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Macroeconomic Influences and the Variability of the Commodity Futures Basis

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ABSTRACT

We provide evidence that the spread between commodity spot and futures prices (the basis) reflects the macroeconomic risks common to all asset markets. The basis of many commodities is correlated with the stock index dividend yield and corporate bond quality spread. Explanatory power is related to exposure to macroeconomic fluctuations: about 40 percent of the variation in the basis of a portfolio of commodities with high business cycle sensitivity is explained by the stock and bond yields. Further diagnostics indicate that these associations are largely due to the presence of risk premiums, rather than spot price forecasts, in the basis.

THIS PAPER EMPLOYS SYSTEMATIC factors to explain variation in the spread between commodity spot and futures prices (the basis). Classic studies of the commodity basis have employed idiosyncratic factors to explain basis variability. In the context of a storage model, for example, the commodity futures basis is affected by expected changes in the spot price of the underlying commodity. Thus, idiosyncratic factors such as expected changes in demand and supply play a large role in explaining the basis. If the commodity is storable, changes in the spot price of the underlying commodity are somewhat smoothed by fluctuations in inventories. Thus, the level of inventories also affects the size and sign of the commodity futures basis. Brennan (1958), Telser (1958), Fama and French (1987), Brennan (1991), and others have used variations of storage cost, inventory level, and seasonal supply and demand variables to explain variation of the basis. On the other hand, the primary cost of storing some commodities like gold and silver is the time value of money lost in carrying an inventory. Therefore, the variation of the interest rate, which is a common factor, is expected to explain some of the basis variation for these commodities.[1]

While the literature has generally tried to explain basis variation at the individual commodity level, it is important to stress that there should exist

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[1] See Fama and French (1987).

common elements driving basis variations across different commodities. The futures price is not solely a function of the expected cash price, since it also contains a risk premium compensating investors for bearing the systematic risks associated with their futures positions. Fama and French (1987) provide evidence of risk premiums at the individual commodity level by showing that the basis can forecast the return on a long futures position. From the perspective of equilibrium asset-pricing theories, it is the systematic risk of commodity prices that should earn compensation. Thus, the risk premiums embedded in the basis in different commodity markets should reflect compensation for the systematic risks in the economy.[2] Variation in premiums for systematic risks can cause common basis variability across different commodity markets.

A cursory examination of commodity market data suggests the presence of a risk premium in the commodity basis. Figure 1 is a plot of the equally weighted average basis of twenty-one commodities computed with monthly observations of futures contracts with approximately six months to maturity. The portfolio aggregates such diverse commodities as wood products, metals, petroleum, grains, cash crops, and animal products. In general, we expect idiosyncratic factors to offset each other in this portfolio, though in some months only a small number of contracts are observed so some of the variation of this aggregate basis may still reflect idiosyncratic factors. The aggregate basis is usually positive, is strongly autocorrelated, and appears to be slowly mean reverting.[3] While expectations of spot price changes may explain some variation in the aggregate basis, the characteristics of the variation are comparable to those of the risk premiums typically found in stock and bond markets.

In this paper, we use observed proxies for risk premiums in stock and bond markets to pursue an explanation for the common basis variation in commodity futures markets. If commodity futures are priced to reflect the economy-wide risk factors which are common to stock, bond, commodity, and other asset markets, there should exist a strong correlation between the common basis variations across commodity markets and measures of stock and bond market risk premiums. Given our hypothesis about the determinants of the commodity futures basis, our empirical methods draw heavily from the mainstream asset-pricing literature. Keim and Stambaugh (1986), Fama and French (1989), and others document the ability of the ex ante default premium in the bond market and the dividend yield in the stock market to forecast realized asset returns due to risk premiums that vary with the

[2] See, for example, Richard and Sundaresan (1981) and Cox, Ingersoll, and Ross (1985). See Hirshleifer (1988) for a model in which the level of transactions costs determines the degree of participation by ordinary economic agents in a particular futures markets and, thus, the relative importance of idiosyncratic versus systematic risks. See Bailey and Ng (1991) for a model and evidence on idiosyncratic default risk and futures pricing.

[3] The autocorrelations of the series for the first twelve lags are 0.59, 0.64, 0.50, 0.47, 0.50, 0.43, 0.47, 0.43, 0.42, 0.34, and 0.45. The autocorrelations are estimated from May 1974 to December 1987, dropping the initial period in which many months have missing data.

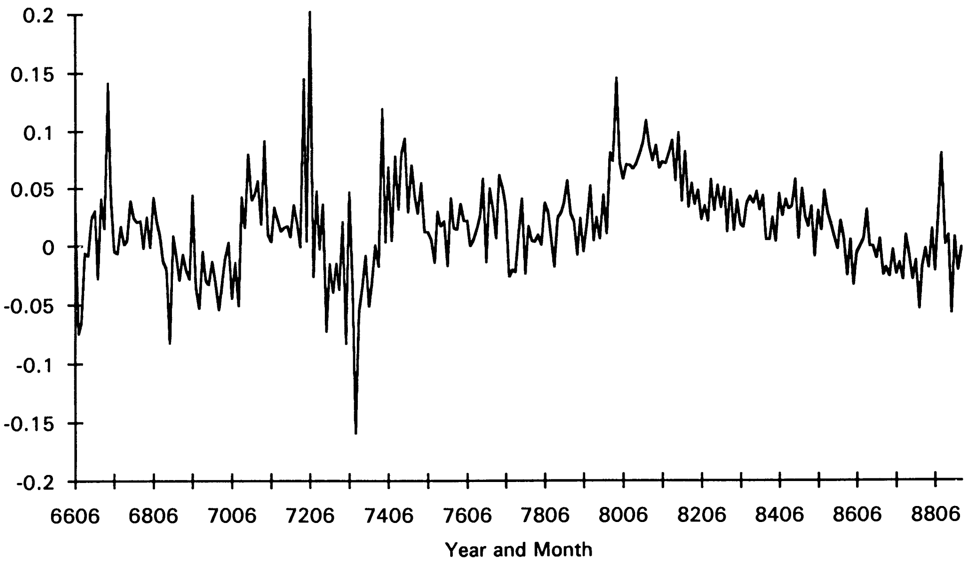

Figure 1. Plot of the average relative basis (difference of futures price over cash price divided by the cash price) of 21 commodity futures contracts.

business cycle. Ferson and Harvey (1991) and Ferson and Korajczyk (1992) show that such forecast power relates to the measured sensitivity of asset prices to the macroeconomic risks specified by Chen, Roll, and Ross (1986) and Chan, Chen, and Hsieh (1985), suggesting the presence of ex ante premiums for exposure to those risks.

