Econ 366

Fall 2012

Hedging in Energy Markets

Useful web resources

- Light Sweet Crude Oil (WTI)Futures and Options brochure from the *CME Group*

http://www.cmegroup.com/trading/energy/files/en-153_wti_brochure_sr.pdf

- Webinar on Hedging from the *CME Group*

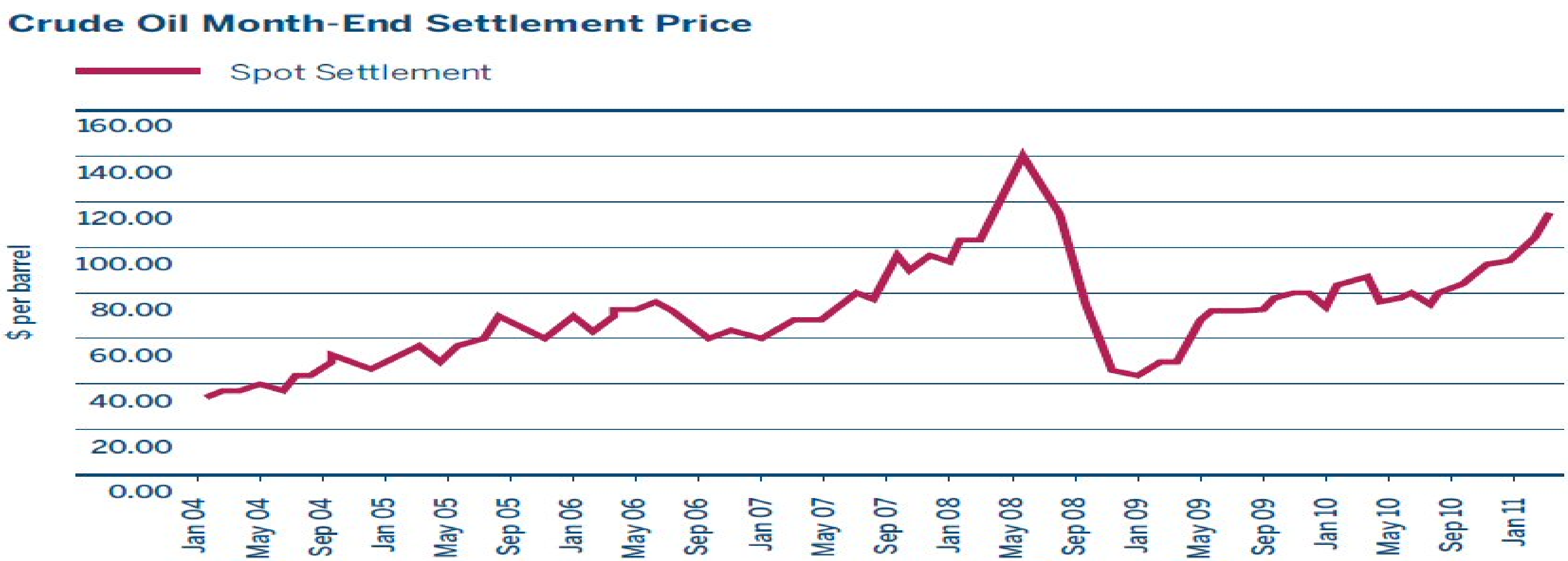
http://www.cmegroup.com/education/interactive/webinars-archived/energy-hedging-terminology.html

- Chapter 30 (Ripple) in International Handbook on the Economics of Energy

http://www.library.ualberta.ca/permalink/opac/4895120/WUAARCHIVE

Price volatility (diagram from CME)

- In many markets, energy prices fluctuate substantially (and unpredictably) over time



Price volatility

- Buyers of energy (airlines, electricity generating plants, industrial users, refineries, etc.) may want protection from unfavourable upward price swings
- Sellers of energy (oil companies, electricity generators, refineries, etc.) may want protection for unfavourable downward price swings

Hedging

- Both sides of the market want to protect their "profit margins" by limiting unfavourable impacts of price swings on costs or revenues
- Available instruments include:
  - Forward contracts (Over The Counter (OTC))
  - Futures contracts (Organized exchanges)
  - Options (OTC or organized exchanges)
  - Swaps (OTC or organized exchanges)

