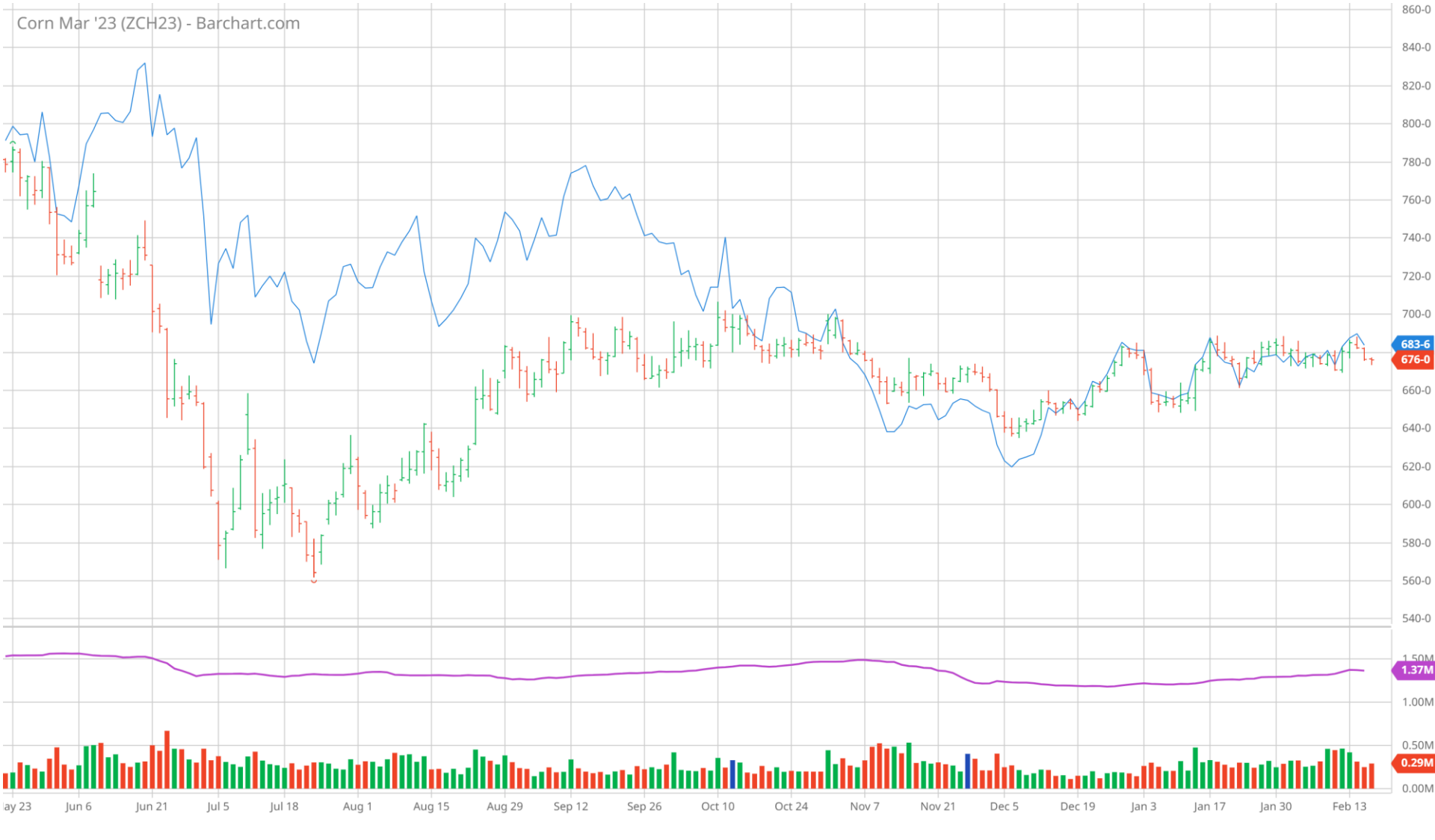
Hedging with Futures and Forwards

Chapter 13

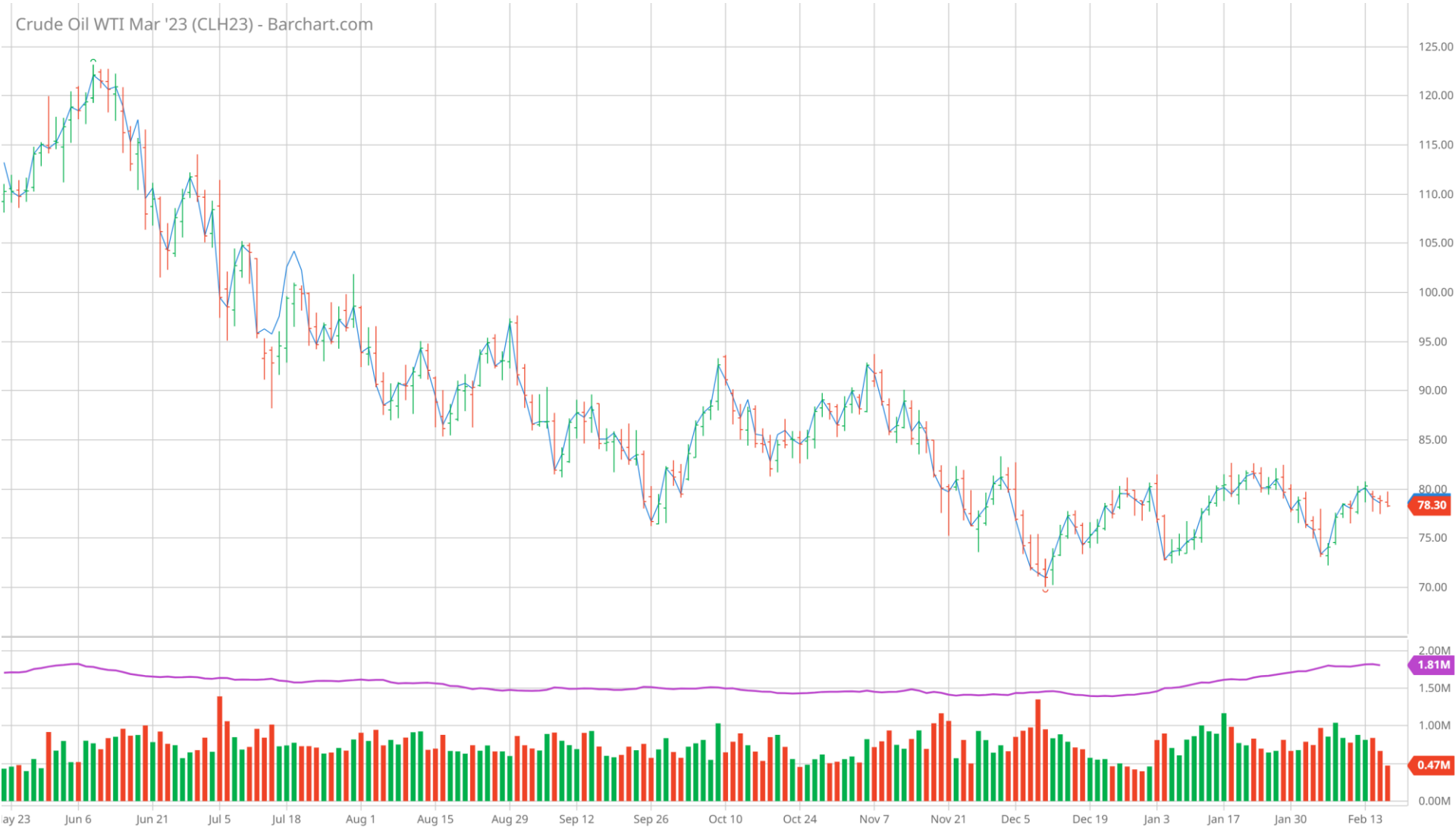
Definition of a Hedge

- A hedge is a position established in one market in an attempt to offset exposure to price fluctuations in some opposite position in another market with the goal of minimizing one's exposure to unwanted risk.
- The hedge position in the futures market is obtained by taking an equal and opposite position to the cash position.

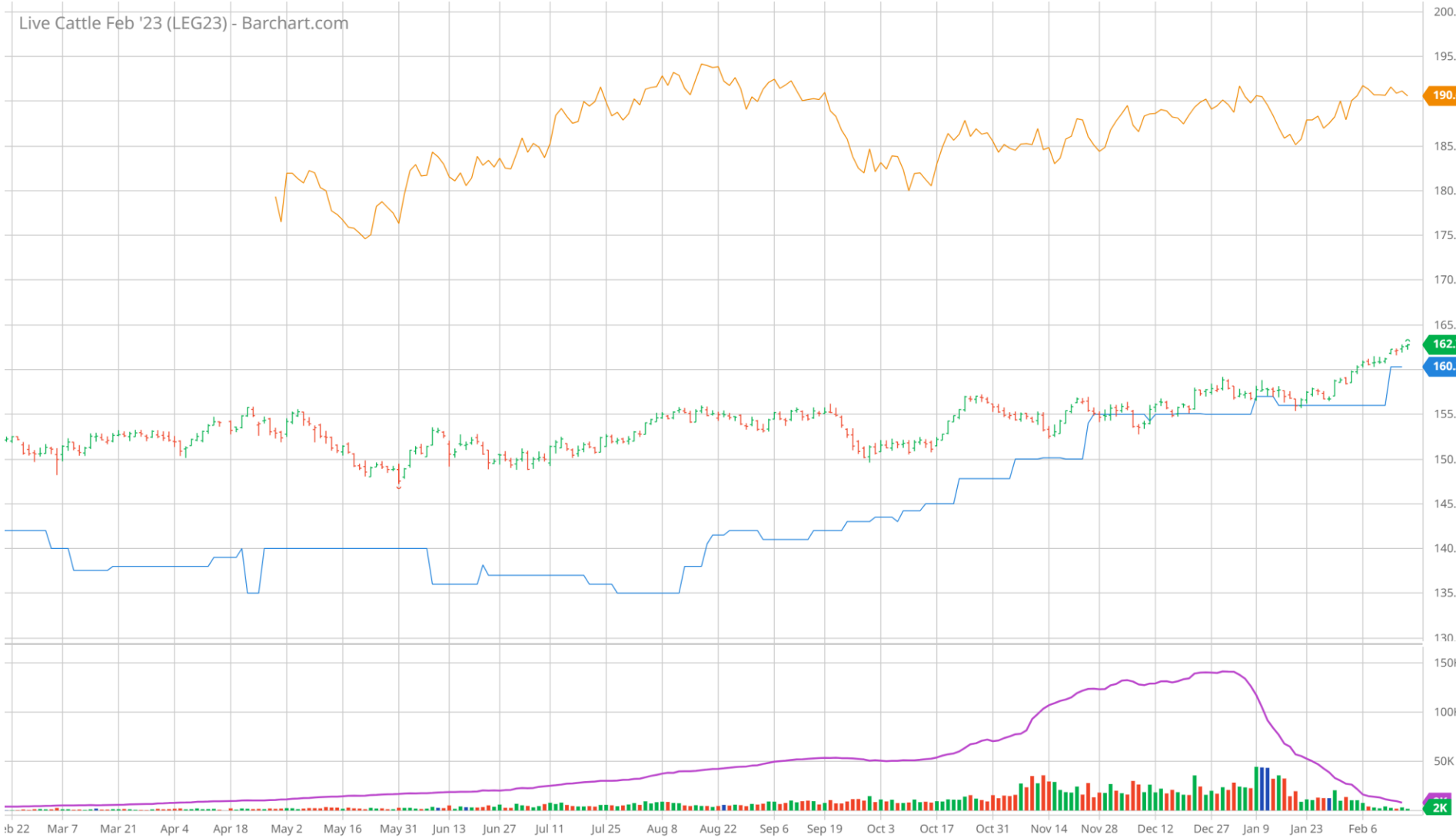
Corn Spot and March 23 Futures



WTI Crude Spot and March 23 Futures



Feeder and Live Cattle Spot and April 22 Futures



Concept of Basis

- Basis is defined as the price spread between the current spot price and the futures price to be used in the hedge
- $B = S(0) – f(t,T)$
- Depending on circumstance the spot price may not be perfectly correlated with the futures price.
- Correlation between cash and futures must be considered when making a hedge.
- Basis may expand or contract between the time that the hedge is placed and the time at which the hedge is lifted.

The Basis Defined

The basis is the difference between the current cash price of a commodity and the futures price for the same commodity.

$$Basis = S_0 - F_{0,T}$$

- S_0 = current spot price
- $F_{0,T}$ = current futures price for delivery of the product at time T
- The basis can be positive or negative
- Spot and futures prices move together usually but not always, so there is *basis risk*
- *Basis risk* is the main reason why futures do not perfectly reduce risk. Note, future basis is not known with certainty. Thus, the reason we call it basis *risk*

- In industry, basis= spot – futures
  - Basis is (usually) a negative number
- In academia, basis = futures – spot
  - Basis is (usually) a positive number
- Our definition will be consistent with business
- Say spot price is 300, futures price 340
- Spot price is 40 lower than futures
- We say "**basis is 40 under**"
- If spot price is 360 and futures 340
- We say "**basis is 20 over**"
- If **basis increases**, we say that the basis "**strengthens**"
- If **basis decreases**, we say that the basis "**weakens**"

The Basis

- The basis is the difference between cash and futures prices
- Basis Convergence
- Spot prices (cash prices) are local prices
- There is only one spot price in each geographical location
- Note that are many futures prices through time, but only one delivery point typically
  - E.g. corn, there is March 2016, May 2016, July 2016, September 2016, December 2016, etc.
- Typically, when people are speaking of basis, they are referring to the difference between a spot price and a specific futures price, usually the closest-to-maturity and at the delivery point

