Markets, Risks, and Risk-Hedging Contracts

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1. Glossary of Standard Market Terms

- **Asset** = Anything of durable value

- **Physical asset**
  - Assets that have physical substance, such as buildings, equipment, automobiles, embodied skills,…

- **Financial asset**
  - Claims against physical assets, such as corporate bonds, stock shares, mortgages, money,…

- **Commodity**
  - *Modern Usage*: Anything of value available for purchase and sale in standardized form (e.g., cell phone minutes)

- **Physical commodity** = Commodities taking the form of services or physical assets
• Purely financial contract
  - Does not involve any physical delivery

Purely financial contract
(e.g., bet on May 1 between persons A and X that the price of wheat will exceed $5/bushel by May 31)
• **Spot trade**
  - An immediate trade, with both delivery and payment taking place “on the spot” (no long-term formal relationship established between buyer/seller).
  - **Examples:** Milk purchase at grocery, haircut purchase from barber

• **Forward contract**
  - Contract between parties for the *future* delivery of something of value at a pre-determined price.
  - Forward contracts that are not standardized with regard to quantity and quality measurements are typically sold in over-the-counter markets rather than through centralized exchanges

• **Futures contract (a type of forward contract)**
  - *Standardized (“securitized”)* contract between parties for the *future* delivery of some *commodity* at a pre-determined price
  - Focus on commodities (standardized quantities/qualities) facilitates formation of markets for these contracts in the form of centralized exchanges.
• **Financial market**
  - A market for some type of financial asset

• **Real market**
  - A market for some type of non-financial commodity

• **Spot market**
  - A market for any commodity for which all trades are spot trades

• **Forward market**
  - A market for forward contracts

• **Futures market**
  - A market for futures contracts
• **Primary market**
  - A market for the *first-time* purchase and sale of an asset, e.g., newly produced homes, newly issued stock shares, etc.

• **Secondary market**
  - A market for the *resale* of previously sold assets, e.g., a used car market, the New York Stock Exchange Euronext (resale of previously sold stock shares and other financial assets)

**NOTE:** The distinction between primary and secondary markets is irrelevant for items that have no durability, hence no possibility of resale.
• **Risk**
  - Possibility of an *unfavorable* deviation from an expected outcome

• **Risk Hedging**
  - Taking actions to reduce risk. These actions can require the payment of a fee (e.g., a monthly premium paid on an insurance policy contract).

• **Perfect Risk Hedge**
  - Actions that can be taken to reduce risk *to zero*. These actions can require the payment of a fee.
• **Investor**
  - Lends assets to borrowers in an attempt to secure a financial return on these assets

• **Hedger**
  - Trades in financial assets to protect wealth (total net asset value) against risk

• **Speculator**
  - Engages in commodity trades in an attempt to profit from anticipated future price changes
  - Typically willing to bear high risk in hopes of large gain
2. Concept of Risk

- **Risk** = Possibility of an *unfavorable* deviation from an expected outcome
- Future is uncertain
- Uncertainty typically entails risk
- Doing business means accepting some risks
- *Willingness to accept risk* varies across people:
  - Venture capitalist versus an old-age pensioner
- *Ability to control risk* varies across people:
  - Professional versus novice stock traders
Some Sources of Risk for Power Systems:

• **External risk**
  - Failure to produce or deliver because of cataclysmic external event (“shock”) affecting the power system
    - Weather, earthquake, war

• **Technical risk**
  - Failure to produce or deliver because of technical problem occurring within the power system
    - Power plant outage, congestion in the transmission system

• **Price risk** *(from fuel costs, supply behaviors, demand changes, ...)*
  - Having to buy at a price higher than expected
  - Having to sell at a price lower than expected
Managing Risks:

• Excessive risk hampers economic activity
  ▪ Not everybody can survive short term losses
  ▪ Society benefits if more people can take part
    • Business should not be limited to large companies with deep pockets

• **How can risk be managed?**
  1) *Reduce* the risk
  2) *Share* the risk (risk pooling & risk spreading)
  3) *Re-allocate* the risk from one bearer to another
1) Reducing Risk

• Reduce consequences of natural catastrophes
  – Design systems to be able to withstand rare events

  **Example:** Having enough crews to repair a power system after a hurricane reduces the extent of damage should the catastrophic event occur.