Forward Contract

- Bilateral agreement regarding any mutually agreed upon commodity, usually facilitated by a financial intermediary (OTC)
  (i) Establish a price for a forward date for a commodity
  (ii) Secure supply / placement of the commodity
- Contract details will include:
  - Exact commodity (what type of oil, for example)
  - Quantity to be exchanged
  - Price
  - Terms for delivery (place, time)
  - Terms for settlement of payment

Forward Contract Positions

- <u>Long</u> forward position: agent agrees to take delivery of the commodity at a future date (buyer)
  - Acquire commodity at a locked in future price → certainty regarding future input costs
- <u>Short</u> forward position: agent agrees to make delivery of the commodity at a future date (seller)
  - Supplies the commodity at a locked in future price → certainty regarding future revenues

Forward Contract

- Not liquid (i.e., can't easily resell)
- Contract between <u>2</u> parties with a physical interest in the commodity
- If one party wants somebody else to take over their obligations, must obtain approval from other party
- Not all risk is removed (default risk still there)

Futures Contracts

- Available on organized exchanges (such as CME, which includes the former NYMEX) for a small subset of energy commodities
  - Heating oil futures introduced on NYMEX in November 1978
  - Light sweet crude (WTI) on NYMEX since March 1983
  - Contracts available for coal, electricity, natural gas .... See Ripple (2009) for a list of available contracts

- Contract details are standardized with specific:
  - Commodity (such as WTI crude oil, for example)
  - Quantity (such as 1000 barrels)
  - Delivery date
  - Delivery location (such as Cushing OK for oil, New York Harbor for #2 heating oil, Mont Belvieu TX for propane, Henry Hub* for natural gas)

    *Louisiana

Futures Contracts

- CME, for example, acts as a clearinghouse and acts as counterparty to every trade (i.e, buyers and sellers aren't "individually" matched), safeguards in place to guard against default risk
- Price is determined by auction (depends on how many people are trying to buy / sell a contract and what they are bidding/offering)
  - (i) open outcry auctions in 'the pit'; and (ii) electronic trading
- Unlike forward contracts, futures contracts are "liquid": a long or short position can be closed out at any time by "unwinding" with the opposite position at the going price

  -Speculators (who have no interest in buying or selling the physical commodity) play an important role in providing this liquidity

An Example: NYMEX (CME) WTI Contracts

- WTI: blend of several streams of US light sweet crude with acceptable ranges of API, etc. (See CME pdf file)
  - Acts as a “benchmark” for other crudes that are often sold at a discount / premium relative to WTI
- Cushing OK: location with several intersecting pipelines and numerous storage facilities
- 1000 barrels
- Delivery dates up to 9 years forward with only June and December listed beyond 6 years

NYMEX (CME) WTI Contracts

- Most parties who enter into a WTI futures contract don’t really want to deliver or receive 1000 barrels of WTI at Cushing OK → most contracts don’t result in physical exchanges.
- Who enters into these contracts?
  - Hedgers: buyers and sellers of WTI or closely related physical products who want to protect themselves against price swings
  - Investors / speculators who have no physical interest in energy products (try to buy low then sell high or sell high and buy back low)

Futures Contracts and Hedgers

- Even for hedgers, making physical exchanges at the expiration date of the contract isn’t necessary.
- Can enter into a futures contract and then unwind your position (i.e., make an offsetting long or short transaction) at or before the expiration (contract delivery) date and then take their financial gains or losses into the “spot” market

Unwinding Positions: An Example

- OK Oil Company will have 1000 barrels of oil to sell in 3 months and wants to protect itself against price decreases. It takes a WTI futures contract short position at $80.
- On the same day, Widgets R Us, who will need 1000 barrels of oil in 3 months takes a WTI futures long position, also at $80.
- In 3 months time, they could just exchange the oil (if they are somehow matched up with each other on the ‘anonymous’ CME exchange)

Unwinding Positions: An Example

- They are more likely to take opposite positions at the end of the 3 months (or earlier should they wish) to close out their contracts.
- Suppose that at the expiration date, the price of the contract (which is now for “next day” delivery) has increased to $100
- At this time, they could:

Example: Options for OK Oil Company

Initial Position
(contract price is $80
per barrel)

OK Oil takes short position at $80 per barrel

3 months later
(contract price, which
is now the spot price,
has increased to $100)