Basis Example

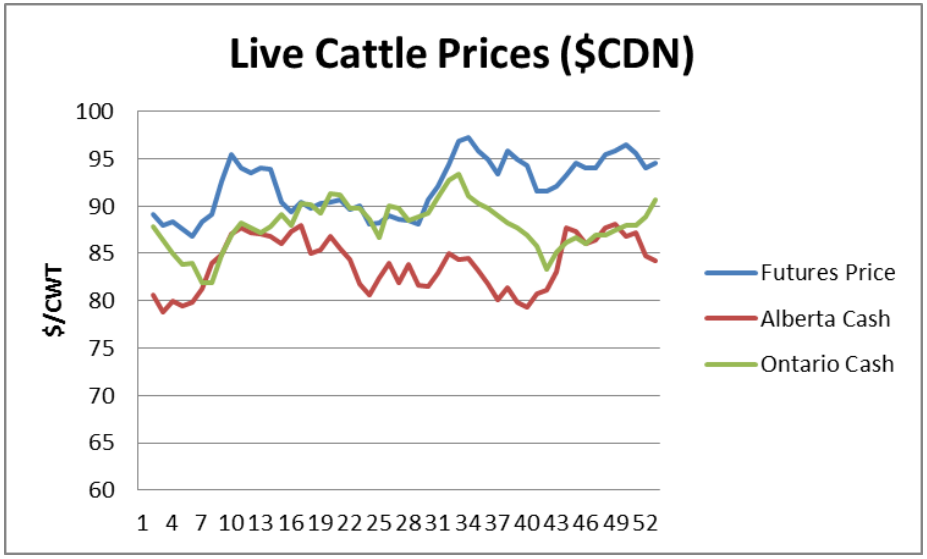
- The CME Dec Corn Futures Price is $4.00/bushel
- The spot price today at a delivery point of interest is $3.50.
- The basis is 3.50-4.00 = -.50
- What if the spot price increases to $3.75? The basis has ‘strengthened’ to -0.25
- What if spot price increases to $4.50? The basis has ‘strengthened’ to +0.50
- What if spot price decreases to $3.00? Basis has ‘weakened’ to -1.00

Spot, Futures and Basis

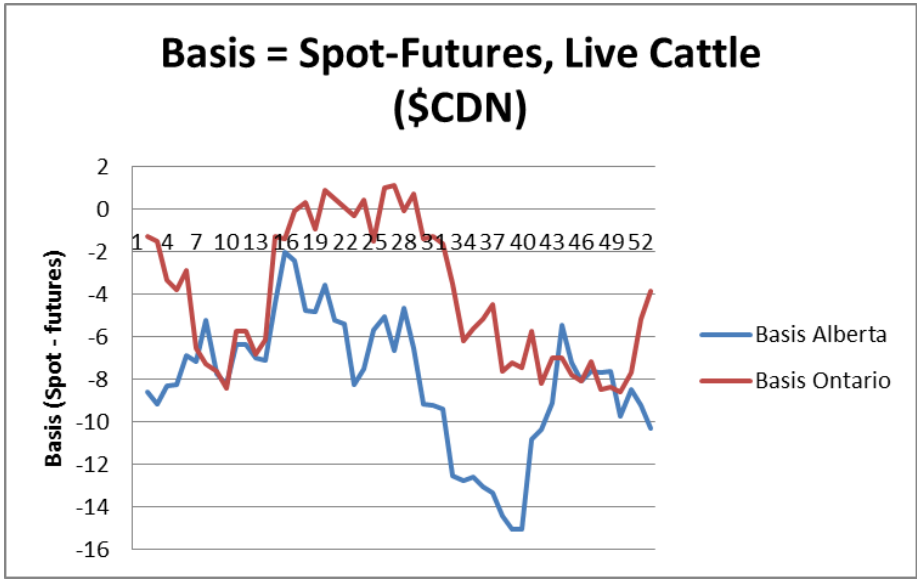
Week	Futures Price	Alberta Cash	Ontario Cash	Basis Alberta	Basis Ontario
3-Jan-97	89.17	80.56	87.88	-8.61	-1.29
10-Jan-97	87.97	78.78	86.46	-9.19	-1.51
17-Jan-97	88.35	80.02	85	-8.33	-3.35
24-Jan-97	87.62	79.39	83.84	-8.23	-3.78
31-Jan-97	86.8	79.9	83.93	-6.9	-2.87
7-Feb-97	88.38	81.22	81.86	-7.16	-6.52
14-Feb-97	89.14	83.94	81.84	-5.2	-7.3
21-Feb-97	92.56	84.82	84.91	-7.74	-7.65
28-Feb-97	95.39	87.12	86.94	-8.27	-8.45
7-Mar-97	94.02	87.65	88.27	-6.37	-5.75
14-Mar-97	93.47	87.13	87.73	-6.34	-5.74
21-Mar-97	94.07	87.05	87.23	-7.02	-6.84
28-Mar-97	93.91	86.79	87.77	-7.12	-6.14
4-Apr-97	90.43	86.03	89.13	-4.4	-1.3
11-Apr-97	89.33	87.33	87.94	-2	-1.39
18-Apr-97	90.38	87.96	90.28	-2.42	-0.1
25-Apr-97	89.81	85.03	90.13	-4.78	0.32

Spot, Futures and Basis

Spot and Futures Prices



Basis = Spot - Futures



Basis Risk 1

$$Basis_t = S_t - F_t$$

$$\sigma^2_{Basis} = \sigma^2_S + \sigma^2_F - 2\rho_{S,F}\sigma_S\sigma_F$$

- Basis risk is defined by variance of spot price + variance of futures price less covariance between spot and futures where $\rho_{S,F}$ is correlation between spot and futures

Basis Risk 2

Use regression definition

$$S_t = a + \beta F_t + \varepsilon_t$$

$$E\left[S_t\right] = a + \beta E\left[F_t\right] + 0$$

$$\sigma_S^2 = \beta^2 \sigma_F^2 + \sigma_\varepsilon^2$$

$$\beta = \frac{\rho_{S,F}\sigma_S\sigma_F}{\sigma_F^2}$$

- Regression of spot against Futures
- Expected spot is related to futures
- Variance of spot based on systematic risk or risk correlated with futures plus non-systematic or uncorrelated risk
- $\beta^2\sigma_F^2$ σ_ε^2
- Beta coefficient measures covariance between spot and futures as in index

