$ is the slope coefficient from a regression of the futures returns on their own hedging pressure. The t-values for $\hat{\theta}$ are based on heteroskedasticity consistent standard errors.

	Avg.	Std. Dev.	$\hat{\theta}$	$t(\hat{\theta})$
Financial				
S&P 500	−6.7	6.1	−0.019	(−0.53)
Value Line	0.3	52.9	−0.001	(−0.13)
T-bond	−1.0	8.3	0.056	(2.87)
T-bill	23.5	16.7	0.005	(3.97)
Eurodollar	−2.2	5.0	0.011	(2.60)
Agricultural				
Wheat	17.8	24.2	0.048	(4.58)
Corn	1.5	15.1	0.119	(5.27)
Soybeans	19.7	18.3	0.066	(4.18)
Live cattle	25.4	15.0	0.013	(1.07)
World sugar	23.6	18.1	0.137	(4.34)
Mineral				
Gold	−0.2	20.5	0.049	(5.47)
Silver	39.4	11.7	0.086	(2.81)
Platinum	33.8	22.4	0.054	(3.80)
Crude oil	−2.1	6.8	0.160	(2.07)
Heating oil	6.7	9.9	0.226	(4.36)
Currency				
Deutsche mark	3.6	26.9	0.050	(10.10)
British pound	1.2	42.7	0.031	(9.45)
Japanese yen	7.8	34.8	0.037	(8.62)
Canadian dollar	15.8	45.8	0.009	(6.93)
Swiss franc	2.7	39.9	0.035	(8.47)

III. Cross Hedging Pressure Effects on Futures Risk Premia

As suggested by the model in Section I, as well as by the models of Stoll (1979) and Hirshleifer (1988, 1989), and as indicated by the empirical work of Carter et al. (1983), Chang (1985), and Bessembinder (1992), hedging pressure variables are important determinants of expected futures returns. This also follows from the last two columns of Table II, which show the slope coefficients and the associated t-values from a simple regression of futures returns on their own hedging pressure variable $\hat{q}^m_{i,t}$. Except for the index futures and live cattle futures, there is always a significant relation between futures returns and the own hedging pressure. Also, the coefficients that are significantly different from zero always have the expected positive sign. These results confirm the findings of Bessembinder (1992), who compares the average futures returns conditional on hedgers being net short or net long. Especially for mineral and currency futures Bessembinder finds that the average futures returns are significantly larger when hedgers are net short than when they are net long. The difference between his results and the results in Table II occurs primarily for the agricultural futures, where we find more significant effects, and the financial futures. Similar to our results, Bessembinder reports insignificant hedging pressure effects for index futures. For interest rate futures however, he finds a negative relation between the own hedging pressure and average futures returns, whereas the first section of Table II shows a positive relation between the interest rate futures returns and their own hedging pressure.

The model outlined in Section I implies that risk premia for all futures contracts are determined by a systematic risk component, as well as hedging pressure variables for all nonmarketable risks, reflecting all nonmarketable positions that agents may face. Replacing expectations by realizations in equation (3b) yields

$$r_{i,t+1} = \alpha_i + \beta_i r_{t+1}^m + \sum_{s=1}^{S} \theta_{i,s} q_{s,t}^m + \varepsilon_{i,t+1}, \tag{6}$$

with $\alpha_i = -\beta_i \eta$,[6] $E[\varepsilon_{i,t+1}] = 0$, and $E[r_{t+1}^m \varepsilon_{i,t+1}] = E[q_{s,t}^m \varepsilon_{i,t+1}] = 0$. Therefore, OLS-estimation of equation (6) will yield consistent estimates of α_i, β_i, and $\theta_{i,s}$.

In order to analyze the effects of hedging pressure from other futures markets on the futures risk premia, we study each group of futures contracts and analyze the effect of the hedging pressure variables within each group on futures returns. As indicated in Section II, due to the correlation structure of the futures and spot returns, and the fact that the market beta's of the futures contracts are usually close to zero, we may expect cross-hedging pressure effects within each group but not between the four groups.[7] Denoting variables referring to futures contract i ($i = 1,\ldots,5$) in group j ($j = 1,\ldots,4$) as $x_i^{(j)}$, the regression model employed in this section is

$$r_{i,t+1}^{(j)} = \alpha_i^{(j)} + \beta_i^{(j)} r_{t+1}^{S\&P500} + \sum_{s=1}^{5} \theta_{i,s}^{(j)} \hat{q}_{s,t}^{(j)} + \varepsilon_{i,t+1}^{(j)}. \tag{7}$$

[6] If $r_{i,t+1}$ is the return on a nonzero-investment asset such as a stock or a bond, the restriction is $\alpha_i = (1 - \beta_i)\eta$.

