NCCC-134
APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

A Framework for Analyzing Prices of Related Temporal Commodity Investment Strategies

by

Bruce J. Sherrick and Michael A. Hudson

Suggested citation format:

Sherrick, B. J., and M. A. Hudson. 1990. "A Framework for Analyzing Prices of Related Temporal Commodity Investment Strategies." Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL. [http://www.farmdoc.uiuc.edu/nccc134].

A FRAMEWORK FOR ANALYZING PRICES OF RELATED TEMPORAL COMMODITY INVESTMENT STRATEGIES

Bruce J. Sherrick and Michael A. Hudson*

Introduction

Many investigations of commodity market efficiency employ methodologies which compare prices of related positions in a commodity (Rendleman and Carabini). For example, forward rates implicit in the term structure of interest rates may be compared to parallel yields on futures contracts (Poole, Lang and Rasche), or futures contract yields may be compared to survey data of expectations (Kane and Malkiel). Others have searched for violations of efficiency by building forecasting models that "outperform" the futures markets. Or, trading rules are constructed and tested for their ability to generate "abnormal" returns (Johnson). Still others test the performance of hedging strategies as risk reducing tools for a production enterprise. To date, there is limited consensus in the literature about the evidence for or against efficiency as tested by the above approaches.

Discussions related to competitiveness and efficiency of commodity markets may be limited by the perspectives employed.[1] Specifically, there is a need to refine the competitive paradigms employed in analyzing related prices in a given sector and develop a framework within which emerging issues may be accurately examined. To begin, we should recognize the similarity between controlling a position in a commodity and making an uncertain investment in an asset. Then, we can bring to bear a new set of theory that conceptually improves the analysis. That is, the problems often encountered in tests of efficiency or competitiveness may be reduced to a discussion of the formation of an optimal portfolio from available assets. Investigations of temporal relationships among related investments then also parallel more traditional term-structure of interest rate investigations.

In the modern interpretation of efficient markets, prices arise as the sum of state-dependent claims for priced states and of market completion premia for newly spanned states (Banz and Miller). That is, if the markets are complete in all possible states, then any two assets with identical payoffs in all possible states

---

*The authors are Assistant Professor of Agricultural Finance at the University of Illinois and Associate Professor, Bruce F. Failing, Sr., Chair of Personal Enterprise at Cornell University. The usual disclaimers apply.

[1] See Hudson, Sherrick and Gregg for a more complete discussion on this point.

will have identical prices. Differing prices imply simple arbitrage. However, it is possible that markets are otherwise complete but have no other traded assets that price states specific to a particular asset. That is, some states may be "spanned" by only one asset. While this condition will serve to complete the market, it will also give rise to conditions that may at first appear puzzling. Two assets with identical payoffs in *all common states* would then not necessarily be priced identically. A singular idiosyncratic state is sufficient to break the equivalence without violating conditions of market efficiency. Trading in assets (commodity contracts) then also serves the additional function of creation of state claims against market completion services. The "re-denomination problem" of converting commodities back to an uncertain future number of dollars is then simply a market completion service which is also appropriately priced.

In the sections that follow, we first postulate an "efficient-markets" framework for analyzing related prices in competitive markets drawing heavily on close analogies from traditional financial markets. We then discuss the ability to make temporal investments in a commodity or in a production enterprise and describe the linkages in related markets for that commodity. The central concept of transforming a current certain value of capital into a greater expected, but uncertain value, is described. Seven strategies for making temporal investments are described and the logical basis for expecting divergence in unit prices of the strategies is discussed. The seven strategies are subsequently illustrated with examples from the well know beef sector, although nearly any commodity could have been used in the discussion.

Related Prices in Competitive Markets

Related prices are those of the alternate means of taking positions in a commodity or security. Common examples include positions in cash markets, futures contracts, options, forward pricing, implicit forward (yield curve constructs), and combinations of these alternatives. An important distinction to draw is that the prices are related because the payoffs to the positions depend on similar economic forces and hence are likely to have certain correlations in movements, not because they are currently denominated in a similar product. Thus, the set of related prices might also include instruments such as interest-rate and index contracts whose values are correlated with the commodity denominated contract due to their common responses to movements in macro-economic variables.

In competitive markets, the form of an investment is irrelevant. Rather, the contribution to the risks and returns of the portfolio in which the position is ideally held determines the price (and hence yield) of the investment. Another way to think of this concept is to consider each investment as consisting of the transaction from dollars to the particular investment and at termination, converting back to dollars so that all investments may be compared in terms of their terminal dollar payoffs alone. A logical consequence of this fact is that any

two investments with equal but uncertain payoffs in all future states will have equal current values. This fact does not imply that uncertainty is unimportant, but rather that equal uncertainties are equally important.