Convergence of Spot and Futures

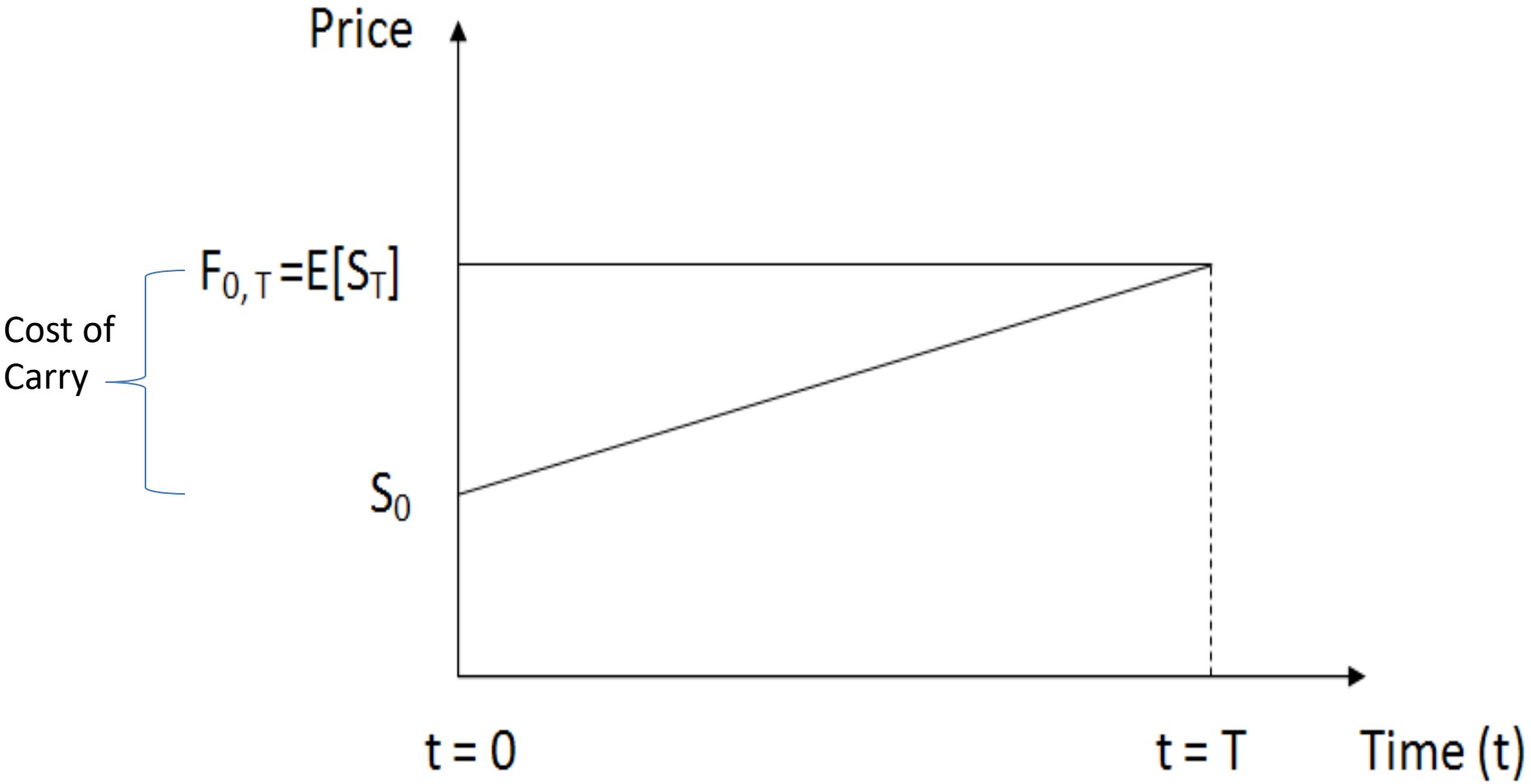
- The basis will typically be larger and also riskier for distant spot markets locations
- Why do we care about basis risk? Reliable hedging depends on a basis that does not vary too much. Understanding basis risk will better help us understand our hedge.
- Nevertheless, basis risk is usually much smaller than price risk, providing an incentive for hedgers to use futures markets to manage risk.

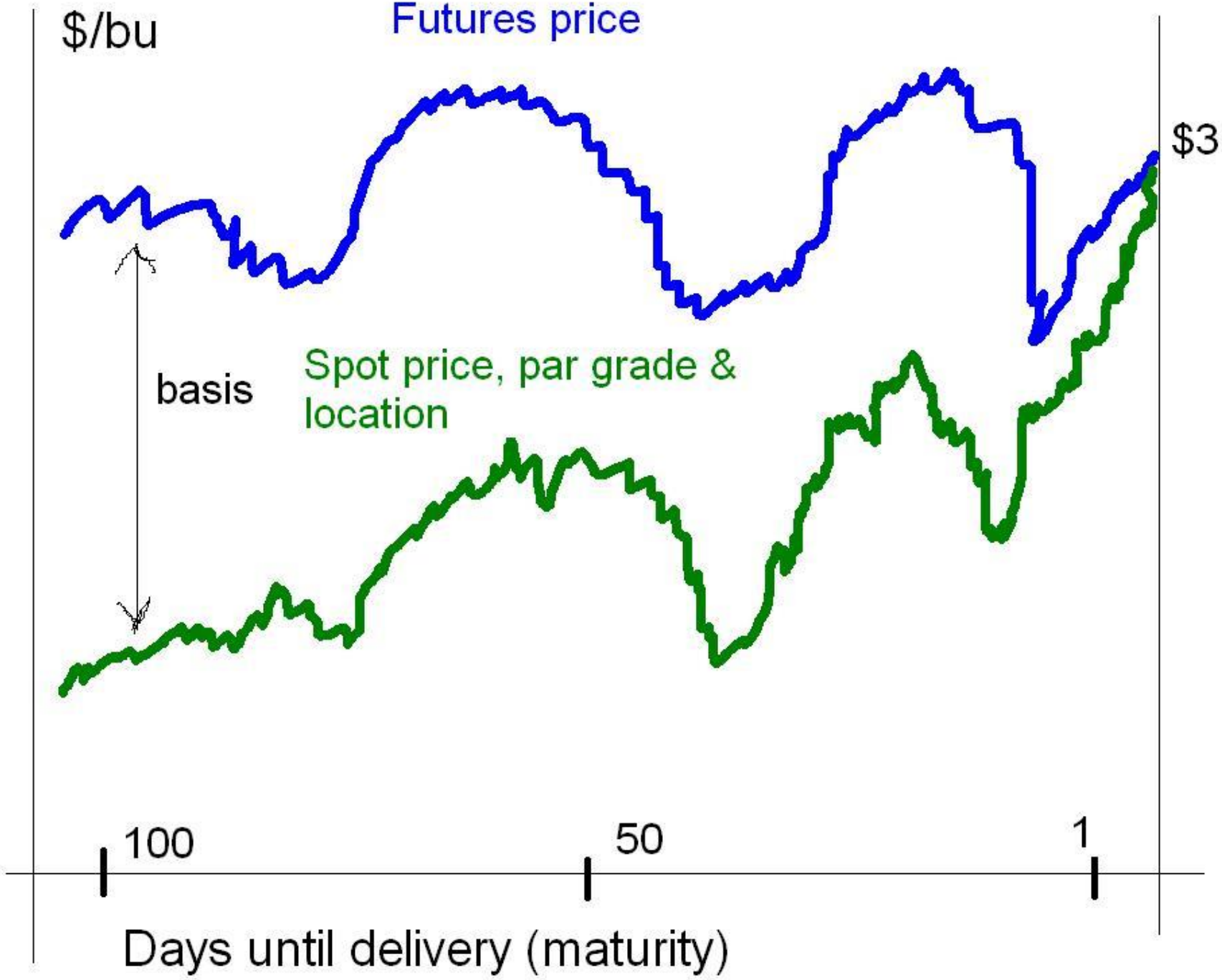
As maturity (delivery) date nears, the futures price should approach the spot price ("converge") so that at maturity, futures price equals spot price, **when grade and location are par**.

