Is Normal Backwardation Normal?

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INTRODUCTION

The theory of normal backwardation originated with John Maynard Keynes more than 60 years ago in his *Treatise on Money.* Reduced to its simplest terms, the theory holds that the futures price is less than the expected future spot price, and that the futures price should rise over time to equal the expected future spot price at expiration. As Keynes puts it: "In other words, the quoted forward price, though above the present spot price, must fall below the anticipated future spot price by at least the amount of the normal backwardation."[1] By calling attention to "normal" backwardation, Keynes signaled his firm belief that this price relationship prevailed for most commodities.

Keyne's reasoning for this belief was clear. To exclude obviously profitable trading opportunities in a risk-neutral economy, futures prices must equal the spot price that traders expect to prevail at maturity.[2] Accordingly, deviations of futures price from expected future spot prices stem from a risk-premium, which can arise if long or short traders are more risk-averse than their counterparts. For example, farmers might sell futures to establish the prices of their coming harvest. If farmers are highly risk-averse, they may willingly sell futures at a price below the expected future spot price of the commodity.[3] In this situation, futures prices persistently fall below the expected future spot price. Keynes also believed that hedgers are normally short, and that the accommodating speculators are normally long.

Since Keynes advanced his theory, researchers have elaborated and tested variants of normal backwardation. As explained in more detail later, most of these tests examine only a few commodities for a relatively short period. In many instances, different methodologies lead to different results for the same commodity. Some authors interpret the normal backwardation hypothesis in the conditional form: If

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[1]Keynes (1930, p. 144). In places, however, Keynes uses "backwardation" to refer to a situation in which the spot price exceeds the futures price [see Keynes (1930), p. 143]. The quoted passage is assumed to express his considered view. "Contango" is defined to be a price process in which the futures price falls over its life.

[2]Strictly speaking, this is true only if interest rates are not stochastic, as has been widely shown. See, for example, Morgan (1981); Jarrow and Oldfield (1981); and Cox, Ingersoll, and Ross (1981). The practical significance of this theoretical point seems to be small. Forward prices do tend to equal futures prices, as Cornell and Reinganum (1981); French (1983); and Park and Chen (1985) showed.

[3]This is the spot price of the commodity expected to prevail when the futures contract expires.

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speculators are net long, then the futures price should lie below the expected future spot price. In this formulation, the researcher undertakes the considerable burden of determining whether speculators are net long or short.[4] In sum, these tests generally focus on different theoretical specifications, consider different commodities, explore varying time periods, utilize diverse statistical methods, and reach conflicting conclusions. As a result, the question posed in the title remains open 60 years after Keynes advanced his theory.

In an effort to further the understanding of the normal backwardation issue, this article applies a standard methodology to an unprecedented number of commodities over the longest practicable period. The data set includes 980,800 daily futures prices for 29 commodities from 1957–1988. This study abstracts from the question of whether speculators are net long or net short, and it tests whether the rising price pattern associated with normal backwardation prevails in futures markets.

If Keynes was correct in his joint hypothesis that speculators are net long and that hedgers pay speculators for bearing risk, a pattern of rising prices should be found. If prices do not rise over the life of a futures contract, then one element of the Keynesian joint hypothesis must be rejected. Because this article examines price behavior without regard to the position of speculators, it provides a weak test of the normal backwardation hypothesis. Nonetheless, the present study provides a more complete description of actual price behavior through the inclusion of more observations, more commodities, and more years than used in previous studies. In general, the results of this study show that normal backwardation is not normal—only a few commodities show prices that rise over the life of the futures contract. However, some commodities exhibit normal backwardation very strongly.

PREVIOUS FINDINGS ON NORMAL BACKWARDATION

For Keynesian normal backwardation to prevail, short traders must be more highly risk-averse than long traders in the aggregate. In this framework, the highly risk-averse short traders use futures to hedge unwanted risk. To induce sufficient long traders to take complementary risk-bearing positions, the short traders pay the long traders a risk-premium. As a speculator, the long trader enters the market and provides risk-bearing services only if he expects a profit. The excess of the expected future spot price over the current futures price is the speculator's expected profit and his reward for bearing risk.[5]

In many markets, both producers and consumers of a good may hedge. In grains, for example, farmers sell futures to hedge, and millers may buy futures to hedge. If long and short hedgers were equally plentiful and equally risk-averse, they could hedge with each other and would not require the risk-bearing services of speculators.[6] In this case, futures prices might well equal expected future spot prices. In

[4]Generally, researchers must rely on the commitments of large traders as reported by governmental authorities. This report shows the aggregated positions of large traders, i.e., those with futures positions above a certain level. The general presumption of most studies is that large traders are commercial interest and, therefore, hedgers. The unreported positions are treated as belonging to speculators. Such a methodology may be the best available, but it is certainly weak because it assumes that large traders and commercial concerns do not speculate.