[7] Formal Wald tests for cross-hedging pressure effects from the other groups support this conjecture. These results are obtainable from the authors upon request.

Table III

Hedging Pressure Regressions

The table presents estimates of the coefficients $\theta_{s,i}^{(j)}$ in the regression

$$r_{i,t+1}^{(j)} = \alpha_i^{(j)} + \beta_i^{(j)} r_{t+1}^{S\&P500} + \sum_{s=1}^{5} \theta_{s,i}^{(j)} \hat{q}_{s,t}^{(j)} + \varepsilon_{i,t+1}^{(j)},$$

where i refers to futures contract i in market j (financial, agricultural, mineral, currency). The variables $\hat{q}_{s,t}^{(j)}$ are the five hedging pressure variables within the own group. $\theta_{s,i}^{(j)}$ therefore measures the sensitivity of the futures return to the hedging pressure variables in its own group. All reported coefficients are $\times 100$. Values in parentheses are t-values based on heteroskedasticity consistent standard errors. The parameter estimates are reported for the nearest-to-maturity contracts. The last two columns present p-values associated with Wald tests for the hypothesis that all reported coefficients are zero, $\theta_{s,i}^{(j)} = 0$, $\forall s$, (W_{all}), and for the hypothesis that all reported coefficients except for the own hedging pressure variable are zero, $\theta_{s,i}^{(j)} = 0$, $s \neq i$ (W_{other}). The Wald tests are based on regressions for both the nearest-to-maturity and second-nearest-to-maturity contracts and use heteroskedasticity consistent estimates of the covariance matrices. All results are based on semimonthly observations over the period January 1986 to December 1994, excluding observations for October 1987.

Panel A: Financial

	$\hat{\theta}_{S\&P500}$	$\hat{\theta}_{Value}$	$\hat{\theta}_{T\ bond}$	$\hat{\theta}_{T\ bill}$	$\hat{\theta}_{Eur\$}$	W_{all}	W_{other}
S&P 500	−0.95	−0.00	−0.10	−0.14	−0.23	34.96	32.59
	(−1.25)	(−0.01)	(−0.18)	(−0.54)	(−0.32)	(0.000)	(0.000)
Value line	1.77	−0.22	1.12	−2.50	0.87	24.81	24.78
	(1.05)	(−0.98)	(0.58)	(−3.63)	(1.07)	(0.006)	(0.002)
T-bond	1.47	0.37	5.29	3.10	−3.34	57.31	31.18
	(0.45)	(1.01)	(2.75)	(3.65)	(−1.07)	(0.000)	(0.000)
T-bill	−0.05	0.05	0.58	0.39	−0.02	87.92	7.11
	(−0.15)	(1.21)	(2.05)	(3.53)	(−0.06)	(0.000)	(0.525)
Eurodollar	0.05	0.06	0.76	0.50	−0.00	103.53	91.65
	(0.18)	(1.49)	(3.00)	(5.43)	(−0.01)	(0.000)	(0.000)
All						(0.000)	(0.000)

Panel B: Agricultural

	$\hat{\theta}_{wheat}$	$\hat{\theta}_{corn}$	$\hat{\theta}_{soyb.}$	$\hat{\theta}_{l.cttle}$	$\hat{\theta}_{sugar}$	W_{all}	W_{other}
Wheat	4.76	2.13	−0.02	0.32	2.54	43.54	9.46
	(4.61)	(1.01)	(−0.02)	(0.17)	(1.47)	(0.000)	(0.305)
Corn	2.35	10.89	−1.13	−0.59	3.22	39.71	8.34
	(1.83)	(5.39)	(−0.59)	(−0.28)	(1.56)	(0.000)	(0.401)
Soybeans	0.81	3.11	5.38	3.00	0.85	35.10	19.74
	(0.84)	(5.39)	(3.12)	(1.37)	(0.54)	(0.000)	(0.011)
Live cattle	1.19	−0.07	−1.35	1.40	−1.02	6.00	4.40
	(1.37)	(−0.06)	(−1.20)	(1.26)	(−1.13)	(0.815)	(0.820)
World sugar	−0.04	−10.27	5.71	−9.35	17.07	41.46	15.56
	(−0.01)	(−2.36)	(1.68)	(−2.26)	(5.11)	(0.000)	(0.049)
All						(0.000)	(0.000)