Unwinds by taking an offsetting long position

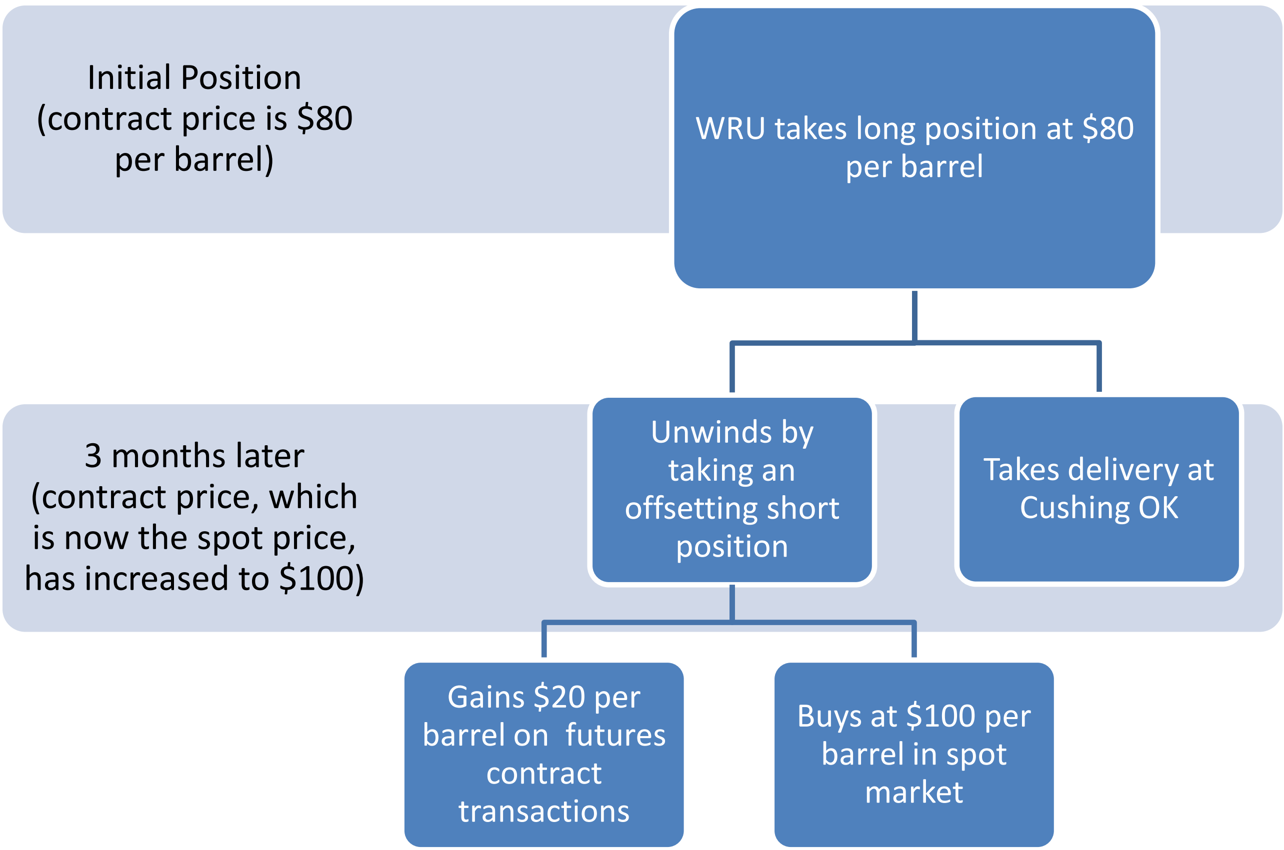
Makes delivery at Cushing OK

Loses $20 per barrel on futures contract transactions

Sells at $100 per barrel in spot market

net price received is $80 per barrel

Example: Options for Widgets R Us



net price paid is $80 per barrel

Example caveats

- If selling / buying a different (but related) product at a different location in different quantities than specified in contract, the financial losses / gains from entering into a contract and unwinding will be used in an analogous way so that agents end up ‘approximately’ fixing the price to be received or paid in advance of the actual physical exchanges

Theoretical Relationship between Futures and Spot Prices

- Arbitrage pricing:

$$F_t^T = S_t(1+r)^T$$

- Today's going price for delivery T periods in the future depends on today's spot price, the rate of interest, and how far in the future T is
- This is the simplest version that doesn't take into account storage costs or convenience yields or liquidity premiums