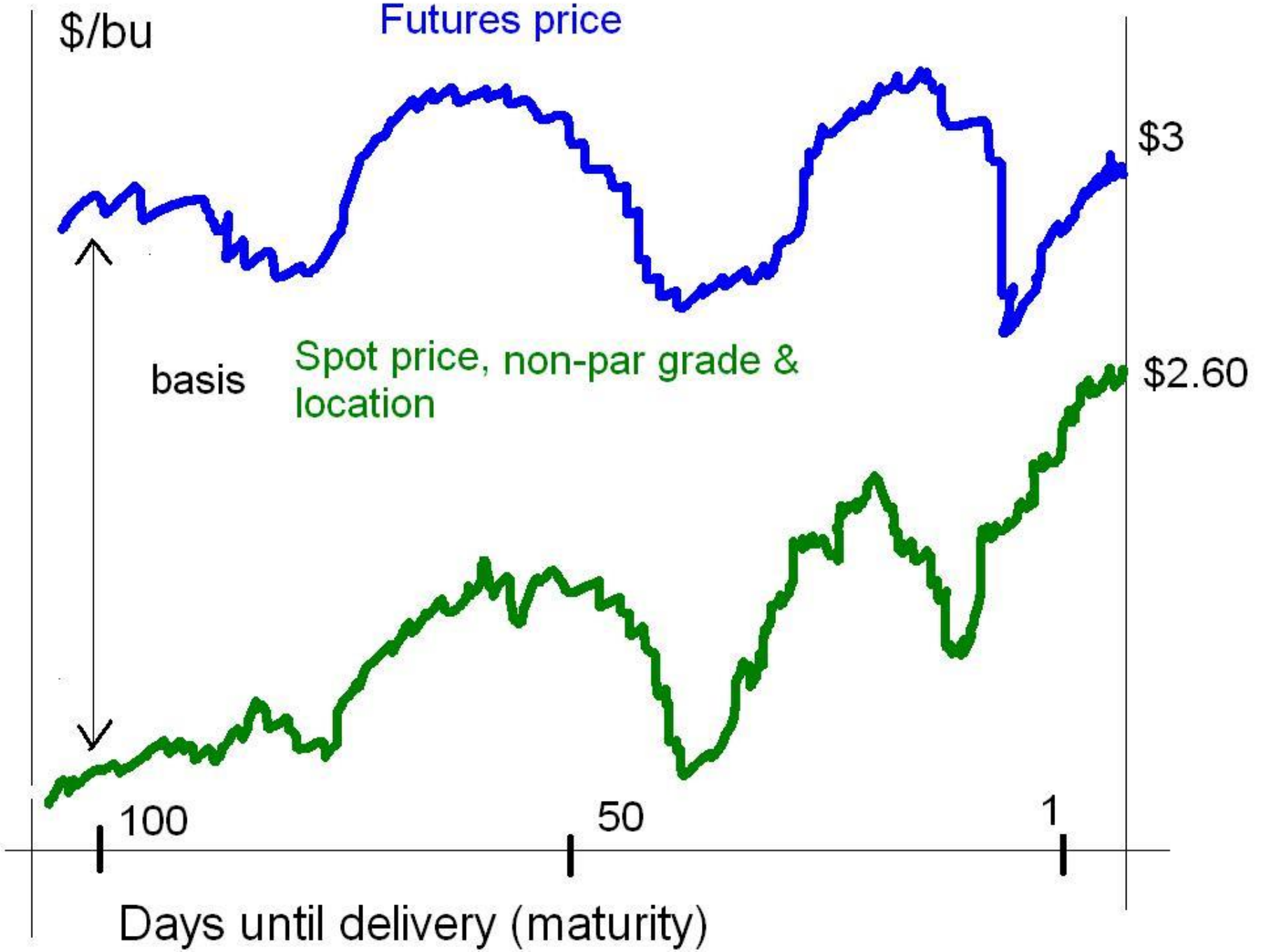
- In practice there is always a some difference caused by transaction costs and other limits to arbitrage

- However, if the spot location considered is not the delivery point, or if the grade is non-par, then substantial differences can arise

Convergence of Spot and Futures Prices Thru Time (storables)




$/bu
Futures price
$3
basis
Spot price, par grade & location
100
50
1
Days until delivery (maturity)


$/bu
Futures price
$3
basis
Spot price, non-par grade & location
$2.60
100
50
1
Days until delivery (maturity)

Convergence of Spot and Futures

- Futures and spot prices will tend to *converge* as we approach expiration of the contract. Why? Because the ability to make/take delivery on the futures contract will create arbitrage opportunities unless the prices converge.
- Convergence will be strong at and very near to the delivery points in the futures contract at expiration.
- As we move farther away from the delivery points, the relationship will be governed mainly by transportation costs