Table III—*Continued*

Panel C: Mineral							
	$\hat{\theta}_{gold}$	$\hat{\theta}_{silver}$	$\hat{\theta}_{plat.}$	$\hat{\theta}_{crude}$	$\hat{\theta}_{heating}$	W_{all}	W_{other}
Gold	2.88	3.03	2.03	2.74	2.56	58.05	19.36
	(2.81)	(1.92)	(2.16)	(0.87)	(1.28)	(0.000)	(0.013)
Silver	2.10	8.07	5.22	−2.91	1.22	29.95	15.99
	(0.99)	(2.75)	(3.15)	(−0.51)	(0.35)	(0.001)	(0.043)
Platinum	−1.63	6.20	6.51	−0.70	1.99	38.74	16.38
	(−1.09)	(2.44)	(4.37)	(−0.11)	(0.52)	(0.000)	(0.037)
Crude oil	2.95	−0.07	−4.94	15.56	24.41	34.77	28.15
	(0.97)	(−0.02)	(−1.52)	(1.59)	(4.03)	(0.000)	(0.000)
Heating oil	1.46	3.05	−4.29	12.99	19.93	35.51	6.98
	(0.42)	(0.74)	(−1.20)	(1.46)	(3.92)	(0.000)	(0.539)
All						(0.000)	(0.000)

Panel D: Currency							
	$\hat{\theta}_{Dmark}$	$\hat{\theta}_{Br\pounds}$	$\hat{\theta}_{Jyen}$	$\hat{\theta}_{Can\$}$	$\hat{\theta}_{Sw.fr}$	W_{all}	W_{other}
Deutsche mark	4.44	0.61	0.60	−0.66	−0.15	125.34	19.47
	(5.09)	(1.50)	(1.18)	(−1.83)	(−0.23)	(0.000)	(0.013)
British pound	2.29	2.90	0.01	−0.06	−0.95	100.70	18.73
	(2.49)	(6.76)	(0.02)	(−0.17)	(−1.25)	(0.000)	(0.016)
Japanese yen	1.99	0.07	3.13	−0.13	−0.33	90.53	11.26
	(1.89)	(0.16)	(6.31)	(−0.36)	(−0.48)	(0.000)	(0.187)
Canadian dollar	−0.01	0.05	−0.21	0.91	0.14	62.03	10.05
	(−0.03)	(0.31)	(−1.19)	(6.63)	(0.63)	(0.000)	(0.261)
Swiss franc	2.82	0.54	0.90	−0.65	1.17	130.58	25.41
	(2.91)	(1.21)	(1.71)	(−1.67)	(1.74)	(0.000)	(0.001)
All						(0.000)	(0.000)

Note that the empirical tests of the pricing model are based on both the first and the second nearest-to-maturity futures contracts, which gives the tests more power than using only the nearest-to-maturity contracts.

Estimates of $\theta_{i,s}^{(j)}$ for the nearest-to-maturity contracts in each of the four groups of futures contracts are presented in Table III. The regression results for the second nearest-to-maturity contracts are very similar and are therefore not reported separately. From this table it can be concluded that, after accounting for market risk, the observed hedging pressure variables indeed have explanatory power for futures returns. Except for the S&P 500 Index futures and live cattle futures, for each contract at least one of the hedging pressures within the own group results in an estimated coefficient $\hat{\theta}_{i,s}^{(j)}$ that is significantly different from zero. Also, many contracts have significant coefficients for hedging pressures other than their own. For instance, in Panel C of Table III all three metal futures show coefficients that are significantly different from zero for the silver and platinum hedging pressure variables. Similarly, in Panel D except for Canadian dollar futures, the hedging pressure for Deutsche mark futures has a significant effect on all currency futures returns, consistent with cross-hedging pressure effects.

The last two columns of Table III show Wald test statistics for the hypotheses that (a subset of) the coefficients $\theta_{i,s}^{(j)}$ are equal to zero, using both the first and the second nearest-to-maturity futures contracts. These tests are based on a multivariate version of the regression in equation (7), where the first and second nearest-to-maturity futures returns are regressed on the market return and the hedging pressure variables. Therefore, the correlations between the two futures returns are taken into account in constructing the test statistics.[8] If hedging pressure effects on futures risk premia are absent, all coefficients $\theta_{i,s}^{(j)}$ in equation (7) are equal to zero. The next-to-last column in Panel A shows Wald test-statistics for this hypothesis (W_{all}) together with the associated p-values. The reported test statistics leave little doubt about the relevance of hedging pressure variables in explaining futures returns. Except for live cattle futures, the hypothesis that all coefficients $\theta_{i,s}^{(j)}$ are equal to zero can always be rejected. The last column shows Wald test statistics for the hypothesis that only the futures own hedging pressure variable is relevant—in other words, that $\theta_{i,s}^{(j)} = 0$, for $i \neq s$ (W_{other}). This hypothesis can be rejected 13 out of 20 times at the 5 percent significance level, which also shows that substantial evidence exists for the presence of cross-hedging pressure effects. Also, the joint tests for each group of futures contracts always reject the null hypotheses at any conventional significance level, indicating that each futures own hedging pressure variable, as well as cross hedging pressure variables within each group, have significant effects on futures returns.

