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Note on Commodity Futures

Background

Chicago has always been the center of commodity futures trading in the United States. The poet Carl Sandburg once described Chicago as a "stacker of wheat" and "hog butcher for the world." Innovation in dealing with agricultural products led to the development of the futures industry as a means to set commodity prices and coordinate buyers and sellers.

By 1877 futures contracts on wheat, corn, oats, and pork traded on the first official exchange, the Chicago Board of Trade. Over the next century futures on almost all imaginable commodities emerged, including contracts for butter and eggs on the Chicago Mercantile Exchange and contracts for potatoes on the Mercantile Exchange in New York.

During the 1970s and early 1980s, the futures industry underwent revolutionary change as exchanges in Chicago and New York introduced contracts on financial products such as the S&P 500, U.S. Treasury issues, mortgage-backed securities, municipal securities, and foreign exchange. The financial futures had great appeal for institutional investors because they created hedging and program trading opportunities.

The growing familiarity with financial futures also stimulated investor interest in commodity futures during the 1990s. Experts estimated that institutional and individual investment in commodity futures grew nine-fold between 1981 and 1990. A number of institutional investors were drawn to the commodity futures market because of the possibilities for attractive returns, a hedge against inflation, or improvement in risk-return tradeoff for a diversified portfolio of stocks and bonds.

The main purpose of this note is to introduce the various commodity futures that exist at present and to describe the pricing structure of these instruments.

This case was prepared by Professors A. Nancy Donahue, Kenneth A. Froot, and Jay O. Light as the basis of classroom discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

Products and Exchanges

By the 1990s futures on commodities such as coffee, sugar, soybeans, oil, cattle, gold, and copper traded on exchanges in Chicago, New York, London, Paris, Tokyo, Singapore, and elsewhere (**Exhibit 1**). Most contracts fell into one of five broad categories: agricultural products, energy products, livestock, precious metals, or industrial metals (**Exhibit 2**).

Futures contracts are standardized instruments that fix a commodity's quantity, quality, and date of delivery. Corn futures, for instance, trade on the Chicago Board of Trade in units of 5,000 bushels. The contracts are written specifically on Number 2 Yellow Corn for delivery in the months of December, March, May, July, or September. Price is the only variable, and it is set through an auction-like process called open outcry in which traders on the exchange floor literally yell bids and offers back and forth across a pit.

For every trader buying a futures contract, there is another trader selling it. Every time this happens a contract is opened, and open interest is the aggregate number of contracts that have been opened. The buyer of a contract has a long position, while the seller has a short position. The actual exchange of cash and commodities will not take place until expiration, that is, the date of delivery.

When the futures contract expires, the trader with a long position has an obligation to take delivery of the commodity. The trader with a short position has an obligation to make delivery. Delivery can only be made at sites designated by the exchange. In the case of corn futures, for instance, delivery can be made to Chicago, Toledo, or St. Louis. Such constraints, however, make actual delivery of the physical commodity extremely rare. In almost all cases the traders close out their positions by making reversing trades. This requires taking on an equal and opposite position near the future's expiration date. Such a reversing trade closes the original opened contract and therefore lowers the aggregate open interest in the future.

Each exchange has a number of safeguards in place to protect the integrity and safety of the marketplace. The clearinghouse guarantees that all futures contracts will be honored by acting as an intermediary between every buyer and seller. Capitalized by the members of the exchange, the clearinghouse makes counterparty credit checks unnecessary and minimizes the risk of default. Margin requirements demand that market participants make and keep an adequate good-faith deposit as assurance of their ability to fulfill contract obligations. Margins can be posted in cash, a bank letter of credit, or in interest-bearing Treasury bills.

Players and Purpose

Futures markets have traditionally provided an arena for risk management and price discovery by bringing together hedgers and speculators. Hedgers typically produce or consume commodities in the normal course of their business and have an interest in protecting the profits of their businesses from adverse price movements. Speculators, meanwhile, are in the market to pursue profits. Through their participation, speculators increase the market's liquidity and assume risk that hedgers are unwilling to bear.

A commodity producer's hedge can be conveyed with the following example. A corn farmer, for instance, may have planted corn in May that he is planning to harvest and sell to a corn flakes cereal maker four months later, in September. Although the corn is not yet ready for market, the farmer can earn a fair margin at the corn prices that prevail today (spot or cash prices). To hedge against the risk of falling prices, the farmer can sell September corn futures that trade on the Chicago Board of Trade.