Our exploration of the commodity basis proceeds as follows. First, we relate individual commodity bases to the ex ante stock and bond market risk premiums previous authors have applied to stock and bond returns. We find that the basis for many commodities is correlated with the ex ante stock and bond market variables, indicating the presence of common influences across stock, bond, and commodity markets. Next, we show that the strength of this correlation is directly related to the exposure of spot commodity prices to macroeconomic shocks. For example, the correlation of the copper futures basis with ex ante stock and bond market indicators coincides with the significant sensitivity of copper prices to changes in industrial production, the price level, and corporate default risk.[4] Next, we highlight the associations between the basis, the measured sensitivity of spot prices to macroeconomic

[4] Using variables inspired by the CAPM, consumption CAPM, or APT, Dusak (1973), Bodie and Rosansky (1980), Breeden (1980), Hazuka (1984), Bessembinder (1992), and Chen, Millon-Cornet, and Nabar (1990) attempt to explain the average risk premium in realized commodity price changes while Bessembinder and Chan (1992) and Cumby (1988) seek to document the time-varying risk premium by forecasting returns on futures or forward positions. However, these papers do not look at the ex ante basis, or relate the behavior of the basis to the systematic risk exposures of ex post spot price changes.

risks, and the ex ante stock and bond market indicators by looking at portfolios of commodities constructed to have differential macroeconomic risk exposures. Finally, we try to pinpoint the source of correlation between the basis and the stock and bond market indicators. We conclude that correlation is due primarily to commodity futures risk premiums (rather than cash price forecasts) which covary with their stock and bond market counterparts.

In addition to increasing understanding of commodity futures pricing, the results complement existing asset-pricing research based on stock and bond market data and also have practical implications for contingent claims pricing and for the use of commodity futures contracts in stock portfolio management. The paper is organized as follows. Section I details our methodology and data set of monthly observations from a cross-section of over twenty commodity markets. Section II presents results on the associations between stock and bond market risk premiums and the bases of individual commodities. Section III relates these associations to the macroeconomic risks that affect spot commodity prices. Section IV is a summary and conclusion.

I. Methodology

A. The Forecast Model of the Basis

We can think of the commodity futures basis as consisting of the expected spot price change and a risk premium term (see Fama and French (1987)):

$$F(t,T) - S(t) = E_t\{S(T) - S(t)|\underline{Z}(t)\} + E_t\{\pi(t,T)|\underline{Z}(t)\} \tag{1}$$

where $F(t,T)$ is the price at time t for a futures contract which matures at time $T > t$, $S(t)$ is the contemporaneous spot price of the commodity, $S(T)$ is the realization of the spot price at maturity, $E_t\{\cdot\}$ is the expectations operator and $\pi(t,T)$ is the realized risk premium, $F(t,T) - S(T)$. The ex ante risk premium, $E_t\{\pi(t,T)|\underline{Z}(t)\}$, can be positive or negative depending on the preferences, beliefs, and endowments of participants in the futures market, and the covariance of spot price changes with relevant variables. Both the expected spot price change and the ex ante risk premium are conditioned on current values of relevant information variables, $\underline{Z}(t)$, observed by economic agents. From the viewpoint of a simple storage model where a risk premium is not present, the $E_t\{S(T) - S(t)|\underline{Z}(t)\}$ term reflects the time value of money, warehousing cost, and expected convenience yield associated with storing the commodity.

To identify commonalities in bases across commodities, we begin by regressing the basis on a subset of information variables including the ex ante stock and bond market indicators employed in earlier studies of stock and bond markets:

$$\frac{F(t,T) - S(t)}{S(t)} = \alpha_0 + \sum\nolimits_{i=1}^{m} \alpha_i Z_i(t) + \epsilon(t) \tag{2}$$

where $Z_i(t)$ is the current level of the ith ex ante stock or bond market indicator and the α_i terms are coefficients. The regression is estimated for each commodity in our sample. The selection of information variables we will employ can be thought of as measures of ex ante risk premiums in the stock and bond markets. Therefore, a significant regression estimate indicates that the basis of the particular commodity covaries with the time-varying risk premiums present in equity and debt markets.

B. Data

B.1. Futures Prices

We attempt to duplicate the database of Fama and French (1987) by collecting information from back issues of *The Wall Street Journal*. We collect beginning-of-month data for various futures maturities for twenty-one different commodities. Matching spot prices are proxied by the price of the currently maturing futures contract. The Fama and French data extend from early 1966 to the middle of 1984. There are many missing observations due to lack of trading, or because not all combinations of commodity and maturity trade each month.

In addition to duplicating the Fama and French data, we make several improvements. First, we extend the data through 1987. Second, we add data on the heavily traded (and economically significant) heating oil contract of the New York Mercantile Exchange.[5] Finally, we address the problem of missing observations by analyzing maturity *ranges* rather than specific maturities. For example, we do not attempt to study gold futures contracts with a maturity of exactly six months, because there will be missing observations for all those months when a gold contract with precisely six months to mature is not traded. Rather, we look at a range of five to seven months: we use six-month contracts when available and a five- or seven-month contract otherwise.