It can be concluded that the evidence in Table III gives clear support to the pricing model in Section I. The fact that both the futures own hedging pressure, as well as cross-hedging pressures are important for many futures contracts, indeed suggests that agents use futures markets not only to hedge risk that arises from the assets underlying the futures contracts, but also

[8] To be precise, let $\mathbf{x}_{t+1} = (1\, r_{t+1}^{S\&P500}\, q_{1,t} \ldots q_{5,t})'$, a seven-dimensional vector. Then the multivariate regression system can be written as

$$\begin{pmatrix} r_{1,t+1} \\ r_{2,t+1} \end{pmatrix} = \begin{pmatrix} \mathbf{x}'_{t+1} & 0 \\ 0 & \mathbf{x}'_{t+1} \end{pmatrix} \boldsymbol{\beta} + \begin{pmatrix} \varepsilon_{1,t+1} \\ \varepsilon_{2,t+1} \end{pmatrix}.$$

The 14×14 matrix $\hat{V}$, consisting of four 7×7 blocks, where the i,j-block is given by $\left(\sum_{t=1}^{T} \mathbf{x}_t \mathbf{x}'_t\right)^{-1} \left(\sum_{t=1}^{T} \varepsilon_{i,t}\, \varepsilon_{j,t}\, \mathbf{x}_t \mathbf{x}'_t\right) \left(\sum_{t=1}^{T} \mathbf{x}_t \mathbf{x}'_t\right)^{-1}$, with $i = 1,2$ and $j = 1,2$, is therefore a heteroskedasticity consistent estimate of the covariance matrix of the 14-dimensional vector $\hat{\beta}$. The hypotheses under consideration impose linear restrictions on $\boldsymbol{\beta}$ that yield standard χ^2-distributions for the Wald test-statistic.

from other (related) assets, thereby creating cross hedges. The resulting cross-hedging pressure effects are not restricted to commodity futures markets. They also occur in currency and financial futures markets.

IV. Robustness of the Results

The empirical evidence presented so far suggests that hedging pressure variables are indeed important in explaining futures returns. However, an alternative explanation of the results presented in the previous section might be given by the traditional *price pressure* hypothesis. According to this hypothesis, an increase in demand (supply) for futures contracts causes an upward (downward) bias in the futures price, which is temporary in nature, and will therefore subsequently be reversed. Therefore, because of the reversal of the futures price change, a sudden demand (supply) of futures contracts will be associated with negative (positive) futures returns.

Notice that price pressure may result from any change in demand or supply of futures contracts, and not merely from a change in hedge demand or supply. If hedging demand induces price pressure, it is important to note that the change in hedging pressure generates price pressure. Whereas the model in equation (3b) implies that expected futures returns will be high whenever the level of hedging pressure is high, the price pressure hypothesis implies that expected futures returns will be high when there is a sizable increase in hedging pressure. In order to see whether futures returns are determined by price pressure or by hedging pressure, Table IV provides estimates of the regression

$$r_{i,t+1} = \alpha_i + \theta_i \frac{\hat{q}_{i,t}}{\sigma(\hat{q}_{i,t})} + \varphi_i \frac{\Delta\hat{q}_{i,t}}{\sigma(\Delta\hat{q}_{i,t})} + \varepsilon_{i,t+1}. \tag{8}$$

The variables $\hat{q}_{i,t}$ are the futures own hedging pressure, and $\Delta\hat{q}_{i,t} = \hat{q}_{i,t} - \hat{q}_{i,t-1}$ measures the futures own price pressure. In order to make the coefficients comparable, the hedging pressure and price pressure variables are scaled by their own standard deviation, $\sigma(\cdot)$.