Theoretical Relationship between Futures and Spot Prices

- If $F_t^T > S_t(1+r)^T$ there is an arbitrage opportunity:
  - Enter into a short position (to deliver 1000 barrels of oil, for example)
  - Borrow at rate r and buy (1000 barrels of oil) in today's spot market
  - At T, deliver the oil and receive the contracted for futures price
  - Repay the lender with interest
  - Earn a profit of ______________ per unit (barrel)

Theoretical Relationship between Futures and Spot Prices

- If $F_t^T < S_t(1+r)^T$ there is an arbitrage opportunity:
  - Enter into a long position (to buy 1000 barrels of oil, for example)
  - Sell (1000 barrels of oil) in today's spot market and invest the proceeds
  - At T, cash in your investment to recover your principal plus your earned interest
  - Pay the contracted forward price
  - Earn a profit of _____________ per unit (barrel)

Theoretical Relationship between Futures and Spot Prices: An Alternative View

- Today's futures prices incorporate expectations about (uncertain) future market conditions:

$$F_t^T = E_t(S_T)$$

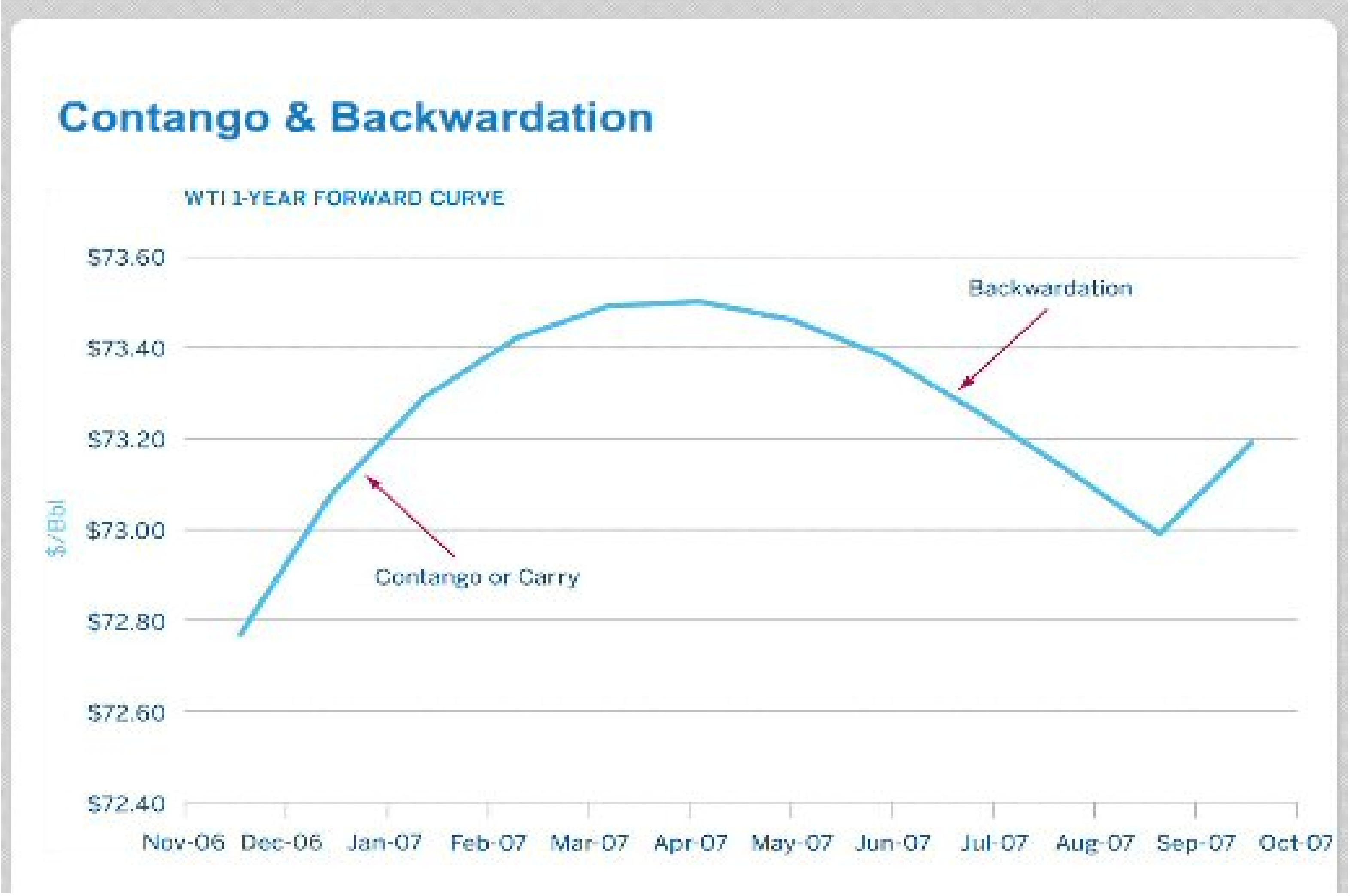
- Today's going price for delivery T periods captures market participant expectations regarding what the spot price is "likely to be" in period T (which is a function of what demand might look like and what supply might look like at time T)
- What would you expect to happen if the equality doesn't hold?