B.2. Ex Ante Stock and Bond Market Risk Premiums

The ex ante variables, $Z_i(t)$, are measured with observed yields from the stock and bond markets. These include CORP SPREAD, the difference between the annualized yield of a low-grade corporate bond portfolio (with a Moody Rating of BAA) and the annualized yield of a high-grade corporate bond portfolio (with a Moody Rating of AAA) observed at the beginning of the month, and DIV YIELD, the dividend yield of the value-weighted market portfolio constructed by the University of Chicago's Center for Research in Security Prices (CRSP). The dividend yield is constructed as the ratio of the total dividends paid in the last twelve months divided by the portfolio value at the beginning of the month. Previous research by Keim and Stambaugh (1986), Fama and French (1989), and others shows that CORP SPREAD and

[5] Trade in heating oil futures on the NYMEX commenced in 1982.

DIV YIELD have predictive power for the returns of stocks and bonds. As such, they can be thought of as ex ante measures of the time-varying risk premia in the stock and bond markets. If, as we hypothesize, futures prices contain time-varying risk premiums that reflect the systematic risk of the underlying commodity, these yield measures should explain variation in futures bases.

We also collect yields on Treasury bills that match the futures contract maturities as closely as possible. From the perspective of the storage model of the basis, the interest rate is a component of the cost of storage. Thus, interest rate variation can affect the variation of the basis even if the basis does not include premiums for systematic risks. The T-bill yield series has a correlation of 0.345 with CORP SPREAD and 0.631 with DIV YIELD.[6] Since the T-bill yield and our stock and bond risk premium measures are significantly correlated, it is possible that estimates of equation (2) may pick up an interest rate effect due to the cost of storage, rather than risk premium effects, if we only use CORP SPREAD and DIV YIELD as explanatory variables. We separate the storage and risk premium effects of the interest rate as follows. First, we include the T-bill yield (roughly of six-month maturity) among the $Z_i(t)$ indicators employed as explanatory variables in equation (2). Second, we use the basis minus the T-bill yield (rather than the raw basis) as the dependent variable in these regressions. Thus, the slope coefficient on the T-bill yield picks up any association between the basis and the T-bill yield beyond a simple storage effect.

II. Evidence of the Common Risk Premium in the Basis

Regression results for equation (2) are reported in Table I. The commodities in the sample are sorted into five groups of commodities: wood products, minerals, grains, cash crops, and animal products groups. One regression is run for each commodity in the sample. The basis is measured using prices on futures contracts with approximately six months to maturity.[7] Standard errors have been adjusted for residual serial correlation using the method of Newey and West (1987). In estimating the equations, residuals can be serially correlated due to overlapping observations or missing variables that are serially correlated.[8]

In interpreting the results in Table I, note that the two ex ante stock and bond variables, CORP SPREAD and DIV YIELD, are countercyclical: when real activity is expected to be high, these variables take on low values. We can also make some predictions about the significance of results across the five groups of commodities. We anticipate strong effects for wood products

[6] CORP SPREAD and DIV YIELD have a correlation of 0.427.

[7] This horizon offers a reasonable tradeoff between the high volume (and accurate prices) of short maturity contracts and the stronger effect of risk factors on longer horizons.

[8] Fama and French (1987), for example, include seasonal dummy variables in regressions with the basis as dependent variable and find they are significant for some commodities.

because they are exposed to systematic risks through the procyclical demand for building materials and due to variables underlying the demand for wood such as mortgage interest rates, housing starts, and the Canada-U.S. exchange rate which determines the competitiveness of imported wood products. Though gold is primarily used for nonindustrial purposes, other metals have many industrial and commercial uses, as does heating oil.[9] Thus, we expect significant results for the minerals group similar to those anticipated for wood products. Results for gold, silver, and heating oil may also be affected by the association between prices for these commodities and inflation. Grains are expected to be less significantly related to stock and bond risk premiums, though internationally traded products like soybeans may be sensitive to exchange rates and interest rates and, therefore, show some correlation. The industrial uses of soymeal and soyoil in the petrochemical and plastics industries, in addition to their well-known uses as foodstuffs, also may cause some correlation. We anticipate few significant statistical associations for the cash crop group given that cocoa, coffee, and orange juice are consumer nondurables. Finally, animal products may be affected by changes in economic conditions that alter relative demand and hence prices. Furthermore, eggs and broilers can serve as substitutes for more expensive foods and thus may exhibit countercyclical effects. At the same time, low price and income elasticity of demand along with the influence of climatic and biological factors on supply are important influences on these commodities. On balance, we expect this group to display little association with the stock and bond risk premiums.

The results in Table I generally confirm the usefulness of the stock and bond risk premiums in explaining commodity futures bases. The regressions indicate significant associations between the stock and bond risk premiums and bases of such business cycle sensitive commodities as lumber, copper, and heating oil. Surprisingly strong results are also found for such food products as soybeans, soyoil, soymeal, coffee, and broilers. Marginally supportive results are identified for plywood, oats, cotton, and cattle. Collectively, the results suggest that stock and bond market risk premiums are correlated with similar forces in commodity markets. Easily stored commodities (gold, platinum, and silver) exhibit insignificant results suggesting little risk premium in common with the stock and bond markets, and no association with the T-bill yield beyond a storage effect.

III. Are Risk Premiums Earned for Macroeconomic Risks?

A. Measures of Macroeconomic Risk

The results in Table I are consistent with the presence of a significant ex ante risk premium in the bases of many commodities. Given the association

[9] Copper has many commercial and industrial uses, particularly in housing and autos. In excess of 50 percent of platinum production is used in the auto and petrochemical industries while about 90 percent of silver production is consumed industrially.

