

The Structure of Commodities Markets

Colin Lawrence and Alistair Milne¹

Introduction

Commodities are traded in both spot and forward markets. They are physical as opposed to financial assets, creating the need for storage and shipping. Because commodities are generally not perishable and can be stored, they are also an asset and can be used as a store of value. Forward markets for commodities have existed for centuries because, with high volatility, risk-averse producers and consumers have attempted to hedge their inventories in forward and futures markets.

This chapter will begin by describing the universe of commodities, the various delivery and settlement mechanisms, and the liquidity of their markets. We further examine why gold is special due to its importance as a reserve asset. We then introduce the reader to the famous arbitrage condition linking forward prices to spot prices and introduce the concepts of convenience yield, backwardation and normal backwardation. We then discuss an analysis of downside risk in a typical commodity trading book and how to estimate the value-at-risk of a commodity portfolio when taking account of the large volatility of borrowing and lending costs; concluding with some further observations on the behaviour of commodity prices.

The Commodity Universe and Anatomy of Markets

Commodity Types and Characteristics²

Commodities are divided into four types: the *metals*, the *softs*, the *grains and oilseeds*, and *livestock*; all of which trade in the spot markets and most have evolved forwards, futures and option-based contracts.

The metals can be decomposed into *base metals*, such as non-ferrous metals (e.g., zinc, aluminium, lead and nickel); *strategic metals*, such as bismuth and vanadium; *minor metals*, such as cobalt and chromium; and *precious metals*, such as gold, silver and palladium. The London Metal Exchange (LME) is one of the key spot-trading centre for base, non-ferrous metals. Gold, Silver, Platinum and Other precious metals are traded over-the-counter (OTC) between producer and consumer in markets such as the London Bullion Market, an informal OTC market. The buyers tend to be automotive, aerospace, pharmaceutical and electrical corporations.

The softs include cocoa, sugar and coffee, and minor softs include rubber, tea and pepper. Most trading of soft commodities involves processors, roasters, refiners, distributors and traders who are 'inventory flow traders' or speculators.

The grains and oilseeds category spans most edible agricultural products. It can be further decomposed into the *grains* (such as wheat, barley, rice and oats), *oilseeds*, (such as soybeans, rapeseed, palm kernel and flaxseed), and *fibres*, (such as wool, cloth and silk).

¹ Dr Colin Lawrence, is Director, Prudential Risk Division, Financial Services Authority, United Kingdom. He is also a Visiting Professor in the Faculty of Finance, Cass Business School, London. Alistair Milne is Senior Lecturer, Faculty of Finance, Cass Business School, London. We are indebted to Carol Alexander and Elizabeth Sheedy for their comments but we remain responsible for all errors.

² This section draws heavily on Reuters (2000, pp. 7–129).

And finally *livestock and other*, including live animals and meat products such as pork bellies. Also included in the latter category are dairy products, such as milk and cheese, and citrus and tropical fruits, such as orange juice.

The Markets for Trading³

There are two types of markets: the spot commodity market and the market for commodity forwards, futures and other derivatives such as options. Spot transactions take place *on the spot*. They are OTC transactions and could take place in auctions or sales rooms. Once the characteristics are agreed, the commodity is sold and payment takes place at settlement. Usually spot trades involve the exchange of cash for the specified commodity at a specified settlement date, usually in 2 to 45 days.

We also need to distinguish between the markets for forwards and for futures. One important difference between the two is that forwards generally trade in OTC markets. They can be tailor-made contracts, with quantity, quality and maturity all designed to the customer's requirements. Like spot, forward settles cash for the physical. In fact, since a spot trade can settle anywhere between 2 days and 45 days, the spot market is in essence a short-dated forward.

Futures often (but not always) trade on the basis of *settlement of difference*. This is when the difference, for instance between the forward and actual cash settlement price at maturity, is settled by a net cash payment. Futures are standardised exchange-traded contracts.