When September arrives, the farmer sells his corn to the cereal maker. If, as he feared, prices have fallen from their May level, the farmer can buy back the futures contracts in September at a lower price. If done in the right amounts, this generates a profit large enough to offset his losses from the fall in the price of corn. This strategy works because the prices of commodity futures in September closely follow the spot prices (**Exhibit 3**).

Other examples of hedgers could include AT&T, a major purchaser of copper for use in telephone wires; Kodak, a leading buyer of silver for film; Cargill, a leading agribusiness firm; and Exxon, an oil producer.

Events such as labor strikes, droughts, and wars have had a dramatic effect on commodity prices. The way hedgers and speculators respond to such events serves an important purpose in the economy known as the price discovery process. The actions of the hedgers and speculators bring to the marketplace information about the expectation of future commodity prices. In essence, futures trading provides a forum for forecasting commodity prices based on many people's differing sets of information.

The Commodity Futures Trading Commission (CFTC), created by the U.S. Congress in 1974, regulates the industry and ensures that the market carries out its economic functions of risk transfer and price discovery.

Pricing Commodity Futures

Cost of Carry Pricing Model

In the simplest model, futures are priced relative to a commodity's current or spot price in a way that creates no arbitrage opportunities. In a perfect market with no transaction costs, the price of a commodity future will equal the commodity's spot price plus the cost of carry for the commodity. The formula for determining the price of a futures contract is typically expressed as

Futures price = Spot price + Cost of carry

One of the easiest commodity futures to price is gold. Arguably, the only important component of its cost of carry is the cost of financing, which is measured by the interest rate at which players in the gold market can finance their positions. Most hedgers or speculators can access capital at risk-free (U.S. Treasury bill) or repurchase (repo or overnight) rates because

they can post the commodity itself as collateral for the loan. The price of a gold future, therefore, can be expressed as

Futures price = Spot price + Cost of financing

or

Futures price = Spot price + Spot price x Interest rate x Time

If the price of gold today were $350 per troy ounce, and the annualized interest rate were 3.75%, the price of a two-month future would be calculated as follows:

Futures price = Spot price + Cost of carry
= Spot price + Spot price + Interest rate x Time
= 350 + 350 x (3.75% x 2 months/12 months)
= 350 + 2.19
= 352.19

The price of an eight-month gold future would be greater than the price of a two-month future because the purchaser would have to finance the cost of carrying the position for a longer period of time. Using the same spot price and interest rate as in the preceding example, we calculate the price of an eight-month future as follows:

Futures price = 350 ÷ 350 x (3.75% x 8 months/12 months)
= 350 ÷ 8.75
= 358.75

Deviations from the $358.75 price in the eight-month gold futures market would create an arbitrage opportunity. If the eight-month futures price were $363.75, for instance, an arbitrageur could borrow money to buy gold on the spot market while simultaneously selling the futures contract, thus establishing a risk-free position. Eight months later the arbitrageur could deliver the gold against the futures contract, using the cash proceeds from the deal to pay back the loan while also pocketing a $5 profit ($363.75 - $358.75). Cash flows for this risk-free arbitrage would look as follows:

Today the arbitrageur would

Borrow money	$350.00
Buy gold on the spot market	-$350.00
Sell an eight-month futures contract	0.00
Net cash flow	$0.00

Eight months later the arbitrageur would

Deliver gold against the futures contract	$363.75
Repay principal on the loan	-$350.00
Repay interest on the loan:	
$350 x (3.75% x 8/12)]	-$8.75
Net Cash Flow	$5.00

It is this kind of arbitrage pressure that keeps futures prices in line with spot prices and serves as the foundation for the cost of carry model.

The pricing of futures in the agricultural commodities market (wheat, corn, cotton, soybeans, sugar, coffee, cocoa) is very similar to the pricing of gold and other precious metals futures. It begins again with the simple formula

Futures price = Spot price ÷ Cost of carry

The concept of cost of carry for agricultural futures, however, includes not only the cost of financing but other carrying costs that are intrinsic to the commodities' production cycle. Most common are the cost of storage for the commodity between the time it is harvested and the time it is consumed; the cost of insurance for protecting the commodity against spoilage; and the cost of transportation between the storage site and the site where the commodity will be accepted for delivery against the futures contract. In the case of agricultural futures, prices can be determined as follows:

Futures price = Spot price + Cost of financing + Cost of storage
+ Cost of insurance + Cost of transportation

Given the following information on soybeans, for instance, a price for a six-month soybean future could be calculated as follows:

Spot price	$5.25/bushel
Cost of financing	3.75%/year
Cost of storage	$.24/bushel/year
Cost of insurance	$.10/bushel/year
Cost of transportation	$.05/bushel

Futures price = Spot price + Expanded cost of carry
= Spot price + Cost of financing + Cost of storage
+ Cost of insurance + Cost of transportation
= 5.25
+ 5.25 x (.0375 x 6 months/12 months)
+ (.24 x 6 months/12 months)
+ (.10 x 6 months/12 months)
+ .05
= 5.25 + .10 + .12 + .05 + .05
= 5.57

If the same information were used to calculate the price of a one-year soybean future, the price would be $5.84, greater than that of a six-month future.