• Reduce frequency/consequences of technical problems

  **Example:** Security margins on transmission lines
  – Limits the cost of problems (e.g., line loss) when they occur.
  – Can also decrease efficiency (i.e., cause resource wastage).
  For example, suppose ISO decides to keep power flow low enough on all lines so that no thermal line limit is exceeded if any one line goes down, called an **N-1 security constraint**.
1) Reducing Risk... Continued

- Give those with ability to reduce risk the incentive to reduce risk, and vice versa
  
  **Example:** Power plant owners and transmission system operators/owners
  - Can reduce outages of plants/lines by proper maintenance and suitable investments in new generation/transmission capacity

- Avoid unnecessary volatility in system outcomes
  - **Example:** Make sure market rules do not encourage “artificial” volatility in electricity markets (e.g., price spikes due to exercise of market power)

**Basic Trade-Off:** Risk reduction can reduce expected gain!
- Excessive concern with grid security can lead to excessive reduction in grid power flows and inability to service load
2) Sharing Risk

• **Risk pooling (e.g., via insurance markets)**
  - Each member of a group (“pool”) is susceptible to a risk
  - Each member pays a small amount to compensate the few who end up actually suffering loss
  - Consequences of a catastrophic event that randomly affects a few individuals are borne by a larger group.

• **Risk spreading (e.g., via financial markets)**
  - Bearer of a large risk (e.g., a corporation investing in a new power plant) sells stock shares to finance a loan
  - Risk is spread across the entire group of stock holders
3) Re-Allocating Risk

- Possible if some agent A is more willing or able to bear risk than another agent B
  - For example, suppose loss is catastrophic for A but not for B
  - This could hold because A is unable to offset loss, but B is able to offset loss against gains in other activities

- **Power Market Example:** Undiversified traders with generation units who wish to hedge (i.e., reduce) their price risk might be able to allocate some/all of this price risk to *speculators* with diversified portfolios of financial contracts.
3. Using Contracts to Hedge Spot Market Risk

- **Spot Market** = Immediate market, “on the spot”
  - Immediate agreement on price
  - Immediate agreement on quantity
  - Immediate delivery
  - Immediate payment
• **Examples of spot trades**
  - Standard grocery store purchases (physical commodities)
  - Purchase of shares in General Motors (financial asset)
  - Dental visits (service)
  - Electric energy (physical commodity) as sold in real-time electric energy markets

• **Spot markets can be formal or informal**
Advantages/Disadvantages of Spot Trades:

- **Advantages:**
  - Simple
  - Flexible
  - Immediate

- **Disadvantages**
  - Prices can fluctuate widely based on circumstances

  **Examples:**
  - Effects of frost in Brazil on price of coffee beans
  - Effects of Middle East troubles on the price of oil
  - Effects of unanticipated changes in electricity demand on real-time price of electric energy!
Spot Market Risks:

- Problems with wide price fluctuations
  - Sellers might have to sell at prices lower than expected
  - Buyers might have to buy at prices higher than expected
  - “Price risk”

- Market might not have much depth ("thinness")
  - Not enough sellers $\Rightarrow$ market is short (on supply)
  - Not enough buyers $\Rightarrow$ market is long (on supply)

- In thin markets, some traders can have lots of ability to move the market price in their favor (i.e., to exercise market power) because their supplies (demands) are essential to match buyer demands (seller supplies).
  
  e.g. “load pocket” GenCos under congested conditions
**Example:** Buying and selling wheat

- Farmer produces wheat
- Miller buys wheat to make flour
- Farmer faces risk of bad weather affecting harvest
- Miller faces risk of breakdown of his flour mill
- Neither farmer nor miller *controls* the price of wheat
Harvest time: Opposing Buyer/Seller Interests

- **If price of wheat is low:**
  - Possibly devastating for the farmer (seller)
  - Good deal for the miller (buyer)

- **If the price of wheat is high:**
  - Good deal for the farmer (seller)
  - Possibly devastating for the miller (buyer)
What should they do?