Temporal Investments

The beef investor, whether at the producer, packer, or retail level, is faced with a standard capital allocation problem. There are critical distinctions between investing, and ownership or control that deserve further exposition. For example, even if ownership of a particular commodity were an end goal, the quantity that can be owned at a given level of risk will be maximized by first investing the capital it represents in the form that generates the highest rate of return consistent with that risk and later converting back to the commodity.

Unfortunately, for many producers in particular, this concept is difficult to internalize and implement. However, the relative ease of using commodity futures and equity markets and increased ability to access information has lowered the barriers to implementation of such strategies. The result of the search for the appropriate mix of assets may indicate that dramatic restructuring of the investments currently held is needed, for example indicating that a producer should be short his commodity. The notion that one should be short the commodity they are now producing is to some an alien notion. But as Thurman points out, "Agricultural producers are not necessarily long in the commodities they produce, and their end goal is not consumption of those products". Simply stated, a dollar is a dollar and business is business. No particular distinctions are granted the agricultural sector because of the underlying assets held.

Many past efforts have focused on commodity-own rates of return -- the rate at which a commodity today may be transferred into that same commodity in the future ignoring the relative risks and returns available to the capital at stake. Below, we present further implications from viewing investment decisions separately from the ownership or production decisions.

Throughout the discussion, prices, rather than yields or rates of return, are used as the central measure in the following analysis. The prices of making competing investments that each yield <u>one expected dollar</u> at a point in time in the future are compared. The per-unit expected payoffs may then be scaled up to any size initial investment. This approach is in contrast to most approaches that begin with per unit yields and compare ending prices. However, since price relatives uniquely define yields, apparent differences between a price and a yield approach are only be a matter of emphasis, not substance (Malkiel).

Algebraically, the relationship between uncertain yields and current prices may be stated as:

$$E_t(P_{k,t}) = E_t[(1/(1+r_k)^k]\alpha_{k,t} \text{ and} \qquad (1)$$

$$E_t[(1/(1+r_k)^k] \geq [(1/(1+E_t(r_k))^k] \quad (2)$$

where E_t is the expectation at time t, $P_{k,t}$ is the time t price of a \$1 expected payoff at k, r_k is the per-period stochastic yield of a k-period investment, and $\alpha_{k,t}$ is the additional risk- and term-preference adjustment (if any) required to place this investment in an investor's equilibrium portfolio. For risk- and term-neutral pricing, $\alpha_{k,t}$ is equal to unity. In (2), the magnitude of the difference between the left-hand and right-hand side generally increases with the dispersion in r_k.

If variability or uncertainty about a value is deemed undesirable, then stochastic values (i.e. value to packer of cattle or to retailer of primal cuts) will elicit current price bids that will be less than the mean of the stochastic value. In other words, if there is uncertainty to the packer as to the yield from buying cattle, the bid will be less than the average value of cattle for any given lot. The size of the divergence between the mean value and the rational bid value is related to the dispersion in possible realized values of the commodity in the future. More variability about this value will lead to a greater risk-penalty discount from mean values.

Further, only the non-diversifiable risk is compensated. In the example above, the packer bearing the risk of the "packed" value of cattle is compensated for bearing the risk by bidding less for the live cattle. If the producer bore this risk by accepting payout based on realized carcass yield, presumably he would realize the mean value for doing so. And, if costless hedges in values are available, there is no need to compensate for bearing risk. The consequence of this concept is that all available sets of hedges (diversifications included) must be considered as potential *investments* to avoid needlessly bearing uncompensated risk. Rates of return may appear to be too low when investments are evaluated in terms of their total risk rather than in terms of the systematic risks alone.

Framework for Analysis

Drawing heavily from the traditional finance literature, we postulate a new framework for analyzing the prices of alternative investments that move capital through time in the form of commodity investments.[2] If the "true" risks and returns among alternate forms of commodity investments per dollar of expected payoff were the same, then each manner of transporting funds through time in the form of a commodity would have equivalent yields. Positions hedged in the futures markets would be equivalent to forward contract hedges and each would also be priced as average cash market positions. However, once we recognize the implicit and explicit costs of guaranteeing futures and forward market

---

[2] Our discussion of the commodity market strategies closely parallels that of Kane who discusses the "temporal fund transportation" problem in terms of interest rate contracts and related investments.

performance, divergence among strategy yields becomes the typical equilibrium state (Kane). The backbone of our argument is, again, that the divergences among the prices per unit of expected payoff from various market strategies over the time intervals may be interpreted as market completion premia -- that is, a return to the agent who completes the market.