The results in Table IV show that for all four categories of futures contracts significant hedging pressure effects exist, even after controlling for price pressure. Although the relations between futures returns and the futures own hedging pressure variables are somewhat weaker than in Table II and the coefficients for price pressure show relatively large t-statistics, the first four columns of Table IV still provide convincing evidence for the role of hedging pressure in determining futures returns. This result is confirmed by the Wald tests, for which the p-values are reported in the last two columns of Table IV. Here we report tests based on the regression

$$r_{i,t+1}^{(j)} = \alpha_i^{(j)} + \beta_i^{(j)} r_{t+1}^{S\&P500} + \sum_{s=1}^{5} \theta_{s,i}^{(j)} \hat{q}_{s,t}^{(j)} + \varphi_i \Delta\hat{q}_{i,t}^{(j)} + \varepsilon_{i,t+1}^{(j)}, \tag{9}$$

Table IV

Hedging Pressure and Price Pressure

The table presents estimates of the coefficients $\theta_{s,i}^{(j)}$ in the regression

$$r_{i,t+1} = \alpha_i + \theta_i \frac{\hat{q}_{i,t}}{\sigma(\hat{q}_{i,t})} + \varphi_i \frac{\Delta\hat{q}_{i,t}}{\sigma(\Delta\hat{q}_{i,t})} + \varepsilon_{i,t+1},$$

where i refers to futures contract i. The variables $\hat{q}_{i,t}$ are the futures own hedging pressure, and $\Delta\hat{q}_{i,t} = \hat{q}_{i,t} - \hat{q}_{i,t-1}$ measures the futures own price pressure. In order to make the coefficients comparable, the independent variables are scaled by their standard deviation. All reported coefficients are ×100. Values in parentheses are t-values based on heteroskedasticity consistent standard errors. The parameter estimates are reported for the nearest-to-maturity contracts. The last two columns present p-values associated with Wald tests based on the regression

$$r_{i,t+1}^{(j)} = \alpha_i^{(j)} + \beta_i^{(j)} r_{t+1}^{S\&P500} + \sum_{s=1}^{5} \theta_{s,i}^{(j)} \hat{q}_{s,t}^{(j)} + \varphi_i \Delta\hat{q}_{i,t}^{(j)} + \varepsilon_{i,t+1}^{(j)},$$

where i refers to futures contract i in market j (financial, agricultural, mineral, currency). The variables $\hat{q}_{s,t}^{(j)}$ are the five hedging pressure variables within the own group; $\theta_{s,i}^{(j)}$ therefore measures the sensitivity of the futures return to the hedging pressure variables in its own group. The variable $\Delta\hat{q}_{i,t}^{(j)}$ is the change in the futures own hedging pressure and therefore controls for price pressure effects. The Wald tests are for the hypothesis that all reported coefficients are zero, $\theta_{s,i}^{(j)} = 0, \forall s$, ($W_{all}$), and for the hypothesis that all reported coefficients except for the own hedging pressure variable are zero, $\theta_{s,i}^{(j)} = 0, s \neq i$ (W_{other}). The Wald tests are based on regressions for both the nearest-to-maturity and second-nearest-to-maturity contracts and use heteroskedasticity consistent estimates of the covariance matrices. All results are based on semimonthly observations over the period January 1986 to December 1994, excluding observations for October 1987.

	$\hat{\theta}$	$t(\hat{\theta})$	$\hat{\varphi}$	$t(\hat{\varphi})$	W_{all}	W_{other}
Panel A: Financial						
S&P 500	−0.26	(−1.14)	0.70	(2.39)	(0.000)	(0.000)
Value Line	0.11	(0.47)	0.31	(1.37)	(0.000)	(0.002)
T-bond	0.32	(2.41)	0.78	(5.28)	(0.000)	(0.000)
T-bill	0.05	(2.57)	0.11	(4.99)	(0.000)	(0.111)
Eurodollar	0.03	(2.08)	0.09	(5.04)	(0.000)	(0.000)
Panel B: Agricultural						
Wheat	0.37	(1.59)	2.52	(9.51)	(0.025)	(0.295)
Corn	0.99	(3.39)	2.94	(12.22)	(0.063)	(0.327)
Soybeans	0.69	(2.32)	1.56	(2.18)	(0.009)	(0.017)
Live cattle	0.12	(0.76)	0.27	(1.19)	(0.764)	(0.851)
World sugar	1.30	(2.32)	4.16	(7.70)	(0.065)	(0.205)
Panel C: Mineral						
Gold	0.47	(2.89)	1.72	(7.80)	(0.000)	(0.150)
Silver	0.26	(0.80)	2.50	(8.08)	(0.039)	(0.042)
Platinum	0.62	(1.81)	2.30	(8.64)	(0.063)	(0.143)
Crude oil	0.85	(1.48)	0.64	(1.55)	(0.000)	(0.001)
Heating oil	1.40	(3.00)	2.20	(3.80)	(0.054)	(0.855)
Panel D: Currency						
Deutsche mark	0.91	(5.93)	1.00	(5.67)	(0.000)	(0.001)
British pound	0.92	(5.83)	1.06	(7.61)	(0.000)	(0.009)
Japanese yen	0.92	(5.41)	0.87	(5.02)	(0.000)	(0.161)
Canadian dollar	0.24	(4.16)	0.51	(9.27)	(0.001)	(0.285)
Swiss franc	0.99	(6.47)	0.99	(6.52)	(0.000)	(0.000)