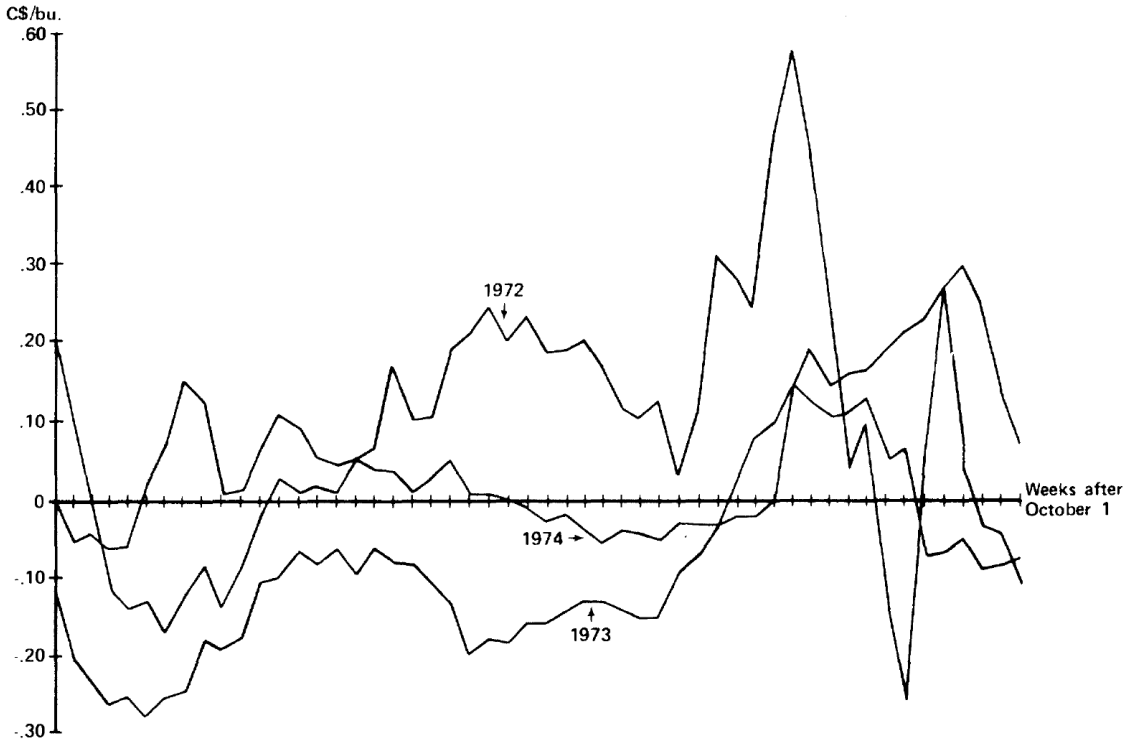
Basis and Convergence Through Time

- So, what determines the basis at any point in time? What about the relationship between the current spot price and the expected future spot price?
- For storable commodities, mainly:

1. Location and transportation costs are the single biggest determinant, including a sudden shortage of barges/rail cars
2. A surprise bumper (large) crop or surplus stocks and limited storage can cause spot prices to fall and basis to "weaken" (become larger)
3. Conversely, a poor harvest or tight inventories cause spot price to rise and basis to strengthen
4. Need for liquidity: producer needs money now, sells spot instead of storing, spot price falls

- Today we will talk mostly about storable commodities

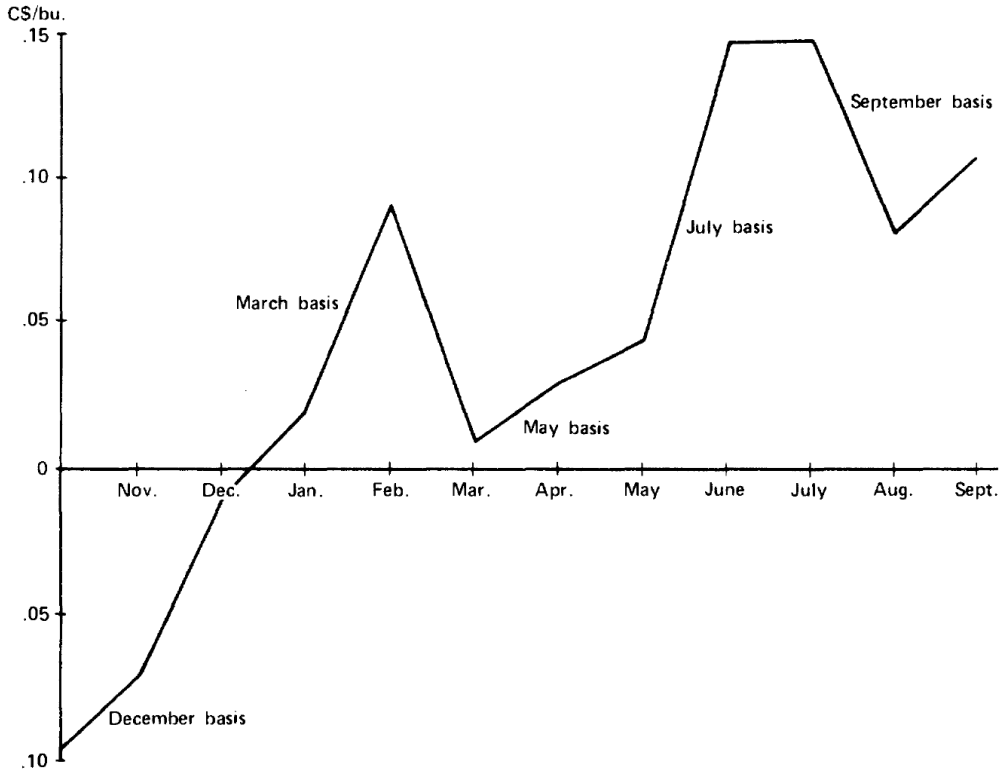
Weekly Basis, Chatham Ont. Source: Martin et al



Note: See footnote [2] for explanation of figure.

Figure 1. Weekly basis for corn, Chatham, Ontario, crop years Oct.–Sept. 1972, 1974, 1975

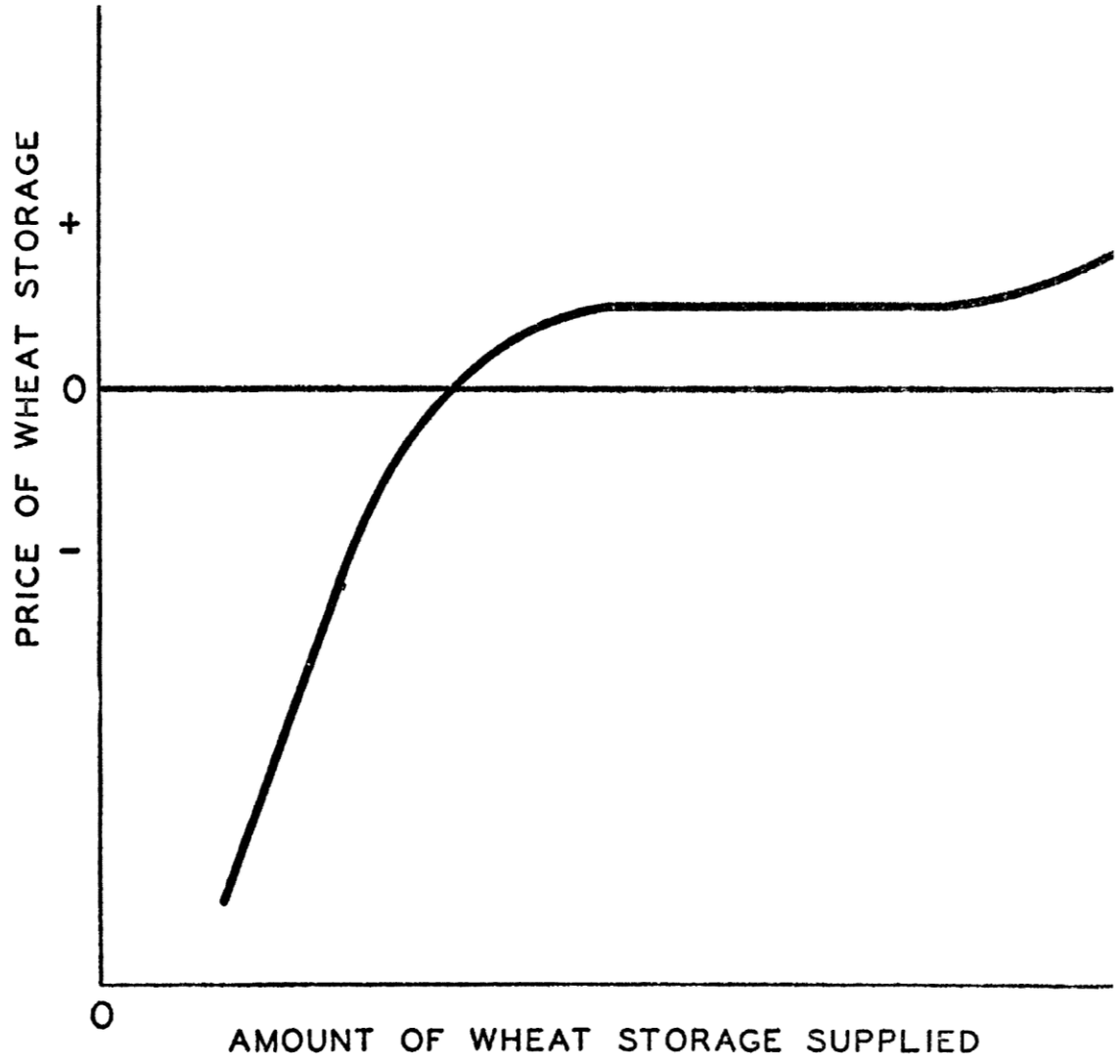
Monthly Corn Basis, St. Lawrence Seaway Effect source:Martin et al.