Investors are assumed to have available to them a known "cash-out" short term interest rate. This rate corresponds to a known $r_{1,t}$ rate over the next one unit of time. In practice, this would correspond to the shortest term riskless cash market investment in which proceeds from other liquidated positions could be readily invested. Longer term rates may be known but implicitly carry a "capital value" risk that is absent from the shortest term instrument. Investors are further assumed to have two-period *investment horizons* composed of the first unit of time during which the known investment can be made and a second period of time of undefined length. Thus, the investors preferred horizons may be as short or long as desired by arbitrarily selecting the length of the second period. The preferred investment horizon is contrasted to the maturity of the *investment strategy* which is defined by the maturities of the particular instruments included in the asset portfolio.

Each of the intervals or, investment *horizons*, may fit into a taxonomy of seven basic investment *strategies*. We rely on the efficiency argument that a unit long is a perfect hedge for a unit short and hence the two have the same value (although one may be positive and the other negative). Further, each of the intervals involve an "underlying commodity", e.g., feeder cattle, fed cattle, carcasses, boxed beef, or components at the retailer. Each of the corresponding "futures" strategies may be thought of as including a futures contract if it exists or a highly correlated position and an asset equal to the difference between the correlated position and a hypothetical pure futures on the underlying if no futures market actually exists for the underlying.[3]

With the length of the investor's second period undefined, we can proceed to analyze the alternate means of making two period investments of any calendar length in commodities. At least seven different strategies exist for mapping out a set of roads along which current funds can travel to destinations n periods in the future (Kane). The first six of the seven strategies correspond to the elements of a matrix with two columns representing whether the underlying commodity is covered or naked and three rows indicating whether the investment horizon is shorter, equal to, or longer than the investment strategy. Simple analogies of the three rows' implications are as follows. Shorter ("rollover" strategy): suppose you wish to invest money for three years but only one year certificates of deposit are available, so at the end of one year you must "rollover" into a new instrument.

---

[3] This poses little difficulty in complete markets where such assets may be synthetically constructed.

Matched (matched strategy): the duration of your fifteen day investment is hedged with the last fifteen days to expiration of a futures contract. And longer ("rollout" strategy): you hedge a thirty-day investment with an instrument that expires in 60 days knowing you will have to "roll out" at a price determined in the future. The "hedges" may take many forms including, but not limited to, positions in futures, forward contracting, repurchase agreements, capital swaps, etc. If the dollar denominated value of the underlying and the hedge matches then it is called a covered position. Net longs or net shorts are called uncovered. The seventh strategy involves creating a synthetic hedge by the use of futures options (i.e. buy a put and sell a call at the same strike price).

Diagrammatically, the strategies may appear as follows:

		Hedge Position: Naked	Hedge Position: Covered
Strategy Maturity	Rollover	1	2
	Matched	3	4
	Rollout	5	6

We adopt the notation from Kane as it is simple and no other uniform set of notation has emerged as a standard. Let $P_{n,t}$ represent the price (per dollar final value) at time t of a commodity receivable for sure at time n. $P_{1,t}$ therefore implicitly defines the known first period rate. It is also the price of a one dollar pure discount bond receivable for certain at the end of the period. Superscripts N and C represent naked and covered positions, and S indicates that the maturity in the spot market strategy is shorter than the investment horizon, L indicates that the maturity of the investment strategy is longer than the investment horizon and RP indicates a repurchase agreement and O is an options strategy. $E_t(P_{n,t+k})$ represents the expected price dollar as of time t of an n period investment for inception at t+k. If k=0 and t is the beginning of the n period interval, it is simply the price per dollar of a pure discount investment. This notation allows us to consider investment intervals that span the current time period (begin now) or that take place entirely in the future such as planned investments or anticipated processing needs.

Given this notation, we can describe the possible forms of the investments algebraically as:

1. Naked Rollover : $P^{NS}_{2,t}=P_{1,t}E_t(P_{1,t+1})\alpha_1$

The price of this strategy is equal to the strategy of investing today at the rate for period 1 and rolling over as the rate changes in the interval from 1 to 2. The implicit capital gains and losses as the investment reprices are governed by the realized rate of return on the investment over the investment interval from period 1 to 2. The value in this investment corresponds to simply holding the investment or inventory for later sale at a price that may fluctuate in the interval between now and sale. The rollover occurs if the investment could be liquidated before the end of period 2, but at a price known only at liquidation. This could also be called a cash market ride and may implicitly be employed by producers. To illustrate, suppose that the price of a risk-free one period bond, $P_{1,t}$, were .92 for receipt one period hence. Further, suppose that yields are expected to rise in the future and that $E_t(P_{1,t+1}) = .91$. Finally, suppose α_1 is .99 to place the asset into an equilibrium portfolio. In this case, the price of an expected dollar to be received two periods in the future would be (.92)(.91)(.99) = .8288 if purchased via this strategy.