[5]Fort and Quirk (1988) show that backwardation can result from conditions other than hedgers paying speculators to assume risk. Extending an intuition of Houthakker's, Fort and Quirk develop a model in which futures prices will exceed expected future spot prices if inventories are large.

[6]Speculators might still be required to provide liquidity, so scalpers could still have a role in the markets as speculators. However, the function of scalpers is different from that of speculators who hold positions that involve risk.

another situation, long hedgers might be more plentiful and more risk-averse than short hedgers. Under these circumstances, futures prices should lie above expected future spot prices. In this case, futures prices would follow a contango, falling over the life of the contract. As these three examples show, futures prices could equally well lie above, at, or below expected future spot prices. Actual price relationships depend on the relative availability of long and short hedgers and speculators and their respective degrees of risk aversion.

Early tests considered whether hedgers were short or long in the aggregate. Under this interpretation, normal backwardation prevailed if speculators, whether long or short, earned profits. For example, Houthakker (1957) extended the theory of normal backwardation to focus on returns to both long and short speculators that hold positions complementary to large hedgers. Examining monthly data for cotton, wheat, and corn, Houthakker found support for normal backwardation. However, Rockwell (1967), using a methodology like Houthakker's, but a larger data set, argued that normal backwardation is neither a consistent nor an important general characteristic of futures markets.

Subsequent studies attempted to incorporate equilibrium financial models, notably the Capital Asset Pricing Model (CAPM). Dusak (1973), for example, found that futures contracts had zero systematic risk and commensurate zero returns. This zero return for futures positions ruled out a risk-premium in her study of wheat, corn, and soybeans. Bodie and Rosansky (1980) found positive returns to long futures positions. This conclusion, they argued, provides general support for Keynesian normal backwardation. Similarly, Fama and French (1987) found positive returns and believe that the data weakly support normal backwardation.

Carter, Rausser, and Schmitz (1983) explored the systematic risk of futures and found evidence supporting normal backwardation. They examined wheat, corn, and soybeans, as did Dusak. However, Marcus (1984) challenged the adequacy of the market index that Carter, Rausser, and Schmitz employed. Baxter, Conine, and Tamarkin (1985) adjusted the market index as Marcus suggested and found no risk-premium for wheat, corn, or soybeans. Ehrhardt, Jordan, and Walkling (1987) extended the equilibrium-based literature by using the Arbitrage Pricing Theory to test normal backwardation in wheat, corn, and soybeans. They concluded that there is no risk-premium.

Raynauld and Tessier (1984) found risk-premiums in corn, wheat, and oats, but concluded that these risk-premiums do not support normal backwardation, because risk-premiums do not tend to be earned by either speculators or hedgers. Chang (1985) employed nonparametric methods to test for the existence of a risk-premium. He used data on traders' position as a proxy for their price forecasts. He examined wheat, corn, and soybeans. Chang found that the representative speculator made profits in these commodities, although his nonparametric procedures did not allow him to measure the size of the risk-premium.[7] Hartzmark (1987) used actual trading data to examine the issue of normal backwardation. He found that trading by hedgers was profitable and that speculators had negative or zero profits. Thus, he concluded, the market did not reward the speculators for the risk they undertook, there is no risk-premium, and normal backwardation is false. Park (1985) analyzed

[7]Thus, Dusak (1973); Carter, Rausser, and Schmitz (1983); Chang (1985); Baxter, Conine, and Tamarkin (1985); and Ehrhardt, Jordan, and Walkling (1987) examine the same commodities (wheat, corn, and soybeans) and use data for much of the same time period. Yet they have diverse results on the backwardation issue. Two of the aforementioned studies support normal backwardation, and three do not.

metal, currency, and plywood futures by regressing the futures percentage price change on time to maturity. Metals exhibited a positive relationship consistent with normal backwardation, but currencies and plywood did not.

These reports tested different interpretations of the normal backwardation hypothesis and employed diverse statistical methodologies. In addition, they used data for different commodities and from time periods. Their conflicting results leave the issue of normal backwardation an open question.

TESTS OF KEYNES' NORMAL BACKWARDATION HYPOTHESIS

One of the strongest no-arbitrage principles in futures markets asserts that the futures price must converge to the cash price at expiration. Let $F_{i,t}$ represent the futures price for a particular contract maturity i with t days remaining until expiration. $P_{i,t}$ represents the cash price t days before contract i expires. Then, the no-arbitrage principle asserts:

$$P_{i,0} = F_{i,0} \qquad \text{for all } i \tag{1}$$

At expiration, the futures price must equal the cash price. This no-arbitrage principle allows the use of $F_{i,0}$ as a proxy for the cash price at expiration. This principle holds throughout this article.

The tests presented here rely on a second assumption. Because the expected future spot price at expiration is not observable, a proxy is required for that expectation. It is customary to use the actual spot price at expiration as a proxy for the previously expected future spot price. This practice essentially implies that market participants can form unbiased expectations of the future spot price, at least in large samples. Therefore, $F_{i,0}$ is used as the spot price expected to prevail when contract i expires.

