# Commodity storage

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Notes

## Commodity storage

- Storage plays an important in stabalizing prices through time.
- The law of one price also applies through time.
  - Remember that the *law of one price* says that there is one price for a commodity once accounting for transaction costs.
- Storage allows for arbitrage between the market today and the market at a later time
- Examples of transaction costs through time:
  - Interest rate;
  - Storage;
  - Spoilage.



Notes

## Resources to understand the storage

- Cost of storing grain from ISU extension.
- Prices over space and time from Mindy Mallory textbook.



Notes

## Storage decision

- To understand the decision to store a commodity, we must compare the price of a commodity today and the expected price for that commodity at a later date.
- Write the price of a commodity today as $P_t$.
- Write today's expectations of the price of the commodity in the next period (e.g. next month) is $E_t P_{t+1}$.

## Price expectations

- Nobody knows the exact price in the next period but everybody can have expectations regarding the price in the next period.
- Market participants can form their expectations about prices in the future using different methods:
  - Price paid in the current period;
  - Projections from economists or other market analysts;
  - Futures prices;
  - Other heuristics.
- The futures price represents what the market thinks the price in the next period will be such that we can write $E_t P_{t+1} = F_t$, where $F_t$ is the current price of a futures contract that expires in the next period.
- However, an individual trader might not agree and his/her expectations of the future might not be the same as the market. For such a trader, is it possible that $E_t P_{t+1} > F_t$ or $E_t P_{t+1} < F_t$.



Notes

## Cost of storage

- Write that the unit-cost of storage per period for a commodity is $s$.
  - This includes all costs such as the physical cost of storage, spoilage and insurance.
  - Assume that it is constant through time (i.e. $s_t = s$).
  - Cost of storing grain provides values for the cost of storing grains. You can also use an excel sheet to check on the profitability of storing grain.
- Write the interest rate for one period as $r$.
  - The interest rate is the opportunity cost of holding money over time.
  - One dollar invested today is worth $1 + r$ dollars in the next period.
  - Or, one dollar in the next period is worth $\beta = \frac{1}{1+r} < 1$ dollars today.



Notes

## Convenience yield

- Write that $c_t$ is the *convenience yield* from holding the commodity for one more period.
  - It represents the gains from the flow of services from holding one unit of the commodity to the next period.
  - This is a very broad term that captures all sorts of gains from holding the commodity, including the gains from reducing uncertainty and breeding in the case of livestock.
  - As an example of the existence of a convenience yield, we can look at the 2012-13 crop year.
- There is good evidence that the convenience yield exists. To simplify here, assume that equals zero (i.e. $c_t = 0$).



Notes

## Return to storage

- The return from selling one unit of the commodity today is $P_t$.
- The expected return from selling one unit of the commodity in the next period is $\beta(E_t P_{t+1} - s)$.
- That is, the expected return is the expected price, minus the cost of storage for one period, all in today's dollars.



Notes

## Temporal arbitrage

- For the holder of a storable commodity, the question is "sell today or sell later?"
- Should sell today if the expected gain is larger then selling in the next period:

$$P_t \geq \beta(E_t P_{t+1} - s).$$

- Should sell later if the expected gain is larger then selling today:

$$\beta(E_t P_{t+1} - s) \geq P_t.$$

- The two inequalities above are the intertemporal arbitrage conditions.



Notes

## Temporal arbitrage - example

- Suppose that you can sell corn today at a price of \$3.25/bu.
- You consider storing a certain quantity of corn. The futures price for corn in March is \$3.90/bu and you expect that the basis in March will be -\$0.25/bu.
- Your cost of storage from the harvest (October) until March is \$0.35/bu.
- The annual interest rate is 6%.
- Given those expectations, should you store corn?



Notes

## Temporal arbitrage - example

- You expect that you'll be able to sell corn at \$3.65/bu = \$3.90/bu -\$0.25/bu.
- The interest rate from October to March (5 months) is $0.06 * 5/12 = 0.025$.
- A dollar in March is worth $0.9756 = 1/(1 + 0.025)$.
- Your expected return is $0.9756 * (\$3.65/bu - \$0.35/bu) = \$3.22/bu$.
- Given those expectations, should you store corn?



Notes

## Temporal arbitrage - example

- The answer is no, because you can earn \$0.03/bu (\$3.25/bu - \$3.22/bu) more by selling now versus selling in March.
- You can verify that if you storage cost is \$0.25/bu that it would be profitable for you to store corn between October and March.



Notes

## No-arbitrage temporal condition

- If intertemporal arbitrage holds, it means that

$$P_t = \beta(E_t P_{t+1} - s).$$

- What this expression says is that, because of arbitrage, the market pays the holder of a commodity his cost of carrying the commodity for one period.