Table I

Regressions of Individual Commodity Basis on Ex Ante Information Variables

Data are sampled monthly from 1966 to 1987. The basis equals $(F(t,T) - S(t))/S(t) - r(t,T)$ where $S(t)$ is the spot price at the beginning of the month and $F(t,T)$ is the contemporaneous price for the futures contract with maturity of approximately six months, and $r(t,T)$ is the yield at time t on a Treasury bill which matures in approprimately six months. Explanatory variables are CORP SPREAD, the corporate default risk premium as measured by the yield differential on BAA versus AAA U.S. corporate bond portfolios, DIV YIELD, the equity risk premium as measured by the annual dividend yield on the value-weighted CRSP stock index, and $r(t,T)$, all observed at the beginning of the month. t-Statistics corrected for residual serial correlation and heteroskedasticity are reported in parentheses.

Market	No. of Observations	Constant	TBILL YIELD	CORP SPREAD	DIV YIELD	$\bar{R}^2$
Lumber	101	−0.350	−0.858	12.779	5.452	0.326
		(−4.65)	(−0.63)	(3.57)	(1.89)	
Plywood	81	−0.158	−1.457	1.504	4.804	0.054
		(−1.65)	(−1.54)	(0.67)	(1.94)	
Copper	213	−0.156	−1.054	3.692	3.257	0.302
		(−3.57)	(−2.17)	(2.77)	(2.97)	
Gold	148	−0.052	0.053	−0.146	0.057	−0.007
		(−0.66)	(0.46)	(−0.68)	(0.23)	
Platinum	143	−0.042	−0.170	1.635	0.389	0.060
		(−1.40)	(−0.72)	(1.67)	(0.46)	
Silver	244	0.063	0.137	−0.419	0.078	−0.009
		(0.50)	(0.89)	(−0.57)	(0.19)	
Heating oil	81	0.035	1.853	3.449	−5.238	0.142
		(0.61)	(4.64)	(1.50)	(−2.93)	
Corn	109	−0.030	−1.329	0.832	1.355	0.026
		(−0.80)	(−2.25)	(0.45)	(1.40)	
Oats	107	−0.021	0.383	−4.995	1.474	0.047
		(−0.36)	(0.57)	(−1.37)	(0.92)	
Soybean	150	−0.137	−0.486	4.709	1.719	0.153
		(−2.31)	(−0.63)	(3.50)	(0.94)	
Soymeal	174	−0.199	−1.300	2.706	4.780	0.228
		(−3.86)	(−1.90)	(1.26)	(3.09)	
Soyoil	175	−0.098	−0.835	8.456	−0.771	0.179
		(−1.64)	(−0.67)	(3.64)	(−0.44)	
Wheat	110	−0.074	−0.764	2.431	1.657	0.049
		(−1.50)	(−1.46)	(1.53)	(1.20)	
Cocoa	106	0.021	0.554	3.375	−3.253	0.053
		(0.36)	(0.57)	(0.97)	(−1.63)	
Coffee	81	0.214	0.532	2.185	−7.760	0.283
		(3.52)	(0.55)	(0.93)	(−3.27)	
Cotton	108	−0.120	−1.511	1.445	2.978	0.051
		(−1.86)	(−3.10)	(0.75)	(1.98)	
Orange juice	126	−0.091	−0.528	3.772	0.784	0.027
		(−1.41)	(−0.56)	(1.31)	(0.35)	
Broilers	70	0.017	−2.173	−9.762	2.742	0.101
		(0.18)	(−1.16)	(−2.37)	(1.27)	
Cattle	135	−0.018	−0.164	−4.290	0.980	0.047
		(−0.41)	(−0.16)	(−1.94)	(0.69)	

Table I—*Continued*

Market	No. of Observations	Constant	TBILL YIELD	CORP SPREAD	DIV YIELD	$\bar{R}^2$
Eggs	93	0.272	−9.495	−2.887	3.814	0.076
		(1.20)	(−1.90)	(−0.37)	(1.13)	
Hogs	141	−0.054	2.921	−2.404	−2.351	0.069
		(−0.71)	(2.62)	(−0.80)	(−0.95)	
Pork bellies	86	−0.066	3.529	−1.613	−1.788	0.070
		(−0.64)	(3.29)	(−0.39)	(−0.66)	

between futures risk premiums and the stock and bond market risk premiums, we conjecture that futures risk premiums are earned for exposure to the same macroeconomic risks that affect stock and bond prices. Our next step is to test this conjecture.

Following Chen, Roll, and Ross (1986), and Chan, Chen, and Hsieh (1985), we measure the macroeconomic risk sensitivity of each commodity with a time-series regression of realized spot price changes on realized changes in macroeconomic indicators:

$$\frac{S(T) - S(t)}{S(t)} = \beta_0 + \textstyle\sum_{j=1}^{n} \beta_j X_j(t) + \xi(t,T) \tag{3}$$

where $X_j(t)$ is the ex post unexpected change in the jth macroeconomic factor and the β terms are coefficients which represent the systematic risk exposures of the commodity.

These estimated macroeconomic risk exposures serve two purposes in our procedure. First, we can see if commodities with a strong correlation between the basis and the ex ante stock and bond market variables also show a correlation between cash price changes and macroeconomic fluctuations. Intuitively, we expect the basis of a commodity whose spot price is sensitive to macroeconomic risks to relate to measures of the ex ante premiums these risks earn in the stock and bond markets. Second, we use the estimated risk exposures to form portfolios of commodities ranked on the significance of ex post exposure. We then show that the basis of portfolios with high macroeconomic risk exposure are strongly correlated with our ex ante stock and bond measures, again suggesting that a commodity's exposure to macroeconomic risks yields associations between the commodity's basis and ex ante measures of systematic risk premiums in other asset markets.