The core testable principle of Keynesian normal backwardation is that futures prices should rise over time. This implies both:

$$E[\ln(F_{i,t}/F_{i,t+1})] > 0 \qquad \textit{and} \qquad E[F_{i,t}/F_{i,t+1} - 1] > 0 \tag{2}$$

This hypothesis is tested for each commodity by computing the one-day simple and logarithmic return across all contract maturities (I) and across all days of returns (T). For a particular commodity, eq. (3) gives the mean return.

$$\mu = \frac{\sum_{t=1}^{T} \sum_{i=1}^{I} \mathrm{RET}_{i,t}}{I \times T} \tag{3}$$

where $\mathrm{RET}_{i,t} = F_{i,t}/F_{i,t+1} - 1$. If returns are positive for a given commodity on average, the average futures price before expiration must be below the futures price at expiration, as normal backwardation implies. Each commodity is tested to determine whether the mean daily return is positive.

Keynesian normal backwardation theory implies that, i.e., if rising futures prices provide speculative profits in exchange for risk-bearing services, then the futures price before expiration should lie below the expected future spot price at expiration:

$$E[F_{i,t} - F_{i,0}] < 0 \tag{4}$$

This implication is tested by examining the relative difference between the futures price and the subsequently observed futures price at expiration. For a single price observation on a particular futures contract, the differential, D, is defined as follows:

$$D_{i,t} = (F_{i,t}/F_{i,0}) - 1 \tag{5}$$

$D_{i,t}$ is the percentage amount by which the futures price for a given contract, i, falls below the terminal futures price of that contract measured t days before the futures contract expires.

The percentage difference between $F_{i,t}$ and $F_{i,0}$ is tested instead of the arithmetic difference for two reasons. First, the price level of many commodities has changed over the 30-year period of this study. Using arithmetic differences would give extra weight to periods when the price level is high. Second, futures prices are denominated in a variety of units ranging from cents per bushel to dollars per hundredweight. By examining percentage differences between $F_{i,t}$ and $F_{i,0}$, the results of this study can be compared across contracts.

The equivalence in eq. (1) and the expectation in eq. (4) together imply that the expected value of the differential should be negative for any contract maturity on any day prior to expiration:

$$E(D_{i,t}) < 0 \qquad \text{for } t > 0 \tag{6}$$

Therefore, the normal backwardation hypothesis can be tested by testing the expectation in eq. (6). For a given commodity and a given day, t, the following measure is computed:

$$M_t = \frac{\sum_{i=1}^{I} D_{i,t}}{I} \tag{7}$$

For all I contracts of a given commodity, M_t is the average percentage amount by which the futures price, t days before expiration, falls below the terminal futures price. Under normal backwardation, M_t should be less than zero for any day $t > 0$.

Under normal backwardation, the measure in eq. (7) should be smaller the longer the time remaining until expiration. In other words, normal backwardation implies:

$$E(M_{t+k}) < \cdots < E(M_{t+1}) < E(M_t) < \cdots E\ (M_0) \tag{8}$$

The expectation in expression (8) is tested for each commodity by regressing:

$$D_{i,t} = \alpha_1 + \beta_i t + \varepsilon_t \tag{9}$$

For random contracts, i, and days to expiration, t, a sample of $D_{i,t}$ and t is constructed for each commodity and the regression indicated in eq. (9) is performed. Under normal backwardation, the differentials should be inversely related to the time remaining until expiration. That is, under normal backwardation, $\beta_i < 0$.

DATA AND TESTS OF HYPOTHESES

Data for this study are from Dunn and Hargitt. Contract expiration dates extend from 1959–1988, with daily observations beginning in 1957 for some commodities. Table I summarizes the data for the 29 commodities studied. Table I also shows the contract expiration months and the years of data in the study. In all, 3330 contracts and 980,800 daily settlement prices are examined.[8]

[8]The normal backwardation hypothesis may not reasonably apply to some commodities. For example, if a foreign currency futures exhibits normal backwardation with prices quoted in dollars, it would exhibit a contango (reverse normal backwardation) when the prices are measured in the foreign currency. Nonetheless, the tests are applied to all commodities for two reasons. First, this article seeks to provide an inclusive exploration of the available data to advance the discussion of normal backwardation. Second, as will be seen, the results for some commodities show that apparently related goods can exhibit quite different behavior with respect to normal backwardation.