where, as before, $r_{i,t+1}^{(j)}$ refers to futures contract i in group j. The variables $\hat{q}_{s,t}^{(j)}$ are the five hedging pressure variables within the own market, and the variable $\Delta\hat{q}_{i,t}^{(j)}$ is again the futures own price pressure. Columns five and six of Table IV show p-values associated with the Wald tests for the hypothesis that there is no hedging pressure, $\theta_{s,i}^{(j)} = 0$, $\forall s$, (W_{all}) and for the hypothesis that there is no cross hedging pressure, $\theta_{s,i}^{(j)} = 0$, $s \neq i$ (W_{other}). As before, the Wald tests are based on regressions for both the nearest-to-maturity and second nearest-to-maturity contracts.

Except for live cattle futures, the results for W_{all} show that there are strong hedging pressure effects for almost all futures contracts after controlling for price pressure and market risk. Similarly, the results for W_{other} in Table IV still show significant cross-hedging pressure effects for 10 out of 20 futures markets, supporting the conclusion that both the futures own hedging pressure and cross-hedging pressures from related markets are important determinants of futures risk premia.

An alternative way to differentiate between price pressure and hedging pressure effects is to look at the returns in asset and commodity markets rather than futures markets. Notice that our hedging pressure variables are constructed from the aggregate positions that agents take in futures markets rather than the spot markets underlying the futures contracts. Therefore, if the results in the previous section are driven by price pressure instead of hedging pressure, the observed relation between returns and our hedging pressure variables should be limited to futures markets and should not be present in the spot markets. Even though futures prices and the underlying values are related through the cost-of-carry relation, especially in the case of commodities it is unlikely that we would also observe this effect in the spot markets because price pressure is a temporary effect caused by demand or supply shocks in the futures markets. Notice that the pricing model in Section I implies that hedging pressure effects should be present in both futures markets and asset markets, as can be seen from equation (3a). A finding of hedging pressure in spot markets, and in particular in commodity markets, would therefore lend further support to the pricing model in Section I.

To address this issue, Table V presents p-values for Wald tests that are based on the regression

$$r_{Ai,t+1}^{(j)} = \alpha_i^{(j)} + \sum_{s=1}^{5} \theta_{s,i}^{(j)} \hat{q}_{s,t}^{(j)} + \varepsilon_{i,t+1}^{(j)}, \tag{10}$$

where $r_{Ai,t+1}^{(j)}$ is the return on the underlying value of futures contract i in group j and $\hat{q}_{s,t}^{(j)}$ is hedging pressure s ($s = 1,2,\ldots,5$) from group j.[9] If hedging pressure variables are irrelevant for explaining asset returns, then all

[9] We have also run regressions in which the return on the S&P 500 was included as an additional variable in the regression in order to account for market risk. These results are almost identical to the results reported in Table V. The exception is the Value Line futures, where inclusion of the S&P 500 returns yields stronger hedging pressure effects.

Table V

Hedging Pressure in Asset Returns

This table presents p-values associated with Wald tests that are based on the regression

$$r_{Ai,t+1}^{(j)} = \alpha_i^{(j)} + \sum_{s=1}^{5} \theta_{s,i}^{(j)} \hat{q}_{s,t}^{(j)} + \varepsilon_{i,t+1}^{(j)},$$

where i refers to the return on the asset underlying futures contract i in market j (financial, agricultural, mineral, currency). The variables $\hat{q}_{s,t}^{(j)}$ are the five hedging pressure variables within the own market. The Wald tests are for the hypothesis that all reported coefficients are zero, $\theta_{s,i}^{(j)} = 0$, $\forall s$, (W_{all}), and for the hypothesis that all coefficients except for the own hedging pressure variable are zero, $\theta_{s,i}^{(j)} = 0$, $s \neq i$ (W_{other}). The test statistics are based on heteroskedasticity consistent estimates of the covariance matrices. All results are based on semimonthly observations over the period January 1986 to December 1994, excluding observations for October 1987.

