Commodity Futures Markets
Futures Exchanges

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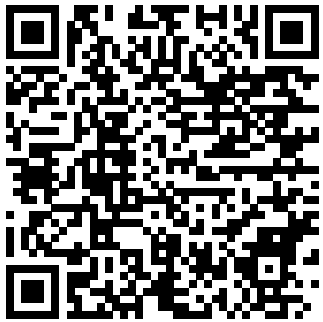


Readings

- H. Geman, Ch.3. Agricultural Commodity Spot Markets, in: *Agricultural Finance*, John Wiley & Sons, 2015.
- L. Nijs, Ch.14. Commodities I: Derivatives Markets, in: *The Handbook of Global Agricultural Markets: The Business and Finance of Land water and Soft Commodities*, Palgrave MacMillan, 2014.

Examples of commodities exchanges

NYMEX	Crude il (WTI) , natural gas, heating oil, propane, unleaded gasoline
IPE (19800 bought by ICE (2005)	Crude oil (brent), natural gas
Nordpool EEX, APX, POWERNEXT, , GMX, OMEL...	ELECTRICITY
LME (LONDON, 1877) Bought by Hong Kong Exchange (HKEX) COMEX,SHFE	
London Bullion Exchange, CBOT, Mumbai, Dubai	Gold, Silver
CBOT (Chicago 1850), bought by CME	Corn, Soybean, Wheat, Rice
CME (Chicago1898) now CME Group	Pork, Bellies, Beef, Lumber
Dubai Exchange, Kuala Lumpur, Bovespa, IMEX (Qatar)	Liquid Natural Gas (LNG)

Forward contracts

An agreement signed at date 0 between two parties A and B. A has the obligation to deliver at a fixed future date T a given quantity of a commodity and B has the obligation to take physical delivery of the commodity and pay A an amount $f(0, T)$ at date 0. T is the maturity of the forward contract.

Terminology

- A is called the seller of the forward contract and has to deliver at date T.
- B is called the buyer and will have to buy at date T.
- The value $f(0, T)$ is called the forward price at date 0 (however no payment or cash flow occurs at date 0, echange cleared forward contracts require payment of collteral).
- Plain OTC (over the counter) forward contracts involve counterparty risk for both sides as the losing party may disappear at date T.
- Forward contracts may be customized if the other party agrees.
- Given no arbitrage then

$$f(T, T) = S(T)$$

So forward contracts at maturity are equivalent to spot contracts.

Observations

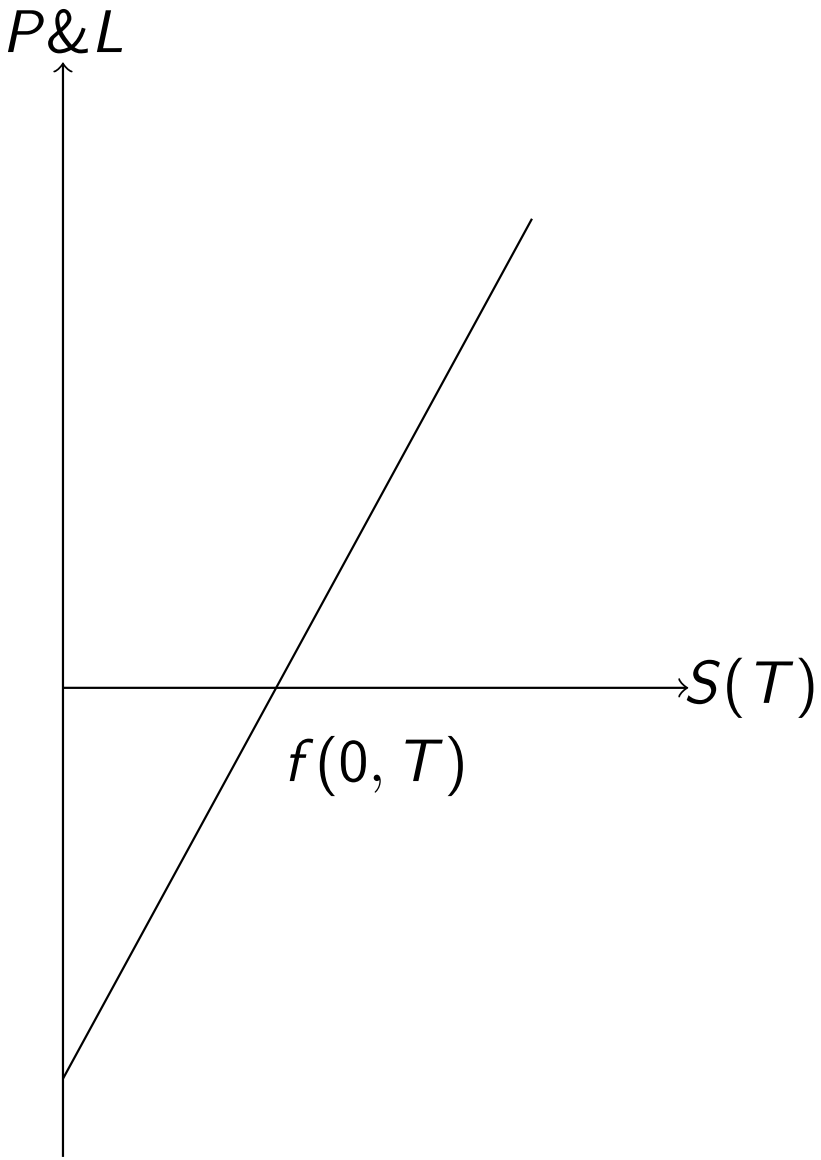
Convergence of $f(t, T$ to when t approaches T is problematic. $f(t, T)$ my not be continuous.