Table I
DATA USED IN THE ANALYSIS

Commodity	Expiration Months	First Expiration Year of Data	Contracts Analyzed	Observations/ Commodity
British pound	3, 6, 9, 12	1977	48	11,988
Cocoa	3, 5, 7, 9, 12	1961	145	49,580
Corn	3, 5, 7, 9, 12	1959[a]	147	41,415
Coffee	3, 5, 7, 9, 12	1979	50	17,108
Crude oil	All months	1983[a]	67	14,468
Cotton	3, 5, 7, 9, 12	1960[a]	142	50,869
Copper	1, 3, 5, 7, 9, 10, 12	1959[a]	195	64,225
T-bond	3, 6, 9, 12	1977[a]	45	27,338
German mark	3, 6, 9, 12	1977	48	11,657
Feeder cattle	3, 4, 5, 8, 9, 10, 11	1974	105	22,639
Orange juice	1, 3, 5, 7, 9, 11	1967[a]	129	41,701
Frozen pork	2, 3, 5, 7, 8	1963[a]	123	33,872
Gold	2, 4, 6, 8, 10, 12	1975[a]	84	35,705
Heating oil	All months	1979[a]	110	23,233
Japanese yen	3, 6, 9, 12	1977	48	10,494
Live beef	2, 4, 6, 8, 10, 12	1966	143	38,845
Live hogs	2, 4, 6, 7, 8, 10, 12	1969[a]	135	38,651
Lumber	1, 3, 5, 7, 9, 11	1974	90	23,947
Oats	3, 5, 7, 9, 12	1959[a]	146	33,102
Palladium	3, 6, 9, 12	1977	48	14,098
Platinum	1, 4, 7, 10	1968[a]	82	27,724
Soybeans	1, 3, 5, 7, 8, 9, 11	1959[a]	203	54,399
Swiss franc	3, 6, 9, 12	1977[a]	48	12,755
Soy meal	1, 3, 5, 7, 8, 9, 10, 12	1959[a]	232	58,005
Sugar	3, 5, 7, 9, 10	1961[a]	137	45,039
Soy oil	1, 3, 5, 7, 8, 9, 10, 12	1959[a]	233	59,257
Silver	1, 3, 5, 7, 9, 12	1964[a]	149	56,787
T-bill	3, 6, 9, 12	1976	52	23,293
Wheat	3, 5, 7, 9, 12	1959[a]	146	38,606
All commodities			3330	980,800

[a]Part year.

The first test of normal backwardation considers the daily simple and logarithmic returns.[9] This simple test is quite critical for Keynesian normal backwardation. If prices do not rise, there are no profits for holders of long futures positions. Table II reports a test of these log returns. The mean log return differs significantly from zero for 13 of 29 commodities. Of these 13, nine are positive and four are negative. The soy complex (bean, meal, and oil) and live animals (beef, hogs, and feeder cattle) dominate the positive returns. Cotton, copper, and frozen orange juice also have significant positive returns. Sugar, lumber, crude oil, and heating oil have significantly negative returns. The mean returns for 16 commodities does not differ

[9]As is well known, positions in futures contracts do not have returns per se as do investments in securities. This difference stems from the fact that futures positions do not require investment. Throughout this study, the term *return* refers to logarithmic price differences or the percentage change in settlement prices from one day to the next.

Table II
TEST OF MEAN FUTURES RETURNS

Commodity	Mean Log Return[a]	*t*-Statistic	Mean Simple Return[a]	*t*-Statistic	No. of Obs.
British pound	0.005362	0.81	0.007977	1.20	11,940
Cocoa	0.011300	1.57	0.024842	3.35	49,433
Corn	−0.004246	−0.77	0.001988	0.36	41,268
Coffee	0.016424	1.33	0.029487	2.38	17,058
Crude oil	−0.048820	−3.23	−0.032338	−2.14	14,401
Cotton	0.019289	4.00	0.025203	5.21	50,727
Copper	0.017319	2.94	0.028408	4.83	64,030
T-bond	−0.002638	−0.49	0.001338	0.25	27,293
German mark	−0.000982	−0.14	0.001824	0.26	11,609
Feeder cattle	0.015064	2.04	0.021195	2.87	22,534
Orange juice	0.033915	4.53	0.045574	6.08	41,572
Frozen pork	0.013508	1.35	0.030446	3.04	33,749
Gold	−0.004265	−0.52	0.007575	0.93	35,621
Heating oil	−0.036018	−3.48	−0.023656	−2.29	23,123
Japanese yen	0.013351	1.92	0.015874	2.28	10,446
Live beef	0.020926	4.11	0.025937	5.10	38,702
Live hogs	0.040150	5.43	0.050693	6.85	38,516
Lumber	−0.033326	−3.61	−0.023152	−2.51	23,857
Oats	0.002944	0.38	0.013015	1.66	32,956
Palladium	0.024928	1.35	0.048695	2.65	14,049
Platinum	0.000278	0.02	0.018659	1.62	27,642
Soybeans	0.018384	3.24	0.027113	4.78	54,196
Swiss franc	−0.006779	−0.96	−0.003591	−0.51	12,707
Soy meal	0.027662	4.14	0.040598	6.06	57,773
Sugar	−0.033210	−2.75	−0.000536	−0.04	44,902
Soy oil	0.034619	5.07	0.048385	7.08	59,024
Silver	−0.005340	−0.68	0.012001	1.54	56,638
T-bill	0.002099	1.85	0.002249	1.98	23,240
Wheat	−0.001399	−0.21	0.006806	1.04	38,460

[a]The mean return as return × 100.

significantly from zero. These sixteen include all precious metals (gold, silver, platinum, and palladium) and all financials (Japanese yen, British pound, Swiss franc, German mark, Treasury bills, and Treasury bonds). Frozen pork, cocoa, and coffee mean returns also do not differ from zero. Perhaps most surprising, the mean returns of wheat, corn, and oats are all indistinguishable from zero.