2. Covered Rollover: $P^{CS}_{2,t}=P_{1,t}P^*_1(t,t+1)\alpha_2$

The price of this strategy is equal to investing at today's rate and simultaneously contracting in the futures market for a sequence of purchases (sales) that span the interval from period 1 to 2. The asterisk denotes either a true futures position or the sum of a correlated asset and one equal to the difference between this asset and a hypothetical pure futures contract. For example, a packer could hedge for his slaughter that spans the expirations of the next two futures contracts forcing a rollover into new contracts.

3. Naked Matched: $P^{N}_{2,F}=P_{1,t}P^F(t,t+1)\alpha_3$

This strategy, also called the implied forward strategy, can be viewed as a buy-and-hold investment where you simply invest today at today's guaranteed 2 period term price. This strategy is the same as 1 above only if the implicit capital gains and losses from rate changes are zero and the rollover short rates are the same as a long interest rate (no term structure changes in yields). This could involve explicit forward contracting to be paid at the end of period 2. The price is known today, but the potential loss or gain relative to market moves will not be fully known until the end of the second period.

4. Covered Matched: $P^{RP}_{2,t}=P_{1,t}P_{1BB}(t,t+1)\alpha_4$

The BB stands for the buyback or repurchase value. The strategy involves investing in a 2 period instrument and simultaneously contracting to borrow against it via a series of repurchase agreements that span the interval from 1 to 2. Although it taxes the imagination to envision its implementation, the strategy is included for logical completeness. The nearest real world example we could generate was to invest in a whole life insurance policy and borrow against the cash value each period at rates determined today.

5. Naked Rollout: $P^{NL}_{2,t}=P_{n,t}[E_t(P^*_{n-2,t+2})]^{-1}\alpha_5$

The naked rollout involves a hedge in an instrument with duration longer than the planned investment horizon. For example, hedging with a futures that expires later than the planned investment in cattle and rolling out at whatever the futures price is at the termination of the investment in the cattle. This corresponds to many investor's idea of a hedge notwithstanding the basis risk.

6. Covered Rollout: $P^{NL}_{2,t}=P_{n,t}[(P^*_{n-2}(t,t+2)]^{-1}\alpha_6$

The covered rollout involves hedging in an instrument with duration longer than the planned investment horizon and simultaneously contracting to sell an n-2 period contract in 2 periods. The asterisk indicates an implied forward futures position. For example, an implied forward futures position is constructed if one were to buy a 6-month futures and sell a 4-month futures to get the 4-month ahead implied 2-month position value. This spreading strategy potentially involves substantial basis and time risks. Packers may implicitly employ this strategy if the price a product is later sold at depends upon the yield, or price paid for the input. As vertical coordination becomes more prominent, we expect this type of behavior to increase. Many "margin" activities may correspond well to this strategy.

7. Options strategy: This strategy involves the synthetic replication of a hedge instrument through the use of options. It is similar to the hedges it may be constructed to replicate (2 or 6) but involves a different set of performance risks.

The above formulation is general enough to address the investment features of producers who tend to be net long cattle, of packers who may be net long or short cattle and meat cuts and retailers, who may again be long or short meat cuts for a particular investment interval. While at first the notation and discussion may seem complex, it may more clearly illuminate the sector linkages when viewed as a series of uncertain investments.

If each of the above strategies could be costlessly guaranteed, they would all promise the same rate of return to the risk underlying the position, hence α_i would each be equal to 1. But, each has one or more sources of temporal risk that rely partly on a counter agent's performance in the offsetting contract. Thus, in addition to the "cost" of temporal risks, there is an implicit insurance premium against counter party non-performance. If complete markets existed in insurance against theses events, we could explicitly include the premia in the pricing equations. We choose rather to interpret the divergences in the prices of the seven strategies as market completion premia that pay for the implicit insurance against counter-party risk, and the other sources of temporal risk. That is, state claims are created in an efficient markets sense that are compensated and lead to different prices of related temporal commodity investments.