Example

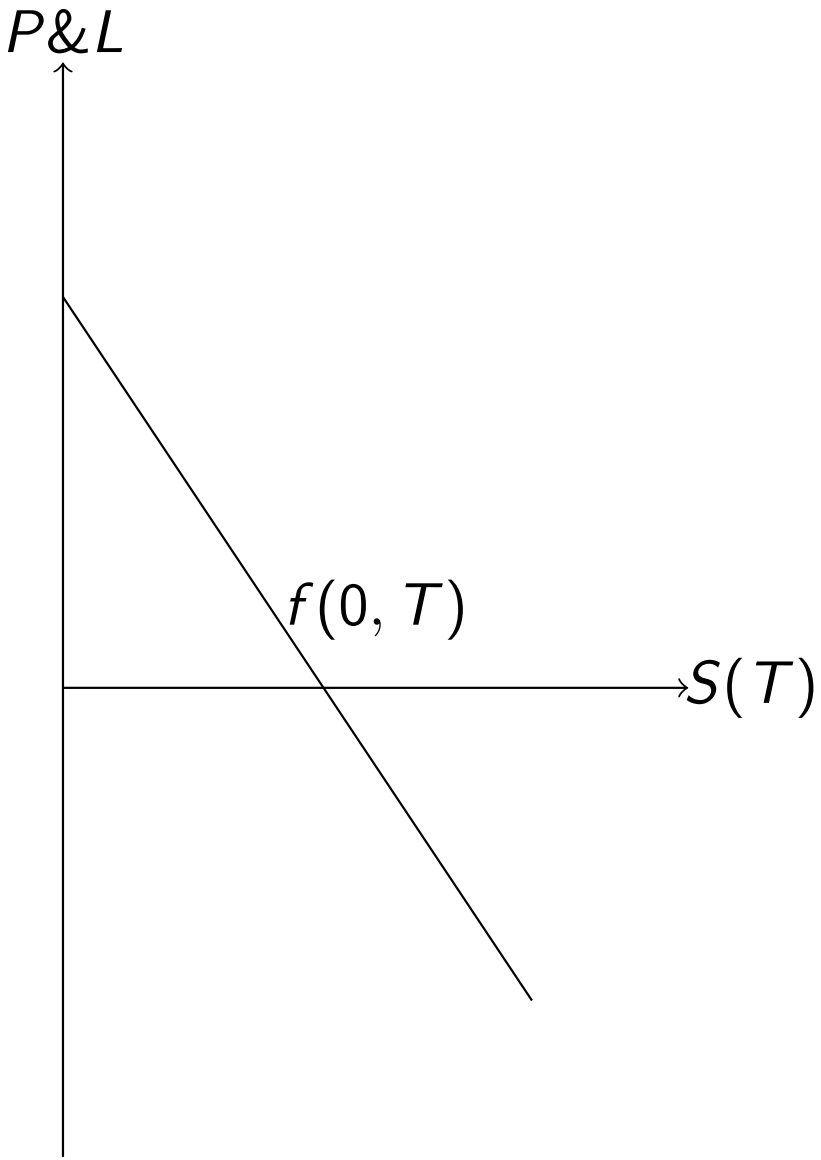
Consider a farmer producing on average Q units of corn each year, the harvest occurs in september and the farmer whishes to purchase new machinery before harvest. The farmer faces two choices:

- Do nothing in january. Wait until september and sell crops in the spot market obtaining revenue $QS(T)$.
- If the spot price is high at date T he will be able to buy equipment. If the spot price is low but he has a good harvest he will be unable to buy equipment (assumpion).
- He could hedge against fluctuating corn prices in september.

Profit and Loss of a long forward position



Profit and Loss of a short forward position



Example: Long position of speculator

$$\text{Payoff} = S(T) - f(0, T)$$

- speculator pays $f(0, T)$ to purchase a promise of delivery at date T, the speculator enters into this contract at time 0 and sells the corn immediately on delivery on the spot market for price $S(T)$.
- Prior to date the profit and loss is random. because the spot price $S(t), t < T$ fluctuates.

Comparison of contracts

Spot trading	Forward contracts	Futures contracts
commercial contract	bilateral agreement	standardized instrument
flexible covenants	flexible covenants	necessity of a physical delivery or termination of the position
juridical commitments of the buyer and seller	replace spot transactions	buyer and seller only
until execution of the contract		refer to the clearing house
⇓	⇓	⇓
long transaction	form of contracting totally	central clearing mechanism
	appropriate for commodities	generating "market prices"
lliquid and	credit risk fully present	price transparency
discontinuous market		
allows the transfer of	flexibility regarding the	liquidity
goods in conditions	optimal transfer of goods	
suiting the demand		
		low transaction costs

The forward curve

- At date 0 the farmer may choose to enter a forward contract matuing in 12/15 months if he has storage for his crop and is able to get a better price.
- Forward contracts may be signed at date 0 with maturiities T and different prices.
- The set of prices $f(0, T), T-1, 2, \ldots$ is called term structure of forward prices
- The graph of the term structure of forward prices is called the forward curve.

The Rational Expectations Hypothesis (interest rates)

Definition

The forward rate is an unbiased estimator of the spot rate observed at a future date

$$f(T, T, h) = E(R(T, h)|F_t)$$

where $h = T - t$ is the time to maturity T and $R(T, h)$ is the spot interest rate of a bond with maturity T and remaining time to maturity h.

Note: relationship does not hold exactly the difference is referred to as a a risk premium and failure to hold is known as the **risk premium puzzle**.

Rational expectations and commodities

$$f(t,T) = E(S(T)|F_t)$$

- again does not hold exactly
- $f(t,T) > E(S(T)|F_t)$ when inventories are low economic intuition is valid.
- Equality holds if expectation is computed under the risk adjusted probability measure.

Futures contracts

Definition

A futures contract is a forward contract traded on an exchange, it is standardized in terms of maturity, quantity of the commodity underlying the futures contract and results in physical delivery by the seller at the maturity of the contract. financial settlement requires existence of a liquid reliable index (legal requirement we covered this in contract law). futures contract entails an obligation not an option to buy or sell.

The Clearing House

- The clearing is house is the counterparty to an exchange with both the buyer and the seller.
- Clearing house requires all market participants to pay a margin deposit at the start. Payment in cash or T-bills.
- Margin calls paid/received each day.
- $F(t+1,T) - F(t,T) < 0$ then payment of a margin call required
- if payment is not made the position is closed and the margin deposit is used to offset the loss.

Price Transparency

- value of futures contracts for all traded maturities must be posted by the exchange
- this results in price transparency for both futures and spot prices due to link between futures and spot prices item first nearby chosen as proxy for spot price in absence of liquid index.

Other Information

- daily traded volume
- open interest, number of contracts with a maturity T with a buyer and seller at each end.
- Number of long and short positions held by "hedgers" (commercials).
- Number of long and short positions held by non-commercials
- Amount of inventory held by the exchanges affiliated warehouses.

Type and grade of commodity

- Type and grade of the commodity underlying the futures contract must be specified
- Grade acceptable for delivery at date T
- Seller has the option to deliver the cheapest grade specified by the contract.