The spot price/futures price relation exhibited by gold and soybeans leads to a pricing structure called contango. The first feature of a contango market is that the futures prices are greater than the spot prices. The second feature of a contango market is that the futures prices decline toward the spot as the time to maturity decreases. The characteristics of the contango market can be illustrated with the previous example of gold, where the spot price was $350 per troy ounce, the two-month future $352.19, and the eight-month future $358.75.

The difference between the futures price and the spot price of a commodity is known as the basis; in the case of gold, the basis is the simple cost of carry and financing cost alone. In all futures markets, the basis diminishes as the contract ages and approaches its maturity date. Said another way, as a futures contract ages, its price converges toward the spot price. Because the futures price is greater than the spot price in a contango market, as time to maturity approaches, the futures price will decrease or converge down toward the spot price. At expiration, the futures price and the spot price will be equal (**Exhibit 4**).

The cost of carry model works best in pricing a future for a commodity that has large, readily available inventories, that can be easily stored and accessed, and that has a stable supply and demand flow. The best example of a commodity that fulfills these criteria and conforms to the cost of carry model is gold. The available worldwide inventory of gold is large, it can be stored almost anywhere with little risk of spoilage or damage, and its supply and demand flows are not seasonal or disruptive. Such factors make it easy for arbitrageurs to keep the price of gold futures in line. For the same reasons, financial futures, including those on U.S. Treasury issues, foreign exchange, and the S&P 500, also conform closely to the cost of carry model.

Many commodity futures prices follow the cost of carry model closely, though not perfectly. There are major exceptions, however.

Deviations from Cost of Carry Pricing Model

Live cattle and live hogs are two commodities with futures prices that historically have not fit well with the simple cost of carry model. Unlike gold, live cattle and live hogs cannot be

easily stored and accessed. The inventory is essentially captive on cattle ranches and hog farms. In addition, live cattle and live hogs are not uniform commodities. Live cattle, for instance, progress through an 18-24 month life cycle of careful feeding and weight gain before they reach their slaughter size of 1,050-1,200 pounds.

The economics of the livestock business and the physical characteristics of live cattle and hogs create a situation where opportunities to arbitrage by transacting simultaneously in the spot and futures markets are not easy. Without arbitrage opportunities, the link that connects spot prices and futures prices in the cost of carry model is weakened. In such instances, futures prices tend to deviate significantly from the simple cost of carry model.

Two other commodities that historically have not conformed to the cost of carry model are oil and copper. Copper and oil tend to be consumed as they are produced. Inventory holdings are small. Access to oil and copper inventories is limited, although not as dramatically as in the case of live cattle and live hogs. An additional force in the markets for oil and copper, however, is that these commodities are prone to frequent supply and demand disruptions. The supply of oil, for instance, is greatly influenced by the OPEC cartel. Major political events in the Middle East like the Iran-Iraq War or the Persian Gulf War play a role in the flow of oil. In the case of copper, the worldwide supply from major producers in Chile, Zaire, and Zambia is often interrupted by mining disasters, labor strikes, or political events in the producing countries.

Therefore, a premium is placed on holding the commodity in the spot market rather than having a futures position. This premium is called a convenience yield. The convenience yield tends to keep spot prices high relative to futures prices. Such a relation between spot and futures prices leads to a pricing structure that is not contango, as it is in the cost of carry markets, but is backward. In general,

Futures price = Spot price + Cost of carry - Convenience yield

The first feature of a commodity market with backwardation is that the convenience yield is so large as to make the futures price less than the spot price. The second feature of a commodity market with backwardation is that the futures price decreases as time to maturity increases. The characteristics of a commodity market with backwardation can be illustrated with an example of oil prices. On January 15, 1991, the price of a barrel of oil on the spot market was $30.55. The price for a two-month future, meanwhile, was $29.05, and the price of a six-month future was $24.14 (**Exhibit 4**).