More specifically, suppose there is a risk averse pricing such that of two investments with equal expected value, agents will always prefer the one with smaller variance of returns. Then, the uncovered strategies will command a lower price than the covered strategies so that the expected additional yield will compensate for the risks borne. Hence, $\alpha_1 \leq \alpha_2$, $\alpha_3 \leq \alpha_4$, and $\alpha_5 \leq \alpha_6$ and all are less than or equal to 1. Another way to look at it is that the α_i in the first column of the matrix will be smaller than those in their respective second columns.

Suppose also, that there were a clear term preference such that investors would pay a premium to maintain a strategy horizon shorter than their investment horizon.[4] Then, investors would bid up current prices of strategies (lower the future yield) of those that were of a shorter duration. In the absence of other frictions (like the risk averse pricing above) the logical consequence of a preference for shorter term strategies is that $\alpha_1 \geq \alpha_3 \geq \alpha_5$ and $\alpha_2 \geq \alpha_4 \geq \alpha_6$.

If there are combinations of other performance guarantees and preferences in addition to the risk averse pricing and term preference, the magnitudes and orderings of the α_i could be quite different.[5] However, when the rates an investment is able to earn are viewed in this context, alternate strategies could easily be expected to command different rates of return.

Summary

A new framework for analyzing related prices in competitive markets was suggested. Investments in commodities are viewed as temporary storages of capital in an alternate form. In this context, the standard portfolio allocation procedures apply. The problem was investigated in one further detail; for

---

[4]This proposition has found widespread empirical support in interest rate markets and translates to a positive liquidity premium.

[5] Kane considers, for example, tax effects, exchange rules and reneging options.

investments in a commodity, at least 7 seemingly similar strategies can be employed in making the commodity investment. A logical basis for comparing prices of these strategies (and implicitly yields) was developed in terms of current prices of an expected future dollar. Relative magnitudes of adjustment factors were briefly described. Investigating the magnitude of these α_i and incorporating the returns for market completion services into the portfolio problem is an improvement in technique that should be considered.

Tests of market efficiency that ignore the differing state-claims inherent in the control of related assets run the risk of sorting out empirical data incorrectly. We suggest that a modest reconceptualization of the control of commodity investments in terms of the efficient markets paradigms could lead to dramatically different conclusions. Rather than search for sources and explanations of inefficiency, examination of the implicit magnitude of market completion services should be conducted.

The above theory, while fairly general may still be difficult to give empirical content. In particular, the data required to accurately asses relative magnitudes of the α_i would be extremely detailed on a wide array of transactions. In addition many of the "value" risks may be best hedged with interest rate contracts rather than with cattle futures. Nonetheless, it is still appropriate to consider or reconsider this approach of conceptualizing the investment-style products that are traded in a commodity disguise.

References

Banz, R. W., and M. H. Miller, "Prices for State-Contingent Claims: Some Estimates and Applications", Journal of Business, 51 (1978):653-71.

Hudson, M.A., B.J. Sherrick and D.R. Gregg, "Linkages Between Packers and Retailers: Motivations, Perspectives and Implications to Producers", in Structural Change in Livestock: Causes, Implications, Alternatives, ed. Wayne Purcell, RILP, Blacksburg, VA, 1990:105-135.

Johnson, R.L., "The Soybean Complex Spread: An Examination of Market Efficiency Using Disaggregated Results", unpublished Master's thesis, The Ohio State University, 1989, 64 pgs.

Kane, E.J., "Market Incompleteness and Divergence Between Forward and Futures Interest Rates," Journal of Finance, 35(May 1980):221-234.

Kane, E.J., and B.G. Malkiel, "The Term Structure of Interest Rates: An Analysis of a Survey of Expectations", Review of Economics and Expectations, 49(Aug. 1960):343-55.

Lang, R.W., and R.H. Rasche, "A Comparison of Yields on Futures Contracts and Implied Forward Rates", Federal Reserve Bank of St. Louis Monthly Review, 60(Dec. 1978):21-30.

Malkiel, B. G., "Expectations, Bond Prices and the Term Structure of Interest Rates," Quarterly Journal of Economics, 76(May 1962):197-218.

Poole, W., "Using T-Bill Futures to Gauge Interest-Rate Expectations", Federal Reserve Bank of San Francisco Economic Review, (Spring 1979):7-19.

Rendelman, R.J. and C.E. Carabini, "The Efficiency of the Treasury Bill Futures Market", Journal of Finance, 34(Sept. 1979), 895-914.

Thurman, W. N., "Understanding Real Interest Rates: Discussion," American Journal of Agricultural Economics, 70(1988):1076-77.