Termination

Futures position can be closed by;

- taking delivery of the goods according to exchange rules
- entering a futures position offsetting the existing one
- cotracting an exchange for physicals

Exchange for Physicals (EFP

An EFP is an off-exchange transaction in which futures are exchanged for physicals. The exchange is then informed of the contract. Transaction can be brokered or direct.

Relationship between forward and futures prices

$$F(T,T) = f(T,T) = S(T)$$

But what happens at $t < T$?

At t=0

Assuming non-stochastic interest rates during the period $(0, T)$, then for the same underlying S and maturity T:

$$F(0, T) = f(0, T)$$

The same result holds in the case of stochastic interest rates if the correlation between R and S is zero (This is worth discussing -e.g. Hotelling result).

Counterparty Risk

Example:
Company ABCD needs to buy corn, in 8 months, They can buy corn on the CBOT at $F(0,8)$ or from a farmer at $f(0,8)$. The latter case involves more risk, the farmer may suffer a bad harvest and is unable to deliver. Pricing in the risk and by the law of one price:

$$f(0,8) + \text{risk premium} = F(0,8)$$

So we conclude $f(0,8) < F(0,8)$.
In general $f(t,T) < F(t,T)$.

Summary

$$f(T,T) - f(0,T) = F(T,T) - F(0,T) = S(T) - f(0,T)$$

difference in forward contract value is the profit and loss of the forward contract.
For futrues margin calls result in :

$$F(T,T) - F(0,T) =$$

$$(F(T,T) - F(T-1,T)) + (F(T-1,T) - F(T-2,T)) +$$

$$\ldots + (F(1,T) - F(0,T)$$

.
The latter tells us why the forward curve is important. Note the posssibility of infinite losses for the seller of a futures contract (buyer can limit losses by selling physical product).

Forward curves

- benchmark for valuation and marking to market
- deal pricing
- P&L
- checking consistincy of trading desk with other derivatives and physical position

Trading strategies

- $\{F(t,T)\}, t < T$ is the forward curve.
- fundamental tool for trading, spot prices possibly unobservable and options not liquid
- Contango: arbitrage by buying spot and selling future. Note you need to cover storage costs.
- Shape of forward curve matches convenience yield, this allows one to form trading strategies based on calendar spreads

Future spread (Example)

Crush spread:

- Soybean, soybean meal and soy oil contracted in a 1:1:1 ratio.
- Long spread: buying meal and oil and selling beans.
- Crushing mils profitability is approximated by value of a short spread.
- CBOT contract specification 48% protein 10 soybean, 9 soy oil and 11 soy meal contracts.

Soybean crush futures spread contract- example

Contract size	50000 bushels
Price unit	Cents per bushel
Spread legs	Short: Long 10 soybeans, short 11 soybean meal, short 9 soybean oil
Contract months	Jan, March, May , July, August, September, October, December
Settlement	Physical
Ticker symbol	SOM

The Theory of Storage

Key references:
Kaldor, N. (1939) Speculation and economic stability, *The review of economic studies*, 7, 1-27. Working, H. (1949) The theory of the price of storage, *American economic review* 39, 1254-1262.

The Kaldor-Working Hypothesis

The convenience yield depends inversely on upon the level of inventories

Two important results

- normal backwardation (Keynes) $f(t, T) < E(S(T, T)$
- theory of storage (inventory and convenience yield)

Why store commodities?

- Buffer against supply fluctuations
- reserve against uneven demand
- Hedge against supply disruptions
- Investment purposes
- Cash and carry strategies