The incentive for trading on an exchange is high for all parties. Firstly, trading continually takes place under guaranteed conditions, the price is determined in a transparent manner and, due to posting of margins, counterparty exposure is minimised. The reduction of counterparty exposure through the posting of collateral is the chief function of a clearing house. The key disadvantage is that transactions are standardised and maturity dates are fixed. The standardisation and lower counterparty exposure are critical ingredients in ensuring 'liquidity' of trading, which is the ability to buy or sell a contract with relative low transaction costs.

Delivery and Settlement Methods⁴

Irrespective of whether the commodity is traded spot, forward or futures, the delivery and settlement methods are critical in determining the actual spot, forward or futures price. There are at least six characteristics of delivery mechanisms:

1. *In store* is the simplest form of physical delivery. It is used for example, in 'softs' such as coffee and cocoa. *The seller is responsible for delivery to an agreed warehouse*. As in all physical deals, quality, quantity and *location* are all negotiated or embedded in the terms of a standardised (futures) contract. A 'warrant' is delivered in the form of a bearer document and is a warehouse claim on a physical commodity. When the trade is concluded the seller transfers ownership of the warrant to the buyer. The product is then shipped to the required location and the buyer exchanges the warrant for the physical or alternatively can transfer it to a third party. Once the contract changes title, the 'warrant is cancelled'.
2. *Ex store* is identical to *in store* except that the seller prepays the storekeeper for loading onto the buyers' transportation. Thus the price will be more expensive in *ex store*. In all physical deliveries, the seller must

³ See Reuters (2000, pp. 31–39).

⁴ See Reuters (2000, pp. 61–129).

- deliver many documents including a grading certificate, the warrant and weight notes. When these are delivered to the buyer, then the latter pays cash.
3. *Free on board (FOB)*. Once the goods have passed over the ship's rail, the seller has fulfilled his obligation. The onus of risk is shifted onto the buyer once goods are loaded, and hence an FOB price will be cheaper by the insurance premium of damage whilst on board as well as the transportation costs. FOB is used mainly when loading and shipping bulk such as gas oils, sugars and soybeans. Once on board a bill of lading is issued by the seller.
 4. *Free alongside ship (FAS)* is similar to FOB. It is a form of delivery where goods are delivered alongside the shipping vessel instead of being loaded. The FAS price will be lower than the FOB price by the cost of loading. In both FOB and FAS it must be specified who pays the tax, import duty, docking fees, value added tax (VAT) etc.
 5. *Cost, insurance and freight (CIF)*. This involves FOB delivery plus the costs of insurance and transportation.
 6. *Exchange for futures or physicals (EFP)*. It is possible to swap a physical position for a futures position, and this will be subject to off-exchange negotiation.

Commodity Market Liquidity

Market liquidity, or lack thereof, is of critical importance in the trading of commodities.⁵ We define liquidity as the ability to buy or sell at fair market value without changing transaction costs. A market is liquid when there are lots of sellers and buyers, and where large volumes can be executed with small transaction costs. We would expect bid-offer spreads to be smaller, the greater the liquidity of the market.

The Special Case of Gold as a Reserve Asset ⁶

Gold has special characteristics relative to other commodities because it is still a reserve asset of central banks and has a history of being pivotal to the international monetary system. As a consequence of the world's central banks' holdings of gold reserves, changes in central banking portfolio behaviour can have profound effects on the gold price.

The total inventory of central banks' holdings is around 32,000 tonnes, about 22% of the above-ground reserves. This is huge relative to annual production, which is estimated at around 2600 tonnes. As a consequence of this, speculators and hedgers of gold scrutinise the behaviour of the central banks. On 26 September 1999 the Washington Agreement on Gold was announced, whereby it was agreed that uncoordinated selling of gold by central banks would destabilise its price. The Accord reached was a pledge not to sell more than 2000 tonnes as a 'collective' over the next five years. The accord halted the decline in the price of gold at around \$250 per ounce and certainly contributed to its rise to \$400 per ounce.