B. Data on Ex Post Macroeconomic Factors

We use some of the economic factors that Chen, Roll, and Ross (1986) and Chan, Chen, and Hsieh (1985) employ in their APT-inspired asset-pricing studies. Let n equal the maturity of a futures contract. To explain spot commodity price variation from t to $t + n$ in equation (3), the set of macro-

Table II

Regressions of Individual Commodity Spot Price Change on Ex Post Macroeconomic Variables

Data are sampled monthly from 1966 to 1987. The spot price change equals $(S(T) - S(t))/S(t)$, where $S(t)$ is the spot price at time t and $S(T)$ the spot price six months hence. Explanatory variables are YIP, the unexpected change in industrial production from $t + 1$ to $t + 13$, UI, cumulative unexpected inflation from t to $t + 6$, and PREM, the unexpected change in the default premium as measured by the spread between low-grade corporate and Treasury bond returns from t to $t + 6$. t-Statistics corrected for residual serial correlation and heteroskedasticity are reported in parentheses.

Commodity	No. of Observations	Constant	YIP	UI	PREM	$\bar{R}^2$
Lumber	97	0.067	1.328	−0.996	−0.292	0.205
		(3.24)	(3.92)	(−0.50)	(−0.73)	
Plywood	76	0.100	1.237	−4.389	−0.744	0.098
		(2.20)	(2.13)	(−1.35)	(−1.27)	
Copper	184	0.039	0.499	0.983	0.840	0.108
		(1.35)	(1.25)	(0.44)	(2.27)	
Gold	138	0.116	−0.436	10.560	−0.135	0.155
		(3.11)	(−0.37)	(2.22)	(−0.21)	
Platinum	131	0.115	1.030	4.439	−0.301	0.045
		(2.77)	(1.29)	(0.91)	(−0.42)	
Silver	226	0.101	−0.491	10.749	1.407	0.079
		(2.28)	(−0.34)	(1.63)	(1.34)	
Heating oil	78	0.139	−0.567	14.404	0.655	0.329
		(5.06)	(−3.03)	(0.00)	(0.97)	
Corn	42	0.032	0.178	5.013	0.541	0.046
		(1.03)	(0.36)	(1.54)	(1.14)	
Oats	46	0.035	−0.638	4.055	1.025	0.095
		(1.29)	(−1.50)	(1.64)	(1.96)	
Soybeans	123	0.063	0.819	4.912	−0.010	0.053
		(1.53)	(2.11)	(1.53)	(−0.03)	
Soymeal	88	0.098	1.342	5.017	−0.175	0.065
		(1.67)	(2.34)	(1.25)	(−0.38)	
Soyoil	88	0.049	−0.296	8.331	1.107	0.129
		(1.18)	(−0.53)	(1.86)	(1.72)	
Wheat	44	0.050	0.373	6.172	0.599	0.062
		(1.26)	(0.85)	(1.25)	(1.14)	
Cocoa	40	0.108	0.890	7.253	−0.852	0.021
		(2.33)	(1.51)	(1.54)	(−1.54)	
Coffee	35	0.082	0.859	1.771	−0.656	−0.070
		(0.97)	(0.81)	(0.25)	(−0.80)	
Orange juice	119	0.070	0.334	2.998	0.869	0.049
		(1.41)	(0.64)	(0.71)	(1.64)	
Broilers	73	0.001	0.371	15.828	0.819	0.302
		(0.06)	(1.06)	(9.19)	(1.95)	
Cattle	123	0.036	0.206	1.738	0.458	0.071
		(2.05)	(1.16)	(1.21)	(2.34)	
Eggs	124	0.070	0.865	−0.958	−1.302	0.032
		(1.39)	(1.23)	(−0.12)	(−3.84)	
Hogs	123	0.035	−0.052	1.073	0.111	−0.022
		(1.12)	(−0.13)	(0.37)	(0.32)	
Pork bellies	40	0.014	−0.694	−8.311	0.548	0.010
		(0.28)	(−0.82)	(−2.05)	(0.72)	

economic factors includes YIP, the yearly innovation in industrial production growth from $t + 1$ to $t + 13$,[10] UI, the sum of monthly unexpected inflation from t to $t + n$,[11] and PREM, the unexpected change in the default premium as measured by the returns of low-grade corporate bonds minus the returns of government bonds over the period from t to $t + n$[12] Correlation between the three series are quite low: −0.067 for YIP and UI, 0.113 for YIP and PREM, and 0.130 for UI and PREM. As in previous studies, we interpret these macroeconomic variables as reflecting the innovations in realized or anticipated macroeconomic conditions that should drive unexpected changes in commodity prices.

The industrial production and inflation variables are used to capture the effects of changes in real activity and purchasing power on commodity prices. The forward change in industrial production is intended to pick up changes in commodity prices due to changes in expected future real activity. Returns on low-grade bonds in excess of returns on high-grade bonds are a function of changes in the default premium. The default premium is affected by the quantity of risk faced by risky firms as well as the price of risk demanded by investors for holding risky assets. For this reason, this variable is sensitive to changes in economic conditions that mark different stages of the business cycle.

Strictly speaking, there is no precise relation between our ex post changes in macroeconomic indicators and the ex ante stock and bond risk premiums. In the APT framework, asset price sensitivities to the ex post factors determine the ex ante premium. However, we cannot observe the ex ante risk premiums that correspond exactly to each of the three macroeconomic factors. Therefore, we employ two widely used risk premium measures, CORP SPREAD and DIV YIELD, to track the ex ante risk premium in the basis.[13] The ex ante premium required to compensate for these risks should be correlated with the dividend yield and the corporate risk premium. Thus, if a commodity's basis is related to our ex ante stock and bond risk premiums, we expect its spot price changes to be correlated with changes in our macroeconomic factors.