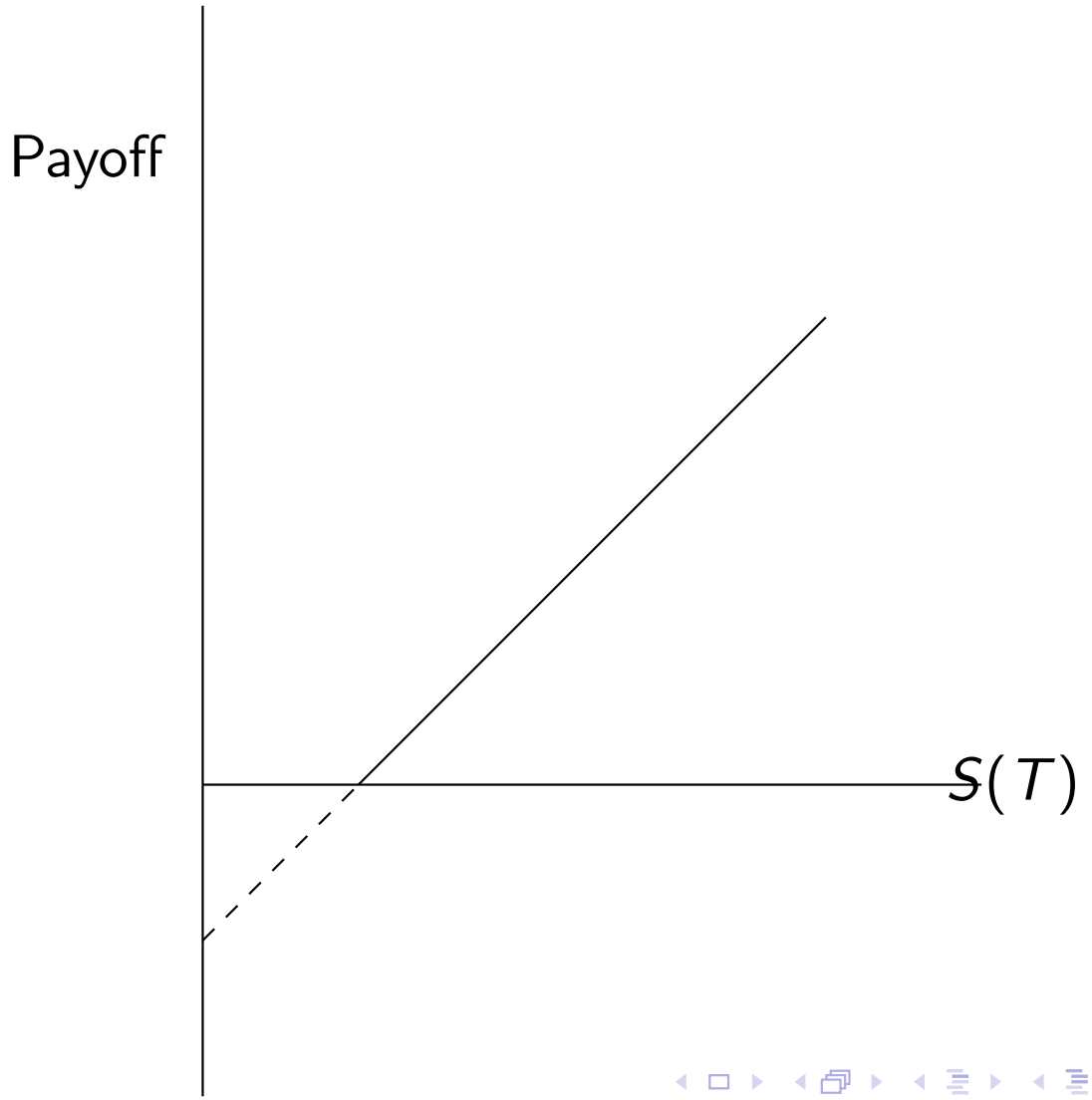
Backardation and contango

- $S(t) > F(T, T)$ backwardation
- $S(t) < F(T, T)$ contango (possibility of arbitrage limits this).

Convex payoffs

$$C(T) = \max(0, S(T) - k) = (S(T) - k)_+$$

where $k = F(0, T)$.



Stochastic modelling of the forward curve

$$f(t,T) = S(t)e^{(r-y)(T-t)}$$

- Note this solution is based on solving a linear ordinary differential equation.
- r is the cost of capital and y the convenience yield. If $S(t)$ is stochastic this solution does not hold.

One approach proposed by Geman is to replace $S(t)$ with $\bar{f}(t)$ resulting in:

$$f(t,T) = \bar{f}(t)e^{S(T)-(T-t)\gamma(T-t)}$$

where $S(T)$ is deterministic (why?) and $\gamma(T-t)$ is stochastic in t.

Extensions

- This equation is the solution of a stochastic differential equation with time changed to time to maturity. In the remainder of the course we will examine how to solve models of this type.
- Not because $f(.)$ depends on two independent variables both t and T a full solution with T varying would require solving a stochastic partial differential equation.

The End

Thanks for listening!