Notes

## The basis through time

- Consider the cash price (right now) and the futures price (or the price under a forward contract) for a commodity.
- Remember that the price of a futures contract represents what the market thinks the price of a commodity will be at the expiration of the contract (i.e. $E_t P_{t+1} = F_t$).
- To focus on how the basis changes through time, **assume for now that the futures contract specifies a delivery location that is the same as the local cash market.** Thus, we assume for now that there are no spatial issues.
- Over time, the price of a futures and the cash price will tend to vary together because of intertemporal arbitrage - if possible.
- However, will the basis be positive or negative?
- The only thing that we know for sure is that the basis will be zero when the futures contract expires.



Notes

## The basis through time for a storable commodity

- For a storable commodity, intertemporal arbitrage is possible.
- This means that the holder of a commodity will make the decision to sell today or wait to sell later.
- This is possible because of storage.
- We can find a relationship in the price over time from the cost of storage and the cost of money (interest rate).



Notes

## Prices through time for a storable commodity

- The ability to arbitrage through time for storable commodities creates a relationship between prices over time.
  - If
$$P_t = \beta(F_t - s),$$
  - and that
$$E_t P_{t+1} = \beta(F_{t+1} - s),$$
  - it means that
$$P_t < F_t < F_{t+1} < ...$$
- That is, as time goes by, the price of a storable commodity should increase to compensate for the opportunity cost of holding the commodity (cost of storage).



Notes

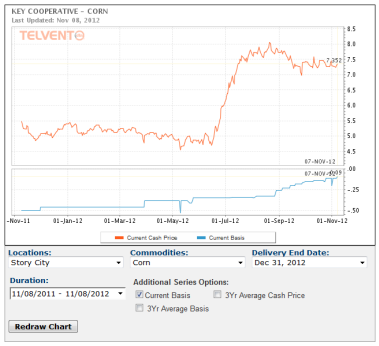
## The basis through time for a storable commodity

- The further from the expiration of a futures contract, the more negative is the basis.
- The implication is that the basis will narrow over time when approaching the expiration date of a contract.
- The relationship between prices at different periods may not hold all the time:
  - In particular, the relationship may not appear to hold because of changes in expectations regarding future prices. For example, a sudden shock may affect $F_t$.
  - It may not hold because of different crop seasons.



Notes

## Example of basis for corn through time




Source: Key cooperative.



Notes

## Information about the basis in Iowa

- The Extension service here at Iowa State compiled data regarding the basis.
- The webpage is available here.
- AMS publishes regional bases for Iowa.



Notes

## Definition: contango

- A market is in *contango* if the price of futures contract is higher than the price on the spot market.
- This is also referred as a *positive carrying charge market*.
- This is a direct consequence of intertemporal arbitrage described earlier.
- See futures prices on Barchart (not all are good examples).
- In the same crop year, the difference between futures price and the spot price reflects the price of storage.



Notes

## Definition: backwardation

- The price pattern between cash and futures prices described before may sometimes not hold.
- A situation where the cash price is higher than the price of a futures contract is referred to as *negative carrying charge* or *normal backwardation*.



Notes

## Backwardation

- Backwardation occurs when

$$P_t \geq \beta(E_t P_{t+1} - s).$$

- Backwardation is considered abnormal: how can it be sustained if commodity traders arbitrage between periods?
- One explanation for backwardation is that there is a small number of transactions. In such case, a risk premium might explain the inversion.
  - In a thin market, buyers may be willing to pay a premium to secure supply early because they fear that they will only be able to buy the commodity in the months ahead at a much higher price later.
  - The market is not paying for the cost of storage.
- Another explanation is a short-term shortage of deliverable stocks (i.e. there is no longer any stock available).



Notes

## Examples of arbitrage through time: storable commodity

- Hay bales;
- Grain elevators;
- Livestock (storing meat on hooves - possible but not for very long);
- Apples (perishable but storable for about 8 months);
- Canning;
- Beer and cheese are examples of storage.



Notes

## What about non-storable commodities?

- For a non-storable commodity, there is no intertemporal arbitrage:
  - One cannot hold onto a non-storable commodity in hope of selling it a higher price later.
  - For examples, fresh fruits can be stored but only for a short period of time.
- Thus, for non-storable commodities, the basis depends on the current market conditions and the expected conditions and the time of delivery for the futures contract.
- The markets for the commodity now and in the future are different.
- There is no link between the market today and the market in the future.



Notes

## In summary...

- The basis for a futures contract has both a time and spatial component.
- Thinking about the basis through time or through space is the same as it is the transaction cost that determine the basis:
  - Opportunity cost of holding a commodity through time;
  - Cost of transportation from one location to another;
  - Time only moves in one direction.
- The cash and futures prices may not converge exactly to the same value because:
  - The local cash market is not a terminal market;
  - Difference in quality;
  - Shocks for which the market takes time to adjust to.



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