Despite the fact that gold standard is a historical event, movements in inventories of central banks are critical not only in changing supply in the market but also in determining lease rates (the rates at which banks lend out their gold) and hence the gold basis. Central bankers lend gold to gold dealers with mismatched books in order to earn a return on their gold holdings. There is a ready demand for gold loans (from gold producers) as a cost-effective means of

⁵ For a useful methodology of both theory and practice in measuring liquidity, see Lawrence and Robinson (1995a, 1995b).

⁶ This section draws heavily on "Gold as a Reserve Asset", World Gold Council. See www.gold.org.

financing their gold production. The gold interest rate paid on gold deposits is called the gold lease rate or gold LIBOR. Thus while most commodities incur storage costs, gold deposits earn a positive return.

To summarise, gold is unique in the commodity universe for the simple reason that the above-ground reserves are so massive and they can earn a positive return. The large scale of these reserves makes it extremely unlikely that a short squeeze (caused by excessive short-term demand) could ever occur.

Spot–Forward Pricing Relationships

We have described cash, forward and futures markets for commodities. We shall now review the relationship between futures/forwards and spot prices, sometimes referred to as 'basis'. Unlike 'normal markets' where forward prices are generally higher than spot, forward commodity prices are often found to be below the spot price. Not only does the basis for commodities differ from most other markets, but it is also highly variable over time because of the possibility of short squeezes. This feature of commodity markets is a concern for risk managers because it can make hedging strategies less effective and create unexpected changes in the value of a portfolio (possibly giving rise to significant margin calls). Thus non-normal distributions, stress testing, and scenario analysis prove to be critical ingredients in the commodity risk manager's toolkit.

Backwardation and Contango

Based on the analysis of typical markets, one might expect the pricing relationship for commodities to be defined as *Forward price = spot price + carrying cost*, where the carrying costs involve storage costs, transaction costs and all other characteristics, especially freight and interest costs.

In studying patterns of spot versus forwards, or short-dated versus longer-dated forwards, we find by empirical observation that the spot price often lies *above* the forward price. Indeed in many commodities we find that the forward can switch from being at a premium to a discount and vice versa.

If the forward or future is traded at a price higher than the spot price, then we say that the forward or future is at a *premium* or (equivalently) that the market is in *contango*.

If the forward is below the spot price, then we say that the market is in *backwardation*.

A key point driving the yield curve or basis is that commodity buffer supplies can run out. We cannot import spot commodities from the future. The risk manager will have to scrutinise demand and supply data carefully. In the case of gold, above-ground stocks are very large relative to flows. Hence any incipient excess demand can be met through an elastic supply of inventory, thus mitigating the kind of backwardation we observe in cyclical commodities such as oil and aluminium.

Gold is an exceptional commodity. The gold market is almost always in contango, as shown previously. But with a lack of inventory to cope with unexpected changes in the flow demand or supply, other commodities can experience shortages – and hence backwardation. For example, in the last decade there has been a surge in food consumption in China and, with her low area of green land per capita, imports fill the deficit. In the 1990s analysts were watching the near monopolisation of grain containers out of Chicago by the Chinese, who pushed prices of food products up by over 13% in 1997. Any gyrations in demand for imports can tilt the yield curve of foodstuffs.

Finally, backwardation is caused by either combinations of rapid demand for immediacy creating scarcity or by manipulation of the market. To illustrate the latter point, in 2003 the LME were concerned when the aluminium basis backwardation flared from 2% to about 5% in 2003.⁷ On investigation they found that the market had been in over-supply since 2000. There was a surplus of 1 million tonnes in 2002 and about 400,000 tonnes in 2003; inventories had risen to over 3.5 million tonnes in July 2003 and a large share of this was in LME warehouses. A strong possibility of market collusion was investigated by the LME. By January 2004 the market was back in contango and it was suspected that the traders that were involved in this 'short squeeze' had backed off. Since this episode the LME has reduced the maximum size of the aluminium contract.

Regardless of whether there has ever been actual market abuse the aluminium market has been subject to large volatility in lease rates with discrete jumps in cash relative to futures. The FSA have noted these squeezes in their market abuse regulations and risk managers have to assess the potential for short squeezes to create an artificial short supply.