• **Option 1:** Accept the spot price of wheat
  - Equivalent to gambling on weather, equipment breakdowns, …

• **Option 2:** Agree ahead of time on a price that is acceptable to both parties
  - Forward contracting
Forward Contract:

Agreement Specifies:

- Date and location of future purchase/sale
- What is to be purchased/sold
- What price is to be paid ("strike" or "exercise" price)
- Time and location of payment
- Penalty imposed if either party breaks contract

Note that forward contracts are firm contracts

- Future purchase/sale not conditioned on future events
Example of a Forward Contract:

Contract (signed on June 1):
Farmer promises to deliver to General Mills 1 ton of wheat for $100/ton on September 1

Delivery Date (September 1):
Farmer delivers 1 ton of wheat
General Mills pays $100/ton
Spot price = $90/ton
Net gain to farmer = $10
Net loss to General Mills: $10
How is a strike price mutually determined?

- Both parties consider possible Sept 1 conditions
- Both parties *forecast* the spot price and possible deviation range for Sept 1
Case 1: Seller forecasts same price as buyer

- Farmer F (wheat seller) forecasts $100/ton
- Miller M (wheat buyer) forecasts $100/ton
- F and M can agree on a strike price of $100/ton for wheat on September 1
Case 2: Seller forecasts lower price than buyer

- Farmer F (wheat seller) forecasts $90/ton
- Miller M (wheat buyer) forecasts $110/ton
- F and M can agree on a strike price lying somewhere between $90/ton and $110/ton
- Exact strike price specified in the forward contract will depend on negotiation ability
Case 3: Seller forecasts higher price than buyer

• Farmer F (wheat seller) forecasts $110/ton

• Miller M (wheat buyer) forecasts $90

• **Agreeing on a strike price is likely to be difficult**

• **Whether a deal is struck will depend on**
  - F and M’s ideas about possible unfavorable divergence of the actual Sept 1 spot price from expected Sept 1 spot price
  - Degree to which this “risk” is viewed as costly (undesirable).

• **Example:** As will be clarified below, a “risk averse” F might agree to pay a “risk premium” to avoid risk, i.e., to contract with M for a strike price below what he expects the future spot price to be.
Sharing Risk:

• The two parties to a forward contract share the risk that the strike price will diverge from their expected future spot prices.

• Difference between strike price and spot price at contract maturity date represents a “gain” for one party and a “loss” for the other

• However, in the meantime they have been able to get on with their business
  ▪ Buy new farm machinery
  ▪ Sell flour to bakeries
4. Attitudes Towards Risk

*Risk Premium: Two Points of View*

- Amount a party to a contract is willing to pay or forego in order to **REDUCE** risk.
- Amount a party to a contract requires in payment in order to take on **MORE** risk.

Suppose a farmer F and miller M have the *same price forecast* $P^e$ for an uncertain September 1 spot price.

- **Case (a): F and M have same degree of risk aversion**
  - Neither F nor M has bargaining advantage when negotiating the strike price $P^f$
  - Most likely bargaining outcome is thus $P^f = P^e$
Case (b): F is more risk averse than M

- Miller M (buyer) can then negotiate a strike price $P_f$ lower than commonly expected future spot price $P_e$

- Farmer F (seller) will agree to a lower $P_f$ (rather than have no forward contract at all) because he gains more than Miller M from reduced risk

- $[P_e - P_f] > 0$: **Farmer F’s risk premium**
  $$= \text{amount foregone to reduce risk}$$
Case (c): M is more risk averse than F

- Farmer F (seller) can then negotiate a strike price $P^f$ higher than commonly expected future spot price $P^e$.