The mean simple daily returns exhibit more significant positive returns. The logarithmic return of sugar is significantly negative, but sugar's simple return is indistinguishable from zero. In total, 15 commodities have significantly positive simple returns. The mean simple returns of cocoa, coffee, frozen power, Japanese yen, palladium, and Treasury bills are significant and positive while their logarithmic returns are not.

This wide discrepancy in results for simple and logarithmic returns challenges some previous results in the literature and sustains others. First, Bodie and Rosansky (1980) analyzed simple quarterly returns and found that 22 of 23 commodities had positive returns, although only three of these were significant. Because they used quarterly data, Bodie and Rosansky had a maximum of 27 observations for any commodity. The paucity of observations partially accounts for their lack of significant results. Nonetheless, all commodities, except for eggs, had positive computed returns. Fama and French (1987) used monthly data to examine 21 commodities. They computed both simple and logarithmic monthly returns. For the simple returns, they found positive returns for 18 of 21 commodities. However, only five of those 18 were significant. Again, this may have been due to a lack of observations. Fama and French included no more than 222 observations for any commodity. Like Bodie and Rosansky, Fama and French also found a negative return for eggs.

When using logarithmic monthly returns, Fama and French found significantly positive returns for cocoa and significantly negative returns for eggs. The other 19 did not differ significantly from zero. They found that some commodities have positive mean simple returns but negative logarithmic returns. Further, Fama and French explicitly noted the substantial differences between the average returns based on simple returns and logarithmic returns. For example, Fama and French found that five commodities showed significant, positive simple returns, but only one commodity showed a significant, positive logarithmic return. The findings of this article, as summarized in Table II, confirm the findings of Fama and French. These wide discrepancies between simple and logarithmic returns emphasize the need to consider both.

Even though the results for the returns test differ between measures of simple and logarithmic returns, some generalizations emerge. Significant, positive returns appear to be rather rare in currencies, precious metals, and financials. For these commodities, the mean logarithmic return does not differ from zero. Even for the simple return measure, only a few commodities have significant, positive returns.

Next, consideration is given to whether futures prices, prior to expiration, tend to be above or below the futures price at expiration. The Keynesian normal backwardation theory expects prices, before expiration, to be lower than prices at expiration. Table III shows the number of prices above and below the final settlement price for each commodity and for the entire sample. The third column shows the percent of the price observations above the terminal futures price. The final column presents a z-score for the test of equal sample proportions.[10]

Table III shows that about 51% of all observations prior to the expiration date are below the terminal futures price. Fifteen commodities have more prices below the terminal futures price and 14 have more prices above the terminal futures price. As in Table II, the commodities with positive mean returns have more prices below the terminal futures price. Likewise, commodities with negative mean returns tend to have prices above the terminal futures price. While the data of Table III are consistent with those of Table II, Table III also shows that the positive or negative returns are not due to just a small fraction of the sample period. For example, the strong negative returns for live hogs is not due to simply a few large price drops. Table III shows that live hogs futures prices are frequently below the terminal futures price; about 63% of the futures observations are below the terminal futures price for the contract.

Eq. (7) defines the average percentage difference between the futures price prior to expiration and the futures price at expiration. For a given commodity, the measure is computed for each of the first 250 trading days prior to expiration. This

[10]The test here is the standard z-test for the equality of the sample proportion to 0.5.

Table III
PRICE OBSERVATIONS ABOVE AND BELOW TERMINAL FUTURES PRICES

Commodity	Observations Relative to Terminal Futures Price Above	Below	% Above	Z-Score
British pound	5,080	6,843	42.61	−16.33
Cocoa	26,317	23,069	53.29	14.65
Corn	21,916	19,137	53.38	13.75
Coffee	6,561	10,480	38.50	−30.85
Crude oil	8,014	6,312	55.94	14.32
Cotton	23,949	26,615	47.36	−11.87
Copper	30,353	33,520	47.52	−12.55
T-bond	14,097	13,140	51.76	5.80
German mark	6,296	5,291	54.34	9.37
Feeder cattle	9,999	12,474	44.49	−16.61
Orange juice	18,350	23,133	44.23	−23.64
Frozen pork	16,142	17,560	47.90	−7.73
Gold	18,627	16,961	52.34	8.84
Heating oil	12,668	10,381	54.96	15.14
Japanese yen	4,649	5,781	44.57	−11.15
Live beef	14,860	23,733	38.50	−46.41
Live hogs	14,343	24,085	37.32	−51.37
Lumber	13,709	10,098	57.58	23.68
Oats	16,951	15,720	51.88	6.82
Palladium	6,270	7,729	44.79	−12.40
Platinum	14,800	12,789	53.64	12.14
Soybeans	24,823	29,205	45.94	−18.91
Swiss franc	7,635	5,057	60.16	23.37
Soy meal	24,350	33,210	42.30	−37.37
Sugar	27,145	17,650	60.60	45.91
Soy oil	27,800	31,052	47.24	−13.43
Silver	31,886	24,358	56.69	32.03
T-bill	10,574	12,578	45.67	−13.22
Wheat	19,433	18,883	50.72	2.81
Total sample	477,597	496,844	50.99	−38509.0