Reasons for Backwardation

Modern portfolio theory and subsequent empirical testing have refuted the Keynesian (1930) and Hicks (1946) views of normal backwardation in favour of the *convenience yield theory* (Kaldor, 1939; Williams, 1986). This focuses on the physical demand and supply of commodities as an input and/or output in the production process. It suggests that spot prices are driven above forwards because users of commodities cannot afford to run out of inventory. They are prepared to pay more in spot markets than the expected future price, in order to ensure that they have immediate access to supply (this is the *demand for immediacy*).⁸ From the perspective of suppliers, they are also prepared to hold more than required inventory in case the market switches from backwardation into contango. Despite the apparent negative return to suppliers, there is a chance that they can get exceptionally high returns from shortages, where producers will borrow commodities and thus drive spot prices very high.

Furthermore, a major cause of sudden switches from contango to backwardation has been the fact that the deliverable commodity to any futures contract at maturity can be subject to manipulation. Whilst the exchanges and regulators have attempted to stop market manipulation with an array of limits on movements in prices per day as well as ensuring the maximum open interest held by one investor is limited, history has been scarred by the omnipotence of squeezes. They can be an Achilles heel for the risk manager and often they are very difficult to detect, and yet they could wipe out economic capital in one stroke!

Convenience yield theory also suggests that shortages of physical delivery arise through either an unexpected shock or an anticipated (or unanticipated) act of Nature such as the seasonal harvest. Producers are willing to hoard commodities since they could otherwise suffer an opportunity loss if they do not have the commodity, especially if it is a key input in a supply chain. A consequence is that there are always premium prices at which producers will be willing to hold excess inventory even if they incur all the carrying costs.⁹ In such circumstances they

⁷ The spot price of aluminium shot up to US\$70!

⁸ Williams (1986) gives a persuasive and cogent analysis of the demand for immediacy and backwardation. Lawrence (2003) shows, however, that there is negligible backwardation in commodities such as gold where inventory supplies (above-ground stocks) are very large relative to production (flows), regardless of the convenience yield.

⁹ See Telser (1958) for a derivation of a commodity model with speculators and the behaviour of storage.

could earn huge returns if there is a market shortage and this creates a backwardation.¹⁰

Empirically, commodity markets can switch from contango to backwardation and back to contango, creating much volatility. Thus it is crucial for the risk manager to understand exactly what factors cause such volatility in prices. Indeed, in stress situations real and artificial physical shortages are a major cause of backwardation.

The Exchange Limits¹¹

The exchange rules, prodded by the CFTC, have changed dramatically. All commodity contracts have two sets of limits: the first are daily maximum movements in price of any contract; and the second are limits on each individual trader. Column 3 in Table 7.1 shows the daily limits on a sample of commodities traded on a number of exchanges. For pork bellies, for example, the contract size is 40,000 lbs. The minimum daily move is US\$4.00 per contract and the exchange will suspend trading if the contract falls or rises by 200 ticks.

In addition to the limits shown in Table 7.1 there are a range of other restrictions. The most important control is the maximum exposure per trader. In pork bellies, for example, no trader is allowed 1000 contracts net long or short in all contract months, and no trader can have (or control) over 800 contracts long or short in any one month. Furthermore, to avoid squeezes traders may not have more than 150 contracts long or short on the Friday in the first week of the expiration month.