Note: See footnote [2] for explanation of figure.

Figure 2. Monthly corn basis, averaged over crop years 1971–75, Chatham, Ontario

H. Working and Theory of Storage



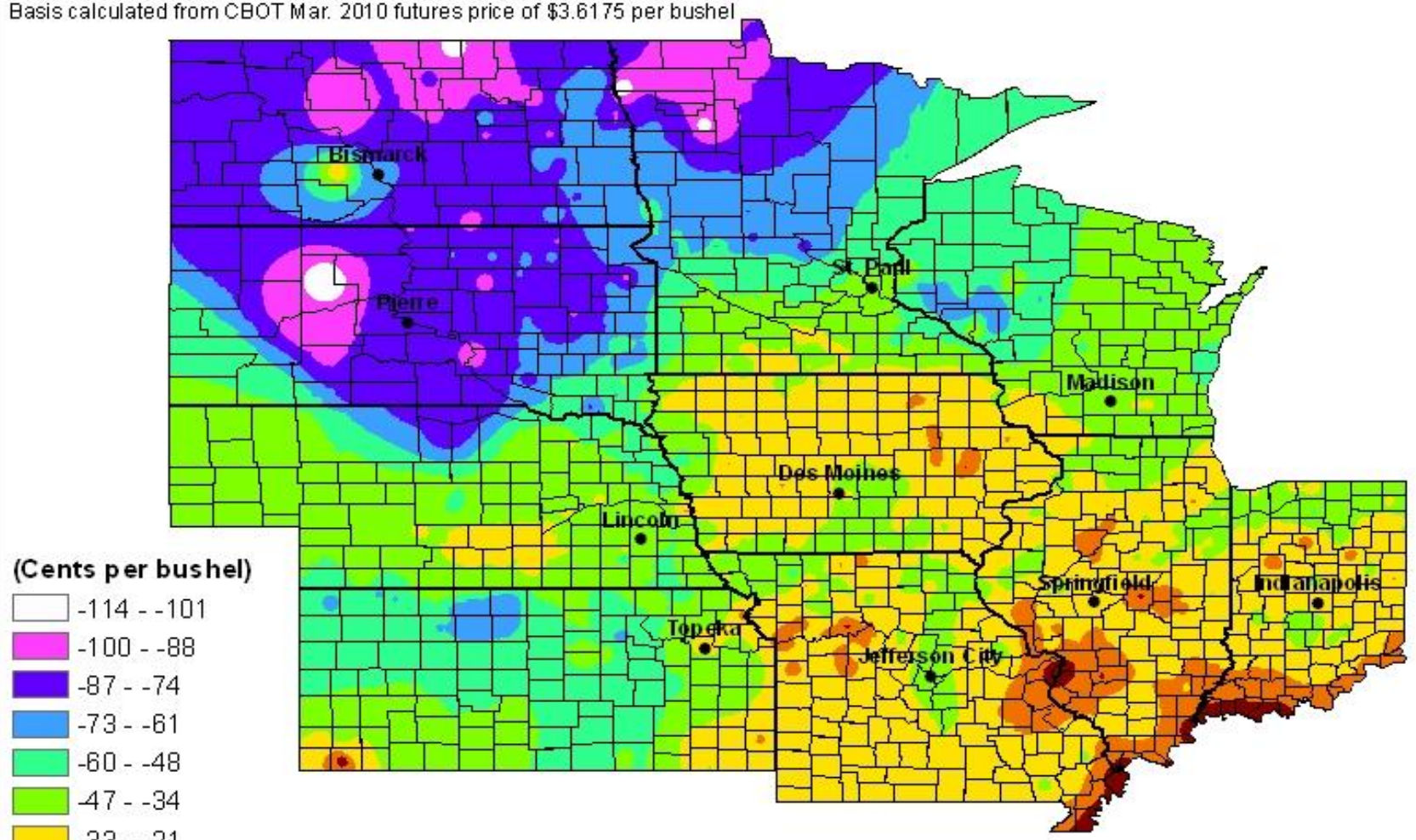
If there is a return to storage then storage will increase
Return to storage caused by higher future demand relative to supply
Storage allows demand to be met
Can get negative returns to storage on weak supply of commodity, excess capacity in storage… negative returns might be accepted because of 'Kaldor's Convenience Yield'

Basis at Different Locations

- Note, basis is a local concept. For each geographical location there is a local spot price, hence a local basis
- The basis will tend to be smaller as you get near the delivery points specified in the futures contract, and larger as you get farther away
- Basis will also tend to *converge* more so near the futures delivery points, and vice-a-versa as we move away from the delivery points