C. Results on Individual Commodities

Estimates of equation (3), where spot commodity price changes are regressed on macroeconomic innovations to estimate the ex post risk exposures,

[10] The variable used in the forecasting equation is annual industrial production growth from $t - 12$ to t.

[11] We use the model of Fama and Gibbons (1984) to estimate expected inflation.

[12] Some preliminary tests also included three additional ex post variables but they were found to have no explanatory power. They are the return on the S & P 500 index as a proxy for changes in aggregate wealth, the change in expected monthly inflation from t to $t + n$, and the unanticipated change in the slope of the term structure, measured by the long-term government bond returns less the short-term interest rate over the period from t to $t + n$.

[13] There is, of course, a close relation between one of the ex ante variables, CORP SPREAD, and at least one of the ex post factors, PREM.

are reported in Table II.[14] Before discussing the results, it is possible to make some predictions about the signs of the estimated exposures. An increase in real activity increases the demand for, and price of, procyclical commodities. Therefore, we expect a positive β coefficient on the procyclical variables, YIP and PREM, for procyclical commodities. A positive shock to inflation is associated with an increase in prices of commodities that hedge inflation, so we expect a positive β coefficient on UI for these commodities.

The results in Table II indicate many significant associations between spot price changes for individual commodities and changes in our macroeconomic variables YIP, UI, and PREM. Also, as expected, commodities such as wood products, copper, and soy products that demonstrated strong associations between the basis and the ex ante stock and bond risk premiums (Table I) often show a significant positive association between spot price change and either one of the business cycle indicators YIP and PREM. Several commodity price change series relate significantly to inflation shocks as measured by UI. The negative slope coefficients reported in Table I for heating oil and cocoa may be partially explained by their negative sensitivities to business cycle indicators YIP or PREM.

On balance, the individual commodity results in Tables I and II are supportive of our conjecture but often have low R^2 indicating that idiosyncratic factors predominate. To get a better picture of the common basis variability in commodity markets, we next turn to examining the behavior of portfolios of commodities.

D. Portfolio Results

Previous sections suggest the presence of significant ex ante risk premiums in the basis and document significant ex post exposures to macroeconomic factors in ex post spot price changes. The evidence is consistent with the presence of futures risk premiums that are earned for the sensitivity of spot commodity price changes to macroeconomic fluctuations. In this section, we provide a more direct demonstration of this association by examining portfolios of commodities.

We begin by constructing "high business cycle exposure" and "low business cycle exposure" commodity portfolios informally based on the commodity exposures to YIP and PREM reported in Table II. We use the following criteria in forming these two portfolios. A commodity enters the "high-exposure" portfolio if, in Table II, it has an exposure to YIP or PREM that is significantly positive at the 10 percent level. Other commodities enter the "low-exposure" portfolio, unless the exposures in Table II suggest a countercyclical commodity (heating oil, eggs) or there are contradictory signs on YIP and PREM (oats, cocoa). Each portfolio is formed as an equally weighted average of the basis observed every month in the sample period, with the

[14] Cotton is dropped because of the small number of observations of matched six-month price changes.

number of constituent contracts varying significantly from one month to the next due to missing observations for particular commodities.

The basis of each portfolio is then regressed on the two ex ante stock and bond risk premiums and the T-bill yield. Results are reported in Table III, along with the composition of each portfolio. Two regressions are reported for each portfolio. The first uses all available monthly observations, even if there are very few commodities in the portfolio in some months. The second uses only the months in which there are at least five commodities in the portfolio.

Table III

Regressions of Commodity Portfolio Basis on Ex Ante Information Variables

Data are sampled monthly from 1966 to 1987. The basis equals $(F(t,T) - S(t))/S(t) - r(t,T)$ where $S(t)$ is the spot price at time t and $F(t,T)$ is the contemporaneous price for the futures contract with maturity of approximately six months, and $r(t,T)$ is the yield at time t on a Treasury bill which matures in approximately six months. The explanatory variables TBILL YIELD, CORP SPREAD, and DIV YIELD are defined in Table I. t-Statistics corrected for residual serial correlation and heteroskedasticity are reported in parentheses.

Business cycle risk is determined by the exposures to the procyclical variables YIP and PREM reported in Table II. High business cycle risk portfolio is an equally weighted combination of the wood products, copper, platinum, the soy products, orange juice, broilers, and cattle. Low business cycle risk portfolio is an equally weighted combination of gold, silver, corn, wheat, coffee, hogs, and pork bellies. Cocoa, oats, heating oil, and eggs are excluded from these two portfolios due to countercyclical or contradictory exposure to YIP and PREM. Unit-risk and no-measured-risk portfolios are a combination of all commodities, with weights determined by monthly Fama-MacBeth cross-sectional regressions of basis on the exposures to YIP, UI, and PREM reported in Table II.

For the unit risk exposure portfolios, the data include any month in which the dependent variable is observable for at least eleven commodities. For the high and low business cycle exposure portfolios, two regressions are reported. The data in the first regression includes any month in which the basis is observable for at least one commodity. The second regression includes any month in which the basis is observable for at least five commodities.