period corresponds almost exactly to a full year of trading before expiration. A test is conducted for each day to determine whether the differential equals zero. For a given day, t, if the measure $M_t = 0$, then one cannot reject the hypothesis that the futures price t days before expiration is an unbiased estimate of the futures price at expiration. If normal backwardation prevails, however, we expect $M_t < 0$. Similarly, $M_t > 0$ indicates a contango. Table IV summarizes these t-tests.

Table IV shows the significant, positive and negative t values for each block of 50 days. Throughout, a 5% level of significance with a two-tailed test is used. Thus, the columns record the number of t-values outside the range −1.96–1.96. The column headed "1–250" shows the total number of t-tests outside the range for a given commodity. The final three columns of the table, show the percentage of the 250 days in each category.

Table IV
FUTURES PRICE DEVIATIONS SIGNIFICANTLY DIFFERENT FROM ZERO, BY DAYS UNTIL EXPIRATION

Commodity	1–50		51–100		101–150		151–200		201–250		1–250		% With Significant t-Statistic		
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+ or −
British pound	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Cocoa	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Corn	1	0	0	0	0	0	0	0	0	0	1	0	0.40	0.00	0.40
Coffee	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Crude oil	0	0	0	0	27	0	50	0	50	0	127	0	50.80	0.00	50.80
Cotton	2	0	0	0	0	0	0	0	0	0	2	0	0.80	0.00	0.80
Copper	0	10	0	7	0	0	0	0	0	0	0	17	0.00	6.80	6.80
T-bond	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
German mark	4	0	0	0	0	0	0	0	0	0	4	0	1.60	0.00	1.60
Feeder cattle	0	7	0	0	0	0	0	19	0	48	0	74	0.00	29.60	29.60
Orange juice	1	0	0	0	0	0	0	8	0	15	1	23	0.40	9.20	9.60
Frozen pork	0	4	0	0	0	0	0	0	0	0	0	4	0.00	1.60	1.60

Gold	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Heating oil	0	0	17	0	50	0	50	0	22	0	139	0	55.60	0.00	55.60
Japanese yen	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Live beef	0	35	0	48	0	50	0	50	0	50	0	233	0.00	93.20	93.20
Live hogs	0	48	0	50	0	50	0	50	0	50	0	248	0.00	99.20	99.20
Lumber	15	0	50	0	50	0	50	0	50	0	215	0	86.00	0.00	86.00
Oats	0	2	0	0	0	0	0	0	0	0	0	2	0.00	0.80	0.80
Palladium	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Platinum	3	0	0	0	0	0	7	0	17	0	27	0	10.80	0.00	10.80
Soybeans	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Swiss franc	4	0	0	0	0	0	0	0	28	0	32	0	12.80	0.00	12.80
Soy meal	0	2	0	0	0	0	0	2	0	0	0	4	0.00	1.60	1.60
Sugar	50	0	50	0	50	0	50	0	50	0	250	0	100.00	0.00	100.00
Soy oil	0	2	0	0	0	1	0	21	0	26	0	50	0.00	20.00	20.00
Silver	0	0	0	0	0	0	4	0	50	0	54	0	21.60	0.00	21.60
T-bill	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Wheat	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00

Using a 5% level of significance, and making 250 t-tests for each commodity, one expects 12.5 spurious significant t-test results per commodity. However, there is less than a 5% chance of observing 18 spuriously significant t-statistics per commodity, whether positive or negative. Likewise, there is a less than 5% chance of observing 11 spuriously significant positive or negative t-statistics per commodity by chance.[11]

From Table IV, the results for six commodities show evidence of backwardation. These are feeder cattle, live beef, live hogs, orange juice, soy oil, and copper. Both live beef and live hogs have more than 230 days with average price differentials below zero. This corresponds with the strong positive returns for these commodities and with their tendency to have futures prices below the terminal futures price. Feeder cattle have 74 significantly negative days, which also strongly supports normal backwardation. With 50, 23, and 17 negative, significant t-statistics, soy oil, orange juice, and copper also tend to have futures prices below their terminal settlement prices.

Seven commodities show differentials that tend to be positive. Lumber and sugar both have more than 200 days with positive t-statistics. Heating oil and crude oil both have more than 100 such days. Platinum, the Swiss franc, and silver also have more significant positive t-statistics than one would expect by chance, although results for these three goods are not as striking.