As in the contango market, the difference between the spot and the futures price is also known as the basis. (In this case, however, the basis is not a function of the cost of carry.) The basis in markets with backwardation also diminishes as the futures contract approaches its maturity date. As the futures contract nears expiration, the futures price converges toward the spot price.

Risk-Return Pricing Model

The cost of carry pricing model determines the futures price from the spot pricing, assuming that the commodity can be arbitraged. When arbitrage is difficult or impossible to accomplish, the cost of carry model is not very useful. Fortunately, there is a second general approach to futures pricing - the risk-return approach - that does not depend on arbitrage. It can, therefore, be applied to *all* futures contracts.

To build up the approach, notice that the total return from holding a commodity is equal to the sum of the capital gain (or loss) in the commodity's value minus the cost of carry plus the convenience yield. That is, the total return is:

Expected capital gain - Cost of carry + Convenience yield

The convenience yield is the value of having the commodity on hand when an interruption in supply makes it otherwise impossible to obtain the commodity on the open market. For example, a utility may put great value on having some oil on hand in case of supply interruptions. Because there is so little refined oil inventory held around the world and severe supply interruptions can take place, it may be impossible to get oil at any price in the open market over a short period of time. The convenience yield is simply the value of the insurance that the utility receives from having contingency stocks of oil on hand. A commodity like gold has essentially a zero convenience yield, since gold stocks can dependably be procured in the open market.

As with any asset, an investor requires a total return that is determined by risk class. An asset with little uncertainty in total return would have its price bid up to the point where it pays a relatively low premium. Conversely, a very risky asset would have a lower price, and a higher overall return as compensation for the risk. Thus, the total return is determined by the asset risk premium:

Expected capital gain - Cost of carry + Convenience yield = Risk premium

By combining this expression with the last expression of the previous section, we have another expression for the futures price, which says that the futures/spot price differential is equal to the expected capital gain on the commodity less its risk premium:

Futures price - Spot price = Cost of carry - Convenience yield
= Expected capital gain - Risk premium

Thus, a market with backwardation is created through the combination of a low expected capital gain and a high risk premium. (Notice that backwardation requires the difference between the cost of carry and the convenience yield to be negative.)

Theories of Backwardation

The preceding expression leads to an understanding of other theories of backwardation that have been proposed. One theory is that backwardation exists in commodity markets where participants have a bearish view of the future. Because the futures markets act as a forum for price discovery, many observers believe that the appearance of backwardation implies that participants in the market expect commodity prices to decline in the near future.

The second theory to explain backwardation was proposed in 1930 by the British economist John Maynard Keynes and is referred to as the theory of normal backwardation. Keynes contended that for any given commodity the long-run average futures price would be less than the long-run average spot price. The basis for Keynes's argument lay in his beliefs about the behavior of hedgers and speculators. First, Keynes believed that both hedgers and speculators were risk-averse actors. Second, he believed that in the aggregate, hedgers owned the spot commodities and sold the futures. This left risk-averse speculators as net owners of futures and bearers of commodity price risk. Backwardation, therefore, was a risk premium granted to the speculators. The reward came as speculators reaped the benefit of futures prices converging upward or increasing to spot prices as time to expiration on the contracts elapsed.

Recent Trends in the Commodity Futures Market

Globalization of Commodity Futures Markets

Although the United States still leads the world in the volume of commodity futures traded, the international marketplace is growing. Exchanges in Europe have benefited as investors more readily accept the use of derivative products.

Developing countries, suppliers of much of the world's agricultural and raw material commodities, also have emerging futures markets. Brazil has futures exchanges in three cities that trade sugar, soybeans, gold, and cattle. In Asia, Kuala Lumpur (Malaysia) and Djakarta (Indonesia) have exchanges that trade futures on coffee, rubber, palm oil, tin, plywood, and tobacco.

A 24-Hour Electronic Marketplace

In 1992, Globex, an electronic system for trading futures and options, made its debut. Developed jointly by the Chicago Mercantile Exchange, the Chicago Board of Trade, and Reuters (an international news agency), Globex is a 24-hour computerized trading system similar to the equity market's NASDAQ. Exchanges in New York and Paris have agreed to link up with the system. Although Globex will be used at first solely for financial futures and options, its potential to increase liquidity, lower transaction costs, and link international trading in commodity markets in the future is dramatic.

Institutional and Individual Investment

The dynamics of the commodity futures marketplace are driven mostly by the actions of hedgers and speculators. Commodity futures, however, offer investors a chance to earn competitive returns, to protect their assets against inflation, and to diversify their portfolios for improved risk-return characteristics.