Backwardation and Contango (Reference: CME Webinar Link*)

- Simplest Arbitrage Pricing equation would imply "Contango" whereby futures prices are higher for delivery months that are farther away. (Not necessarily the case for more complex models with complications such as storage and convenience yields.)
- Backwardation occurs when future prices are lower in later delivery months than in the nearest delivery month

* Click on *Important Terminology* then on *Contango and Backwardation*

Backwardation and Contango: Figure from CME Webinar



Contango and Backwardation in Oil Markets

- From diagram we see that in November, market is in *contango*:
  - "front-end" (Nov) prices lower than "back-end" (Mar) prices
  - 'oversupply' in November, but expectations are that this will be rectified during 'heating' season
- From diagram we see that in April, market is in *backwardation*:
  - "front-end" (Apr) prices higher than "back-end" (Aug) prices
  - Heating season ending (demand expected to fall); US refineries coming off annual maintenance in May (supply expected to increase)

Other Related Hedging Instruments: Options (on a futures contract)

- Unlike forward and futures contracts, options only place an obligation on only one party: the seller (writer)
- Seller (writer) of an option takes a payment in exchange for an obligation, buyer pays a price in order to obtain a right (with no obligation)
- Call: holder has right to purchase at the strike/exercise price
- Put: holder has the right to sell at the strike price

Call on a Futures Contract

- Holder buys the right to purchase a futures contract from the writer at a pre-determined exercise (strike) price
- Writer is obligated to deliver
- American call: option can be exercised any time during the option’s life
- European call: option can be exercised only at the maturity date

Call on a Futures Contract

- A call is generally exercised when the current price is higher than the strike price.

  → can re-sell the commodity bought at the strike price and earn a profit

  - Or can take delivery of the commodity to use in the production process, paying a lower price than is currently available on the market

More Complicated Tools: Swaps

- One party ‘swaps’ an uncertain floating price for a (series of) fixed price(s) agreed upon by the two parties (after looking at futures markets)
- Payments are then made between the parties based on the difference between the fixed price(s) under the Swap conctract and an agreed upon reference price from a particular market (ex. IATA’s “jet fuel price monitor” or Platts)
- Can be structured as a series of forward positions (details beyond the scope of this course …)

Jet fuel swap example (Ripple)

- Airline industry: main cost is aviation fuel (but there are no CME futures contracts for this)

  →Want to hedge against fuel price risk by 'swapping' volatile aviation fuel prices for a fixed set of certain prices over a set of months / years via a swap

  - May agree, for example, on $2.50/gallon ($105/barrel) for each month in the first year, $2.60/gallon in the second year, etc.

Jet fuel swap example (Ripple)

- At a given payment date in the first year
  - If reference price is \$2.50, neither party owes anybody anything
  - If reference price is \$2.55, party who sold the fixed price is obliged to pay the airline \$0.05 / gallon
  - If reference price is \$2.45, airline pays the other party \$0.05 / gallon

Establishing the Fixed Jet Fuel Price

- Must be mutually agreed upon
- Can look at futures markets to establish a ‘reasonable’ price (future price related to expected future spot price)
- But there is no NYMEX (CME) aviation fuel contract (see Table 30.4 in Ripple for a list of available futures)
- Can look at crude oil and heating oil futures, for example, since heating oil and jet fuel are chemically similar

Establishing the Fixed Jet Fuel Price

- Value of jet fuel can be linked to the value of the underlying feedstock
  - Use crude and heating oil futures
  - Determine crude oil / heating value crack spread*
  - Estimate a jet fuel / heating oil differential based on historical information

  → basis for a mutually acceptable fixed price to be used in the swap

* Crack spread: difference in value of (a weighted average of) refined output(s) and the cost of crude input