Panel A: Financial			Panel B: Agricultural		
	W_{all}	W_{other}		W_{all}	W_{other}
S&P 500	(0.709)	(0.581)	Wheat	(0.003)	(0.362)
Value Line	(0.698)	(0.825)	Corn	(0.000)	(0.582)
T-bond	(0.004)	(0.153)	Soybeans	(0.001)	(0.089)
T-bill	(0.000)	(0.000)	Live cattle	(0.363)	(0.490)
Eurodollar	(0.000)	(0.000)	World sugar	(0.000)	(0.027)
Panel C: Mineral			**Panel D: Currency**		
	W_{all}	W_{other}		W_{all}	W_{other}
Gold	(0.000)	(0.018)	Deutsche mark	(0.000)	(0.096)
Silver	(0.000)	(0.019)	British pound	(0.000)	(0.051)
Platinum	(0.001)	(0.309)	Japanese yen	(0.000)	(0.114)
Crude oil	(0.000)	(0.002)	Canadian dollar	(0.000)	(0.882)
Heating oil	(0.001)	(0.287)	Swiss franc	(0.882)	(0.008)

coefficients $\theta_{s,i}^{(j)}$ should be equal to zero. The (W_{all}) column in Panel A shows p-values associated with Wald tests for this hypothesis. These values show that there are strong hedging pressure effects in spot markets as well. Except for the two indices and live cattle, the hypothesis that there are no hedging pressure effects is strongly rejected for all markets. Recall from Table III that for live cattle we did not find evidence of hedging pressure in the futures markets.

Finally, the last columns of the Table V panels show Wald test statistics for the hypothesis that there are no cross-hedging pressure effects—that is, that $\theta_{s,i}^{(j)} = 0$ for $i \neq s$. Although in general the evidence of cross-hedging pressure effects is somewhat weaker for the spot markets than for the futures markets, we do find evidence of cross-hedging pressure effects for half of the spot markets, at least at the 10 percent significance level. Also, the results for the spot markets are comparable to those for the futures markets. The main differences occur for the financial markets, where we find strong evidence of cross-hedging pressure in the index and T-bond futures markets but not for the indices and bonds themselves. On the other hand, cross-hedging pressure effects in the T-bill futures markets appear to be absent, though we do find those effects for the T-bills themselves. As for the other markets, the main difference between assets and futures is found for platinum, where cross-hedging pressure effects are found for the futures but not for the spot market.

To summarize, this section shows that, although somewhat weaker, hedging pressure effects in futures markets are also present after controlling for price pressure. Moreover, hedging pressure effects are also found to be important in explaining returns in spot markets.[10] Our results show a significant relation between hedging pressure variables and spot returns that is similar to the relation between hedging pressure variables and futures returns, although the cross-hedging pressure effects appear to be somewhat weaker for spot markets relative to futures markets. The finding of hedging pressure effects in spot markets is consistent with the pricing model in Section I, but not with the price pressure hypothesis.

V. Summary and Conclusions

In this paper we model futures risk premia in terms of the covariance of futures returns with the market return and hedging pressure variables. The model identifies hedging pressure variables from the own futures market as well as from other related futures markets as relevant variables in explaining futures returns. Hedging pressures from other markets are referred to as cross-hedging pressures. We analyze the relevance of hedging pressure variables for a set of 20 futures contracts that can be grouped into four categories: financial, agricultural, mineral, and currency futures. Our specification of the pricing model uses hedging pressure variables from within each futures own group as the relevant variables.

We show that hedging pressure variables have a significant effect on futures returns, after controlling for market risk. These results are also obtained when controlling for price pressure effects. Also, hedging pressure effects are not only relevant for futures returns, but also for the returns on the assets underlying the futures contracts.

[10] We also tested for the presence of hedging pressure effects in asset markets after controlling for price pressure. Employing the same regressions and Wald tests that we used for the futures markets in Table IV, we also find significant (cross-) hedging pressure effects in most asset markets after controlling for price pressure. These results can be obtained from the authors upon request.