Exhibit 1

Selected Commodity Futures Exchanges

USA and Canada

Chicago Board of Trade
Chicago Mercantile Exchange
New York Mercantile Exchange
Commodity Exchange NY
Coffee Sugar Cocoa Exchange NY
NY Cotton Exchange
Citrus Associates of the NTCE
Mid America Commodity Exchange
Kansas City Board of Trade
Montreal Exchange
Winnepeg Commodity Exchange

Europe

Matif France
London Metal Exchange
London Meat Futures Exchange
London Grain Futures Exchange
Liverpool Cotton Associates
Rotterdam Energy Futures Exchange
International Petroleum Exchange
Bolsa Merci Italy

Japan

Tokyo Commodity Exchange
Tokyo Grain Exchange
Osaka Textile Exchange
Kobe Rubber Exchange
Hokkaido Grain Exchange
Tokyo Sugar Exchange
Maebashi Dried Cocoon Exchange

Singapore Int'l Monetary Exchange
Hong Kong Futures Exchange
Chinese Gold and Silver Society
Kuala Lumpur Commodity Exchange
Jakarta Commodity Exchange

Bolsa de Mercadorios Brazil
Bolsa Mercantile Brazil

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Exhibit 2

Leading Commodity Futures Contracts

	Exchange	Months	Size
Agriculture			
Soybeans	CBT	Jan., Mar., May, July, Nov.	5,000 bushels
Wheat	CBT	Mar., May, July, Sept., Dec.	5,000 bushels
Corn	CBT	Mar., May, July, Sept., Dec.	5,000 bushels
Sugar	CSCE	Mar., May, July, Oct.	112,000 pounds
Coffee	CSCE	Mar., May, July, Sept., Dec.	37,500 pounds
Cocoa	CSCE	Mar., May, July, Sept., Dec.	10 metric tons
Cotton	NYCE	Mar., May, July, Dec.	50,000 pounds
Energy			
Crude oil	NYMEX	Jan.-Dec. (all 12 months)	1,000 barrels
Heating oil	NYMEX	Jan.-Dec. (all 12 months)	42,000 gallons
Unleaded gas	NYMEX	Jan.-Dec. (all 12 months)	42,000 gallons
Livestock			
Live cattle	CME	Feb., Apr., June, Aug., Oct., Dec.	40,000 pounds
Live hogs	CME	Feb., Apr., June, July, Aug., Oct., Dec.	40,000 pounds
Precious Metals			
Gold	COMEX	Feb., Apr., June, Aug., Dec.	100 troy ounces
Silver	COMEX	Mar., May, July, Sept., Dec.	1,000 troy ounces
Platinum	NYMEX	Jan., Apr., July, Oct.	50 troy ounces
Industrial Metals			
Copper	COMEX	Mar, May, July, Sept., Dec.	25,000 pounds
Aluminum	LME	Jan.-Dec. (all 12 months)	25 metric tons
Zinc	LME	Jan.-Dec. (all 12 months)	25 metric tons

CBT = Chicago Board of Trade; CSCE = Coffee Sugar Cocoa Exchange NY; CME = Chicago Mercantile Exchange; COMEX = Commodity Exchange NY; LME = London Metal Exchange; NYCE = New York Cotton Exchange; NYMEX = New York Mercantile Exchange.

Exhibit 3

Hedging with Commodity Futures

Spot price for corn in May	$2.50/bushel
Futures price in September	$2.65/bushel

It's May and the farmer needs to earn at least $2.50/ bushel of corn to break even. He likes corn prices today, but his crop will not be ready for harvest until September. What can he do if he fears the price will fall to $2.25/bushel by the time he harvests his corn?

May:	Farmer sells September future	$2.65/bushel
September:	Sells Corn crop	$2.25
	Buys back September future	$2.30
Cash Flow:	Sale of crop	$2.25/bushel
	Profit in the futures market	$.35
	Net income	$2.60

Okay, the farmer made his money. But what would have happened if prices hadn't fallen as he expected? What if corn prices in September had hit $2.75/bushel?

May:	Farmer sells September future	$2.65/bushel
September:	sells corn crop	$2.75
	Buys back September future	$2.80
Cash Flow:	Sale of crop	$2.75/bushel
	Loss in the futures market	$.15
	Net income	$2.60

No matter what happens, the farmer still earns $2.60/bushel.

Note: This example does not take basis risk into account

Exhibit 4

Actual Spot and Futures Prices, January 15, 1991