The results of tests on 16 commodities (see Table IV) are consistent with the theory that futures price before expiration is an unbiased predictor of the terminal futures price. These commodities include all of the grains—wheat, corn, and oats. As with the near-zero grain returns, differentials close to zero are inconsistent with normal backwardation. Both debt futures, T-bonds and T-bills have differentials near zero. Most of the currencies, the pound, yen, and mark, and precious metals have differentials that do not differ from zero. Gold and palladium also have near-zero differentials. Cocoa, coffee, and frozen pork have zero mean logarithmic returns, and their differentials tend to be zero as well. As Table II shows, cotton, soybeans, and soy meal have positive mean returns. However, Table IV shows that futures prices for these goods before expiration do not differ significantly from futures prices at expiration.

If normal backwardation describes the behavior of futures prices, one expects futures prices to rise over their trading lives. Prior to expiration, one expects these prices to be below the futures price at expiration. In addition, one expects futures prices to be farther below the futures price at expiration the greater the amount of time remaining until expiration, as expression (8) shows. The relationship between (8) and the regression of eq. (9) is tested. For any given commodity, i, $D_{i,t}$ will be highly correlated with $D_{i,t-1}$. Therefore, one cannot simply examine each contract, or the residuals from eq. (9) will be highly autocorrelated. To create a data set for a given commodity, a contract, i, and a day, t, are selected for a given commodity. The selection is random, except that each contract is weighted by the number of prices available for the contract. This procedure ensures that each price for a given commodity has an equal chance of being selected. Following this procedure, 5000 observations for each commodity are selected and the $D_{i,t}$ and the t area

[11]These probabilities are computed using the binomial formula. For example, the probability of 18 or fewer successes in 250 trials with a 0.05 chance of success is 95.26%. In other words, there is less than a 5% probability that one would observe more than 18 significant t-statistics by chance.

recorded. Table V presents the results of these estimations for the 29 commodities. Twenty-five of the 29 betas are significant. The Durbin–Watson statistics are all close to 2.0. Table V also presents the mean $D_{i,t}$ and t for each sample.

Based on the above results, feeder cattle, live beef, live hogs, orange juice, copper, cotton, soybeans, soy meal, and soy oil seem to follow normal backwardation. Under normal backwardation, one expects the shortfall in the futures price to be larger the greater the time remaining until maturity. As Table V shows, feeder cattle, live beef, live hogs, orange juice, cotton, and soybeans all have negative and significant betas. These results accord exactly with the expectations of normal backwardation. However, the betas for soy meal and soy oil are positive, but not significant. Copper has a significant, but positive, beta. Together with the negative $D_{i,t}$ for copper, this positive beta implies that copper futures prices are lower than terminal futures prices and that they diverge farther from that terminal price. The relevant contango commodities are: crude oil, heating oil, lumber, and sugar. For the potential contango commodities, all betas are positive and significant. For them, this result implies that their prices tend to be higher, relative to the terminal futures price when expiration is distant. That is exactly what one expects for a commodity that follows a contango.

Thus, four commodities (feeder cattle, live beef, live hogs, and orange juice) follow normal backwardation. For each of these, mean simple and logarithmic returns are positive, futures prices before expiration are frequently and significantly below the futures price at expiration, and the longer the time remaining until expiration, the lower the futures price relative to the futures price at expiration. Somewhat weaker evidence suggests that copper, cotton, soybeans, soy meal and soy oil follow normal backwardation. These five commodities have positive returns and more price observations below the terminal futures price than above. However, cotton, soybeans and soy meal futures prices are not significantly below the futures price at expiration. For copper, soy meal, and soy oil, futures prices do not tend to be lower the farther the contract is from expiration. The evidence presented in this article strongly suggests that heating oil, crude oil, and lumber all follow a contango. These commodities have negative returns, their prices are frequently and significantly above the futures price at expiration, and their prices tend to be higher the longer the time remaining until expiration. The evidence supports a contango for sugar as well, except sugar's mean simple return does not differ significantly from zero.

Most commodities, however, tend to follow neither a contango nor normal backwardation. Of the 29 commodities, only seven have clear evidence of following normal backwardation or contango. Most of the other commodities appear to have futures prices that are relatively unbiased estimators of the futures price at expiration. These include all precious metals (gold, silver, palladium, and platinum), all currencies (yen, mark, pound, and franc), and all debt instruments (T-bonds and T-bills). The fungibility of the underlying goods and the ease with which traders can arbitrage these goods, may well prevent any persistent risk-premium. Keynes probably did not have such financially oriented assets in mind when he advanced his theory. However, this study finds that normal backwardation does not hold for some of the oldest commodities traded on futures markets. Wheat, corn, and oats all seem to be the kind of goods to which Keynes' theory most clearly applies; however, none show any evidence of following normal backwardation.