- Miller M (buyer) will agree to a higher $P^f$ (rather than no contract at all) because he gains more than the farmer from reduced risk.

- $[P^f - P^e] > 0$: Miller M’s risk premium = amount foregone to reduce risk
Risk Premiums and Forward Markets:

- Since there are numerous farmers and millers, separate forward markets for wheat can be organised for different future maturity dates at different locations.

- Wheat strike price determined in a wheat forward market for a specific maturity date & location will represent the aggregated expectations of farmers and millers regarding the spot price for wheat at this maturity date and location, plus some form of risk premium.
What if...

- Suppose farmers (sellers) are MORE risk averse than millers.
- Strike price < forecasted spot price (farmers “pay” risk premium).
- But **actual** spot price turns out to be much lower than strike price because of a bumper harvest!
What if...

• Farmers (sellers) breathe sigh of relief…
• Millers take big loss (pay strike price >> spot price).
• For the following year the millers ask for a much lower strike price.
• Is agreement between farmers and millers going to be possible?
5. Risk Diversification Through Futures Contracts

Dangers of Undiversified Risk:

- Farmers and millers deal only in wheat
- Their risk is undiversified
- Can only offset “good years” against “bad years”
- Risk remains high
- Reducing the risk further would help business
Benefits of Diversification:

• **Diversification** = Engage in trades that involve more than one commodity

• Helps to hedge against risks associated with any one commodity
Physical Participants vs. Speculators

• **Physical participants** (Kirschen/Strbac term, 2.4.3, p. 37)
  - Can produce, consume, and/or store a physical commodity
  - Face undiversified risk since they trade only in this one commodity

• **Speculators** (as defined by Kirschen/Strbac, 2.4.3, p. 36)
  - Do not produce, consume, or store physical commodities
  - Hence do not take **delivery** of physical commodities
  - Engage in commodity trades in an attempt to secure gain from anticipated future price movements
Speculators…Continued:

- Speculators can reduce costs for physical participants by sharing risks (because they tend to be less risk averse).

- **But speculators must balance their physical commodity positions (net zero) on date of delivery**
  - Quantity they buy must equal quantity they sell because they do not produce, consumer, or store physical commodities
  - On date of delivery they must buy or sell from spot market as necessary to achieve this balance

◆ Futures (standardized) contracts enable speculators to share risks while ensuring balanced physical commodity positions.
Futures Contract Illustration:

Wheat future contracts bought/sold on June 1, each requiring delivery on September 1.

- 2 tons at $110/ton
- 2 tons at $90/ton
- 1 ton at $95/ton
- 1 ton at $115/ton
Wheat sales by speculators on morning of September 1 at spot price $100/ton (needed to balance positions)

bought 2 tons at $110/ton
bought 1 ton at $95/ton
sold 1 ton at $115/ton

bought 2 tons at $90/ton
sold 1 ton at $95/ton

sold 2 tons at $110/ton
sold 2 tons at $90/ton

sells 2 tons at $100/ton
bought 1 ton at $115/ton

sells 1 ton at $100/ton
bought 1 ton at $115/ton

delivers 4 tons
“Opportunity Cost” Net $ Gains and Losses on Sept 1 from Futures/Spot Trades in Comparison With Spot-Trade-Only Outcomes

September 1 Spot Price = $100/ton

bought 2 tons at $110/ton
bought 1 ton at $95/ton
sold 1 ton at $115/ton
sold 2 tons at $100/ton
net gain: $ 0

sold 2 tons at $110/ton
sold 2 tons at $90/ton
net gain: $ 0

bought 2 tons at $90/ton
sold 1 ton at $95/ton
sold 1 ton at $100/ton
net gain: $15

net loss: $15
bought 1 ton at $115/ton
bought 3 tons at $100/ton
Importance of Information:

- In the previous example, the speculators are dealers who own some of the wheat before delivery to the miller.
- They carry price risk -- the risk of a change in the spot price of wheat -- during this ownership period.
- Need deep pockets.
- Without additional information, this is pure gambling.
- Information helps speculators make profits.