Appendix A. Derivation of the Equilibrium Model

We give a derivation of the model outlined in Section I. Using the notation in Section I, define the $(K + L)$-dimensional vectors $\mathbf{w}^j \equiv (\mathbf{w}_A^{j\prime}\mathbf{w}_F^{j\prime})'$ and $\mathbf{r}_{t+1} \equiv (\mathbf{r}'_{A,t+1}\mathbf{r}'_{F,t+1})'$. Given the assumption made earlier that the portfolio problem of the agent depends on the mean and variance of portfolio return only, the problem that agent j has to solve is, using obvious notation,

$$\max_{\{w\}} f^j(E_t[\mathbf{r}_{t+1}^j], Var[\mathbf{r}_{t+1}^j]), \tag{A1}$$

$$\text{s.t. } E_t[r_{t+1}^j] = \mathbf{w}^{j\prime}E_t[\mathbf{r}_{t+1}] + \mathbf{q}^{j\prime}E_t[\mathbf{r}_{S,t+1}], \tag{A2}$$

$$\begin{aligned} Var[r_{t+1}^j] = {} & \mathbf{w}^{j\prime}Var[\mathbf{r}_{t+1}]\mathbf{w}^j + 2\mathbf{w}^{j\prime}Cov[\mathbf{r}_{t+1},\mathbf{r}_{S,t+1}]\mathbf{q}^j \\ & + \mathbf{q}^{j\prime}Var[\mathbf{r}_{S,t+1}]\mathbf{q}^j, \end{aligned} \tag{A3}$$

$$\mathbf{w}_A^{j\prime}\boldsymbol{\iota} = 1, \tag{A4}$$

where f^j is increasing in its first argument and decreasing in its second argument, and where $\boldsymbol{\iota}$ is a K-dimensional vector of ones. Differentiating with respect to $\mathbf{w}^j$, the first-order conditions imply for the expected asset and futures returns respectively:

$$E_t[\mathbf{r}_{A,t+1}] - \eta\boldsymbol{\iota} = \gamma^j\{Cov[\mathbf{r}_{A,t+1},\mathbf{r}_{t+1}]\mathbf{w}^{j*} + Cov[\mathbf{r}_{A,t+1},\mathbf{r}_{S,t+1}]\mathbf{q}_t^j\}, \tag{A5}$$

$$E_t[\mathbf{r}_{F,t+1}] = \gamma^j\{Cov[\mathbf{r}_{F,t+1},\mathbf{r}_{t+1}]\mathbf{w}^{j*} + Cov[\mathbf{r}_{F,t+1},\mathbf{r}_{S,t+1}]\mathbf{q}_t^j\}, \tag{A6}$$

where $\gamma^j = -\frac{1}{2}f_2^j(.)/f_1^j(.)$, and η is the Lagrange multiplier for the restriction that $\mathbf{w}_A'\boldsymbol{\iota} = 1$, which equals the zero-beta return that corresponds to the optimal portfolio $\mathbf{w}^*$.

Notice that the market portfolio is of the form $\mathbf{w}^m = (\mathbf{w}_A'\mathbf{0}')'$; in other words, futures contracts do not enter the market portfolio since they are in zero net supply. If the market portfolio $\mathbf{w}^m$ is efficient in the sense that it satisfies equation (A5) for γ^m, the market risk aversion coefficient, and $q_{s,t}^m$, then it is straightforward to show that equations (3a) and (3b) hold.

Appendix B. Futures Data

We provide some additional details about the futures contracts used in this paper. For all futures contracts the exchange at which they are traded is given, as well as a list of the delivery months.

Table BI

Details of Futures Contracts

Contract	Exchange	Delivery Months
Financial		
S&P 500	Chicago Mercantile Exchange	3,6,9,12
Value Line	Kansas City Board of Trade	3,6,9,12
T-bond	Chicago Board of Trade	3,6,9,12
T-bill	Chicago Mercantile Exchange	3,6,9,12
Eurodollar	Chicago Mercantile Exchange	3,6,9,12
Agricultural		
Wheat	Chicago Board of Trade	3,5,7,9,12
Corn	Chicago Board of Trade	3,5,7,9,12
Soybeans	Chicago Board of Trade	1,3,5,7,8,9,11
Live cattle	Chicago Mercantile Exchange	2,4,6,8,10,12
World sugar	Coffee, Sugar and Cocoa Exchange	3,5,7,10
Mineral		
Gold	Commodity Exchange, Inc.	2,4,6,8,10,12
Silver	Commodity Exchange, Inc.	1,3,5,7,9,12
Platinum	New York Mercantile Exchange	1,4,7,10
Crude oil	New York Mercantile Exchange	All
Heating oil	New York Mercantile Exchange	All
Currency		
Deutsche mark	Chicago Mercantile Exchange	3,6,9,12
British pound	Chicago Mercantile Exchange	3,6,9,12
Japanese yen	Chicago Mercantile Exchange	3,6,9,12
Canadian dollar	Chicago Mercantile Exchange	3,6,9,12
Swiss franc	Chicago Mercantile Exchange	3,6,9,12

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