Table 7.1: Commodity Contracts and Daily Limits on Price Movements

CONTRACT	EXCHANGE	LIMIT	TICK MOVE	CONTRACT SIZE	UNITS
Cocoa	CSCE	88	\$10.00	10 tonnes	\$/tonne
Pork bellies, frozen	CME	200	\$4.00	40,000 lbs	c/lb
Cotton #2	NYCE	300	\$5.00	50,000 lbs	c/lb
Copper, hi-grade RTH ¹²	COMEX	2000	\$2.50	25,000 lbs	c/lb
Corn RTH	CBT	120	\$6.25	5,000 BU	c/BU
Platinum	NYMEX	250	\$5.00	50 troy oz	\$/oz
Kansas City wheat	KCBT	250	\$6.25	5,000 BU	c/BU
Rape seed (canola)	WCE	100	CAD 2.00	20 tonnes	CAD/tonne

Risk Management at the Commodity Trading Desk

This section explains the first golden rule for commodities: that one must decompose risks into those associated with an outright spot position and those defined by the borrowing cost of commodities. Such decomposition can greatly ease the computational burden when calculating value-at-risk (VaR) for a portfolio of commodities. Furthermore, it enables the risk manager to assess where the concentration of risk is based. We show that for a typical market making commodity portfolio in cash and derivatives, most risk comes from volatility in the convenience yield. The portfolio includes all the hedges of the trading desk, and of course if VaR limits or other limits are imposed then these will also affect the VaR of the observed portfolio. Generally, traders will hedge out their spot exposure – the reason is that the market is relatively liquid but long-dated interest-rate risk is more expensive to hedge, and thus traders must balance transactions costs with the uncertainty of the un-hedged exposures.

¹⁰ Normal backwardation, according to Keynes (1930), implies that the *forward price will lie below the expected spot price*. This hypothesis has been thoroughly scrutinised and refuted by more modern economists.

¹¹ For an insight into the setting of limits and the relationship between the exchanges and the CFTC, see Geisst (2002).

An example of the decomposition of variance as measured by a standard deviation, for aluminium and gold futures at 3 months and 27 months, is given in Table 7.2.

Table 7.2: Decomposition of risk in computing VAR

Commodity	Decomposition of Volatility			Decomposition of Net Borrowing Volatility		
	Forward Volatility	Spot Volatility	Net Borrowing Cost	Net Borrowing Costs Volatility	Net Convenience Yield	Interest Rate
Alum 3M	17.54%	19.10%	-1.56%	2.48%	2.44%	0.05%
Alum 27M	16.67%	8.48%	8.19%	19.07%	19.40%	-0.33%
Gold 3M	4.86%	5.06%	-0.20%	1.05%	0.35%	0.69%
Gold 27M	4.82%	4.81%	0.00%	1.87%	0.62%	1.25%

Several features stand out. A position in a forward is analogous to a portfolio of two risk factors: spot plus borrowing costs. For shorter-dated base commodities, the spot affect dominates. In aluminium three-month forwards the outright volatility is 17.54%, indeed the borrowing costs reduce overall the risk. In contrast, aluminium long-dated 27-month contract risk is shared equally between net spot volatility of 8.48% and net borrowing cost of 8.19%. In gold the spot rate dominates the overall contribution of, risk with borrowing costs contributing little.

The immediacy premium is related to the volatility of net borrowing costs. The right-hand side of the table shows that the interest rate affect dominates the immediacy premium for gold. However, it is the convenience yield that determines the (much higher) immediacy premium for aluminium. Lawrence (2003) has analysed the key reason why base metals tend to have more volatile convenience yields than gold. Gold essentially has extremely large above-ground stocks that can readily be converted into inputs to meet industrial demand. The law of diminishing marginal utility from liquid commodities such as gold leads to a small and less volatile convenience yield.

What Drives Commodity Prices?

Lawrence (2003) has explored the key drivers of commodity prices and has concluded that:

- Using regressions of commodity returns on gross domestic product, inflation, monetary growth, short- and long-term yields as proxies of the business cycle, prices fluctuate with the business cycle for each commodity.
- Consequently, commodities can be categorised into two classes: those that are correlated with the cycle (through one or more variables) and those that are not.
- Most commodity prices are related to a business cycle, through varying channels. Only zinc and gold appear to have no systematic risk.
- Any commodity that does not have excessive above-ground stocks relative to production flows, such as aluminium or oil, will tend to be affected by cyclical movements.

The astute risk manager should perform stress tests and scenario analysis and be aware that estimates of correlations vary dramatically over the cycle.