Examples of Relevant Information:

- Long term weather forecast and its effects on future wheat harvest, hence on the *farmer’s supply of wheat*.
- Long term forecasts regarding *retail demand for bread*.
- Effects of retail bread demand on miller’s need for flour, hence on the *miller’s demand for wheat*.
6. Risk-Hedging Through Options

- Spot trades, forward & future contracts
  ➜ unconditional (“firm”) delivery

- Options ➜ conditional delivery
  - *(European) Call Option* = Right (not obligation) to *buy* a specified quantity at a specified unit price on a specified future expiry date
  - *(European) Put Option* = Right (not obligation) to *sell* a specified quantity at a specified unit price on a specified future expiry date

- Two types of prices associated with each option contract:
  - *Exercise (or strike) price* = Specified unit price on expiry date
  - *Option fee (or premium)* = Price paid for the option itself on the day of option purchase, either through contractual arrangement (e.g., bilateral trade) or in a market at a price determined by demand and supply.
European Call Option: Example
Exercise Price = $100/ton, Quantity = 8 tons, Expiry Date = Day D, Option Fee = F

- **Call option value on D** = \([\text{spot price} - $100/\text{ton}] \times 8 \text{ tons}\) if spot price > $100/ton, otherwise $0

- If spot price on D is $90/ton, then call option value on D is $0/ton and call option is not exercised.

- If spot price on D is $110/ton, then call option value on D is $10/ton \times 8 \text{ tons} = $80 and call option is exercised.

- Call option holder will attain a positive net earnings from call option purchase if and only if call option value on D exceeds the option fee F.
European Put Option: Example
Exercise Price = $100/ton, Quantity = 8 tons, Expiry Date = Day D, Option Fee = F

• \textit{Put option value on D} = \[\$100/\text{ton} - \text{spot price}\] \times 8 \text{ tons} if \ $100/\text{ton} > \text{ spot price}, \text{ otherwise } \$0.\]

• If spot price on D is $90/ton, then put option value on D is $10/ton \times 8 \text{ tons} = $80 and put option is exercised.

• If spot price on D is $110/ton, then put option value on D is $0 and put option is not exercised.

• Put option holder will attain a positive net earnings from put option purchase if and only if put option value on D exceeds the option fee F.
Contract for Difference (CFD):

- Combination of a call and a put option for the same strike price $\Rightarrow$ CFD will always be exercised as long as the market price deviates from the strike price.

- **Example:** Buyer agrees to buy 50 tons of wheat from seller at a price of $100/ton on a future day D

**Case 1:**

- Day D spot price = $110/ton
- Buyer pays $5500 for 50 tons on Day D spot market
- Seller receives $5500 for 50 tons on Day D spot market
- Seller pays buyer $500
- Buyer *effectively* pays $5000, in accordance with CFD
- Seller *effectively* receives $5000, in accordance with CFD
Case 2:

- Day D spot price = $90/ton
- Buyer pays $4500 for 50 tons on Day D spot market
- Seller gets $4500 for 50 tons on Day D spot market
- Buyer pays seller $500
- Buyer *effectively* pays $5000, in accordance with CFD
- Seller *effectively* gets $5000, in accordance with CFD

- CFDs can insulate traders from actual market prices
- However, additional financial contracts are needed to provide buyers/sellers full insulation from price risk in markets with locational marginal pricing since buyers can pay different LMPs than sellers receive, given congestion.