Portfolio	No. of Observations	Constant	TBILL YIELD	CORP SPREAD	DIV YIELD	$\bar{R}^2$
High business cycle exposure	272	−0.136	−0.888	3.361	2.498	0.246
		(−5.51)	(−1.70)	(3.26)	(3.24)	
	154	−0.156	−0.768	4.256	2.614	0.380
		(−4.94)	(−1.52)	(3.73)	(3.06)	
Low business cycle exposure	268	−0.039	0.140	0.792	0.211	0.008
		(−1.68)	(0.56)	(1.02)	(0.34)	
	124	−0.057	0.262	0.688	0.433	0.041
		(−2.33)	(1.16)	(0.99)	(0.73)	
Unit industrial production exposure	148	−0.160	−0.897	4.247	2.803	0.191
		(−4.38)	(−1.77)	(2.65)	(2.66)	
Unit unexpected inflation exposure	148	0.012	−0.035	−0.015	−0.269	0.089
		(2.54)	−0.83	(−0.10)	(−2.49)	
Unit low-grade bond return exposure	148	−0.144	−0.756	2.653	3.023	0.189
		(−4.50)	(−1.84)	(2.07)	(3.42)	
No measured exposures	148	−0.023	0.344	−0.473	0.357	−0.014
		(−0.54)	(0.73)	(−0.36)	(0.35)	

This data requirement cuts down the number of time-series observations considerably, from about 270 to 150. Regardless of the number of observations, there is strong evidence that risk exposures common to all futures markets yield risk premiums that are significantly related to their stock and bond market counterparts. The regression for the "high business cycle exposure" portfolio yields strongly significant positive slope coefficients and an R^2 of 24 to 38 percent, depending on the treatment of missing variables. Explanatory power is due entirely to the CORP SPREAD and DIV YIELD variables, rather than the T-bill yield. This suggests that much of the explanatory power of the ex ante stock and bond yields over the bases of individual commodities is due to the sensitivity of the basis to production and corporate default risk. Comparable regressions for the "low business cycle exposure" portfolio yield insignificant slope coefficient estimates and an R^2 close to zero. In particular, the insignificant slope on the T-bill yield suggests an association with the interest rate that does not differ from a simple storage effect. Combined with the evidence on the "high business cycle exposure" portfolio, this suggests that a predominant storage effect in the basis occurs only for easily stored commodities not strongly exposed to macroeconomic fluctuations.

We offer further evidence by constructing an additional set of portfolios. For each of the macroeconomic factors YIP, UI, and PREM, we create a portfolio with unit risk exposure to that factor and zero risk exposure to the other two factors. We also create a portfolio with no exposure to any of the factors. The basis series for the unit risk exposure portfolios are the series of slope coefficients from monthly cross-sectional OLS regressions of individual commodity bases on measured exposures to YIP, UI, and PREM reported in Table II. The basis series for the no-exposure portfolio is the series of intercept coefficients from these regressions.[15] The basis of each portfolio is then regressed on the two ex ante stock and bond risk premiums and the T-bill yield.[16] Results are also reported in Table III. The portfolios with unit risk exposure to YIP or PREM exhibit significant correlation between their bases and the two ex ante stock and bond risk premiums, consistent with our earlier predictions about procyclical commodities. They also exhibit a marginally negative exposure to the T-bill yield, indicating that the explanatory power of the interest rate over the basis reflects a futures risk premium above the storage effect. The portfolio with unit risk exposure to UI exhibits negative correlation between its basis and the stock market risk premium, perhaps indicating an inflation risk premium that is negatively correlated with business cycle risk premiums. The insignificant association between the

[15] See Fama and MacBeth (1973), Chan, Hendershott, and Sanders (1990), Ferson and Harvey (1991), and Ferson and Korajczyk (1992) for computational details.

[16] The dependent variable in the regressions for the unit YIP, UI, and PREM portfolios is the raw basis, rather than the basis minus the T-bill yield, because the Fama-MacBeth procedure creates these portfolios with weights which sum to zero. Therefore, the bases of these portfolios represent differences in individual commodity bases and the storage effect of the T-bill yield nets out.

basis of the "no-exposure" portfolio and the stock and bond market indicators also supports our prediction. A commodity portfolio that has no exposure to systematic risk factors should not exhibit a risk premium in common with the stock and bond markets, and the behavior of the basis of the "no-exposure" portfolio bears this out. Again, this suggests that we have successfully identified the macroeconomic risk premium element in commodity markets. Furthermore, the basis of the "no-exposure" portfolio is not significantly correlated with the T-bill yield, suggesting no impact of the T-bill yield beyond a simple storage effect. This is consistent with the result found earlier for the "low business cycle exposure" portfolios constructed from cursory assignment of commodity contracts.

E. Additional Diagnostics

Having demonstrated the importance of systematic influences for the determination of the basis, we now address the concern that we may not be picking up the variation of the risk premium. The primary variables of interest, CORP SPREAD and DIV YIELD, used in equation (2) are typically thought of as measures of ex ante stock and bond market risk premiums. Thus, we interpret associations between commodity futures bases and these ex ante stock and bond variables as indicative of time-varying premiums for macroeconomic risks common to stock, bond, and commodity markets. However, it is possible that these two variables forecast the future course of the business cycle and, thus, pick up the expected future spot price component of the basis ($E_t\{S(T) - S(t)\}$) in equation (1) rather than the risk premium component.

We diagnose this potential interpretation problem with an additional time-series regression for each commodity in our sample. If our ex ante stock and bond risk premiums are picking up the expected future spot price component of the basis, they should be able to forecast spot price changes directly:

$$\frac{S(T) - S(t)}{S(t)} = \phi_0 + \phi_1 \text{ CORP SPREAD } (t) + \phi_2 \text{ DIV YIELD } (t) + \mu(t,T) \tag{4}$$

where the ϕ_i terms are coefficients. Regression (4) allows us to see whether the stock and bond variables can forecast spot price changes. If it can be shown that they have little forecasting power for the future spot price changes, their power to explain the basis is likely to be due to the correlation between commodity market risk premiums and their stock and bond market counterparts.

Table IV presents the regression results. We find very little correlation between spot price changes and the ex ante risk premium measures. This is true even for commodities where there is a strong correlation between the basis and the stock and bond risk premium measures. For example, Table I shows that the basis regression for copper has an R^2 of about 30 percent and significantly positive slope coefficients on CORP SPREAD and DIV YIELD. The corresponding spot price change regression reported in Table IV is

Table IV

Regressions of Commodity Spot Price Change on Ex Ante Stock and Bond Risk Premiums

Data are sampled monthly from 1966 to 1987. Spot price change equals $(S(T) - S(t)/S(t))$, where $S(t)$ is the spot price at time t and $S(T)$ the spot price six months hence. The explanatory variables CORP SPREAD and DIV YIELD are described in Table I. t-Statistics corrected for residual serial correlation and heteroskedasticity are reported in parentheses.