Table V
REGRESSION RESULTS

Commodity	α	t_α	β	t_β	$D_{i,t}$	R^2	D–W	t
	$D_{i,t} = \alpha_i + \beta_i t + \varepsilon_{i,t}$							
British pound	0.0104	3.5712	−0.0001	−5.4890	−0.0033	0.0058	1.98	127
Cocoa	0.0109	1.3429	0.0001	2.3777	0.0274	0.0009	2.04	171
Corn	−0.0085	−1.9783	0.0002	7.7173	0.0198	0.0116	1.98	142
Coffee	−0.0068	−0.7688	0.0002	4.2087	0.0251	0.0033	1.98	179
Crude oil	−0.0749	−9.7509	0.0015	27.9403	0.1057	0.1349	2.02	118
Cotton	0.0021	0.4187	−0.0001	−3.9713	−0.0153	0.0029	1.99	180
Copper	−0.0487	−8.2743	0.0002	6.8029	−0.0155	0.0090	1.97	176
T-bond	0.0040	0.8392	−0.0000	−2.2547	−0.0051	0.0008	2.00	329
German mark	0.0033	1.1331	0.0001	5.4746	0.0172	0.0058	1.99	125
Feeder cattle	0.0088	2.5817	−0.0002	−9.0041	−0.0175	0.0158	1.99	111
Orange juice	.0074	1.2467	−0.0002	−6.5455	−0.0262	0.0083	2.00	169
Frozen pork	0.0091	1.4163	0.0001	1.5196	0.0174	0.0003	1.99	143

Gold	−0.0186	−2.0794	0.0003	9.8604	0.0572	0.0189	2.01	227
Heating oil	0.0033	0.6637	0.0003	8.4990	0.0395	0.0140	2.01	109
Japanese yen	−0.0023	−0.8168	−0.0000	−2.0578	−0.0071	0.0006	1.99	115
Live beef	−0.0059	−1.9476	−0.0001	−7.8101	−0.0262	0.0119	2.00	140
Live hogs	−0.0176	−3.7242	−0.0002	−7.4629	−0.0481	0.0108	1.99	148
Lumber	−0.0135	−2.2437	0.0008	20.0928	0.0894	0.0746	2.02	136
Oats	−0.0068	−1.8181	0.0001	2.0684	−0.0001	0.0007	2.02	115
Palladium	0.0334	2.9575	0.0000	0.3848	0.0372	−0.0002	1.95	153
Platinum	0.0318	4.0336	0.0001	2.1498	0.0464	0.0007	1.97	175
Soybeans	−0.0008	−0.1644	−0.0001	−2.2700	−0.0097	0.0008	2.00	136
Swiss franc	−0.0039	−1.2148	0.0002	10.8161	0.0259	0.0227	1.97	137
Soy meal	−0.0134	−2.5162	0.0000	0.4770	−0.0112	−0.0002	1.97	128
Sugar	0.0570	3.5729	0.0010	12.1650	0.2236	0.0286	1.99	167
Soy oil	−0.0136	−2.2115	−0.0000	−1.1702	−0.0198	0.0001	2.00	130
Silver	−0.0758	−6.3572	0.0009	18.1747	0.1079	0.0618	1.98	199
T-bill	0.0006	0.7455	−0.0000	−5.7029	−0.0034	0.0063	1.95	234
Wheat	−0.0002	−0.0511	0.0002	6.2277	0.0248	0.0075	1.98	134

CONCLUSION

This study examines the most important implications of the theory of normal backwardation—the claim that futures prices normally are lower than expected future spot prices. Normal backwardation has three principle testable implications: (1) that futures returns should be positive; (2) that futures prices prior to expiration should be below the terminal futures price; and (3) that futures prices should be lower the longer the time remaining until expiration.

These hypotheses are tested for 29 commodities with 980,800 daily settlement price observations ranging from 1957–1988. Feeder cattle, live beef, live hogs, and orange juice conform well to the normal backwardation hypothesis. They have positive returns, their prices tend to be below the terminal futures price, and their prices tend to be lower the longer the time remaining until expiration. Copper, cotton, soybeans, soy meal, and soy oil partially conform to normal backwardation, but each of these five commodities fails at least one of the three tests just outlined. None of the other 29 commodities are good candidates for normal backwardation. Three commodities, crude oil, heating oil, and lumber, appear to follow the reverse of normal backwardation, (a contango). For these commodities, returns are negative, their futures prices are above the terminal futures price, and the futures price tends to be higher the longer the time remaining until expiration. Sugar also seems to follow a contango, except that one return measure is positive.

Most commodities exhibit no risk-premium. Their returns are near zero, prices before expiration approximate the price that will prevail at expiration, and their prices do not tend to be lower or higher the longer the time until expiration. Commodities generally without a risk-premium include precious metals, currencies, and financials. More surprisingly, the grains also appear to have no risk-premium. While some commodities do follow normal backwardation, about as many follow a contango. Most commodities follow neither special process and appear to have no risk-premium. Thus, it is concluded that normal backwardation is not a general feature of futures markets—normal backwardation is not normal.

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