Commodity	No. of Observations	Constant	CORP SPREAD	DIV YIELD	$\bar{R}^2$
Lumber	97	0.056	2.062	−1.227	−0.015
		(0.34)	(0.35)	(−0.36)	
Plywood	76	0.149	0.300	−2.248	−0.019
		(0.57)	(0.06)	(−0.39)	
Copper	184	0.113	−2.037	−1.477	−0.003
		(0.75)	(−0.36)	(−0.40)	
Gold	138	−0.139	−21.553	11.465	0.228
		(−0.51)	(−2.65)	(1.65)	
Platinum	131	−0.018	−15.575	6.732	0.055
		(−0.08)	(−1.51)	(1.06)	
Silver	226	−0.202	−19.487	12.904	0.057
		(−0.78)	(−1.37)	(1.30)	
Heating oil	78	0.252	16.686	−12.019	0.134
		(1.13)	(1.69)	(−2.48)	
Corn	42	0.126	4.789	−4.243	−0.016
		(0.94)	(0.86)	(−1.15)	
Oats	46	0.201	1.949	−4.539	−0.006
		(1.82)	(0.43)	(−1.65)	
Soybean	123	0.208	11.910	−8.121	0.067
		(1.00)	(1.84)	(−1.43)	
Soymeal	88	0.339	11.979	−10.916	0.075
		(1.18)	(2.13)	(−1.51)	
Soyoil	88	0.286	11.939	−10.014	0.080
		(1.29)	(1.22)	(−1.79)	
Wheat	97	0.194	−0.835	−3.939	−0.020
		(1.04)	(−0.13)	(−0.83)	
Cocoa	40	0.516	15.648	−16.117	0.192
		(3.16)	(2.23)	(−3.65)	
Coffee	35	0.027	9.783	−2.461	−0.038
		(0.10)	(0.85)	(−0.29)	
Orange juice	119	0.101	6.383	−3.102	−0.002
		(0.67)	(1.11)	(−0.94)	
Broilers	73	0.132	−8.926	−0.218	0.002
		(0.57)	(−1.55)	(−0.05)	
Cattle	123	0.047	−4.332	0.840	0.007
		(0.63)	(−1.46)	(0.39)	
Eggs	124	0.208	8.192	−6.883	0.023
		(0.85)	(0.85)	(−1.13)	
Hogs	123	0.076	−4.346	0.246	−0.006
		(0.52)	(−0.81)	(0.06)	
Pork bellies	40	0.110	−3.965	−0.204	−0.048
		(0.51)	(−0.43)	(−0.03)	

Table IV—*Continued*

Commodity	No. of Observations	Constant	CORP SPREAD	DIV YIELD	$\bar{R}^2$
High business risk portfolio	235	0.111	0.459	−1.932	0.007
		(1.34)	(0.132)	(−0.95)	
Low business risk portfolio	206	−0.081	−13.51	7.519	0.070
		(−0.54)	(−1.79)	(1.38)	

insignificant. To summarize the information in Table IV, we run the regressions with the two portfolios constructed earlier to have different business cycle exposure. The dependent variable is the equally weighted percentage change in the six-month spot price for each portfolio. From the basis regression, the basis of the portfolio with high business cycle exposure is strongly correlated with the two risk premium measures. But when the dependent variable is the six-month spot price changes of this portfolio, the two risk premium measures have no explanatory power. This supports our interpretation of the basis regressions as picking up commodity risk premiums, rather than changes in expected spot commodity prices. For the portfolio with low business cycle exposure, the CORP SPREAD variable has marginal significance but the sign is opposite to the sign when the basis is the dependent variable. In sum, there appears to be no evidence that the explanatory power of CORP SPREAD and DIV YIELD in the basis regressions proxies for expected spot price changes.

IV. Summary and Conclusion

There are significant common elements to futures basis variability across a broad variety of commodity markets. To address the issue of whether these common elements represent ex ante risk premiums common to all financial markets, we have borrowed concepts and methodological tools from the growing body of research which examines the significance of time-varying risk premia and business cycle factors for stock and bond returns. We show that the default yield spread in the bond market and the dividend yield in the equity market can explain a large portion of the common variation in futures bases. We produce evidence that the macroeconomic risks that previous authors have shown to affect stock and bond markets also appear to be the contributing factors to these risk premiums embedded in the basis series. In particular, production and corporate default risk appear to earn significant time-varying risk premiums in commodity markets. A broader selection of ex ante risk premium measures and ex post risk variables and a more extensive time-series and cross-section of futures prices might yield evidence that exposure to other systematic and commodity-specific factors earns an ex ante risk premium in commodity futures markets.

Our results are significant. First, they are consistent with previous evidence on the presence of time-varying risk premiums due to macroeconomic influences in the stock and bond markets. Second, they suggest that studies of commodity futures markets may be improved by including risk premium and business cycle variables like those we have used. Third, the results imply that multifactor models may be needed to value commodity-contingent claims like futures and options contracts. Typical contingent claims models based only on the dynamics of the cash price cannot capture the variety of factors that our results indicate are significant determinants of the cash-futures basis. Fourth, the results have implications for portfolio management strategies based on multifactor models like the APT. The commodity contracts we have shown to be exposed to macroeconomic risks are traded in liquid markets. Therefore, they may represent an efficient medium with which to manage the risk exposure of a stock portfolio. They may also be useful in strategies that attempt to both mimic the risk and outperform the return of some benchmark portfolio. Finally, our results highlight the commonalities across markets that we expect to find in a rational economy in equilibrium.

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