Jan. 28, 2010 Corn Basis

Basis calculated from CBOT Mar. 2010 futures price of $3.6175 per bushel



Jan. 28, 2010 Corn Basis

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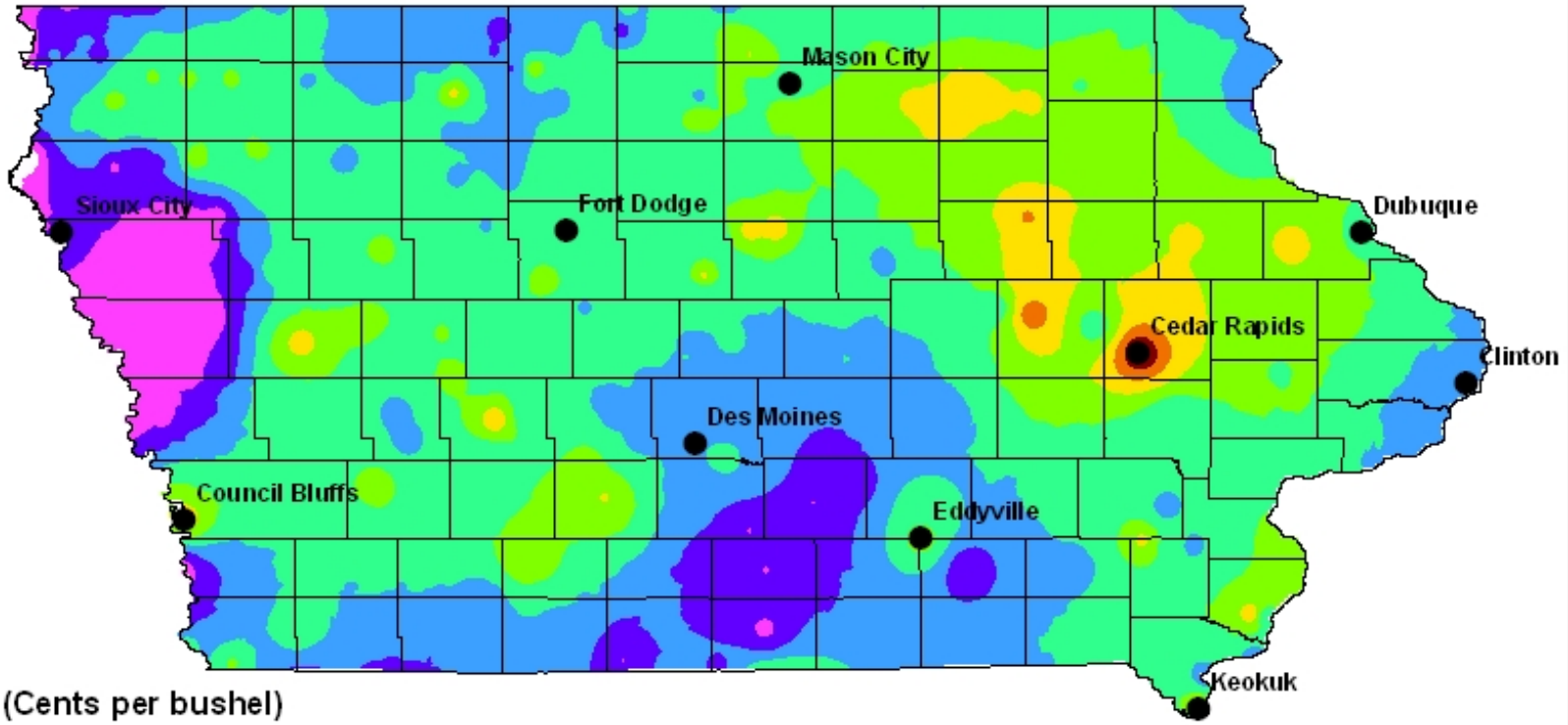


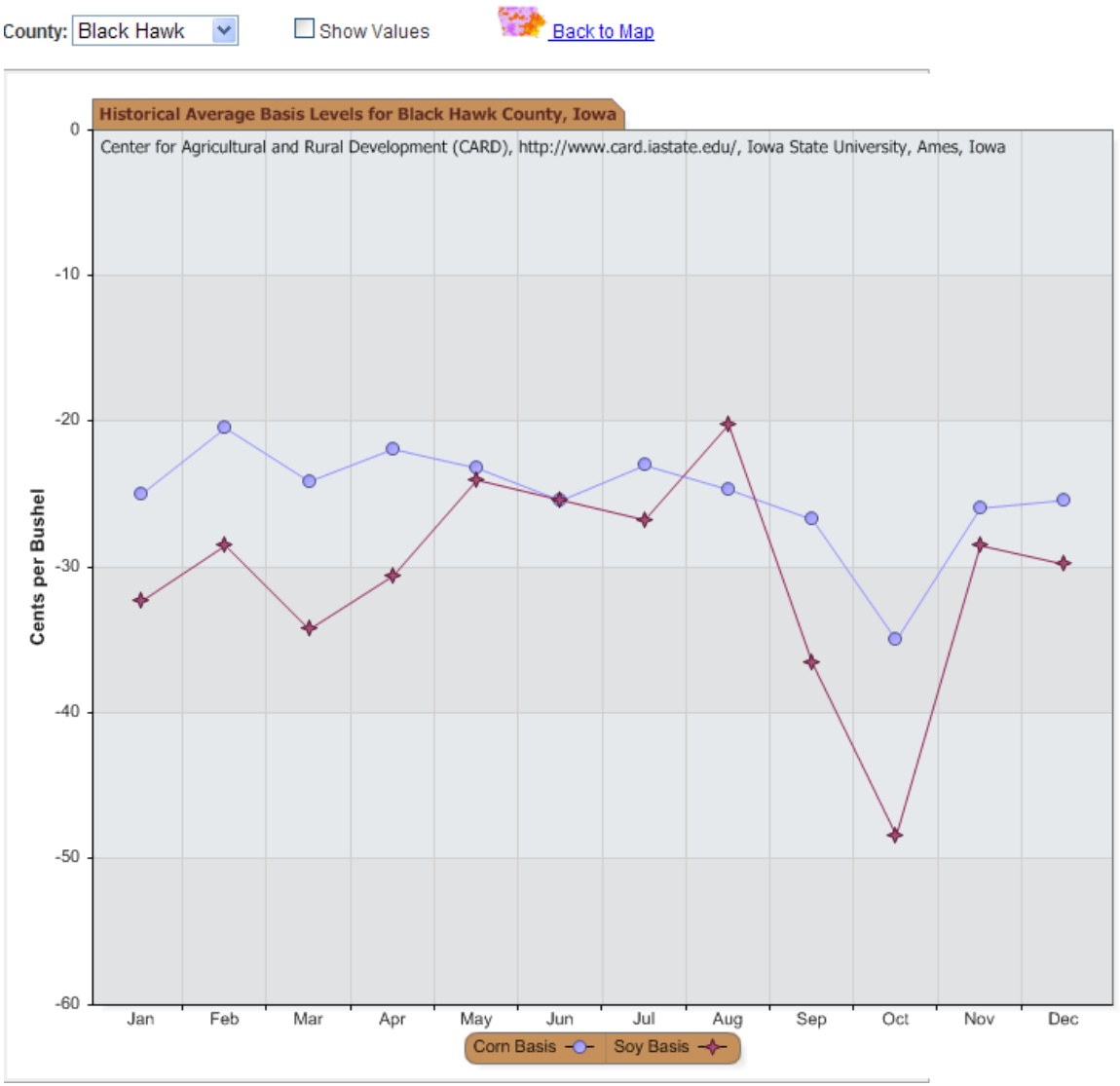
(Cents per bushel)

- -54 - -49
- -48 - -44
- -43 - -38
- -37 - -33
- -32 - -27
- -26 - -22
- -21 - -17
- -16 - -11
- -10 - -6

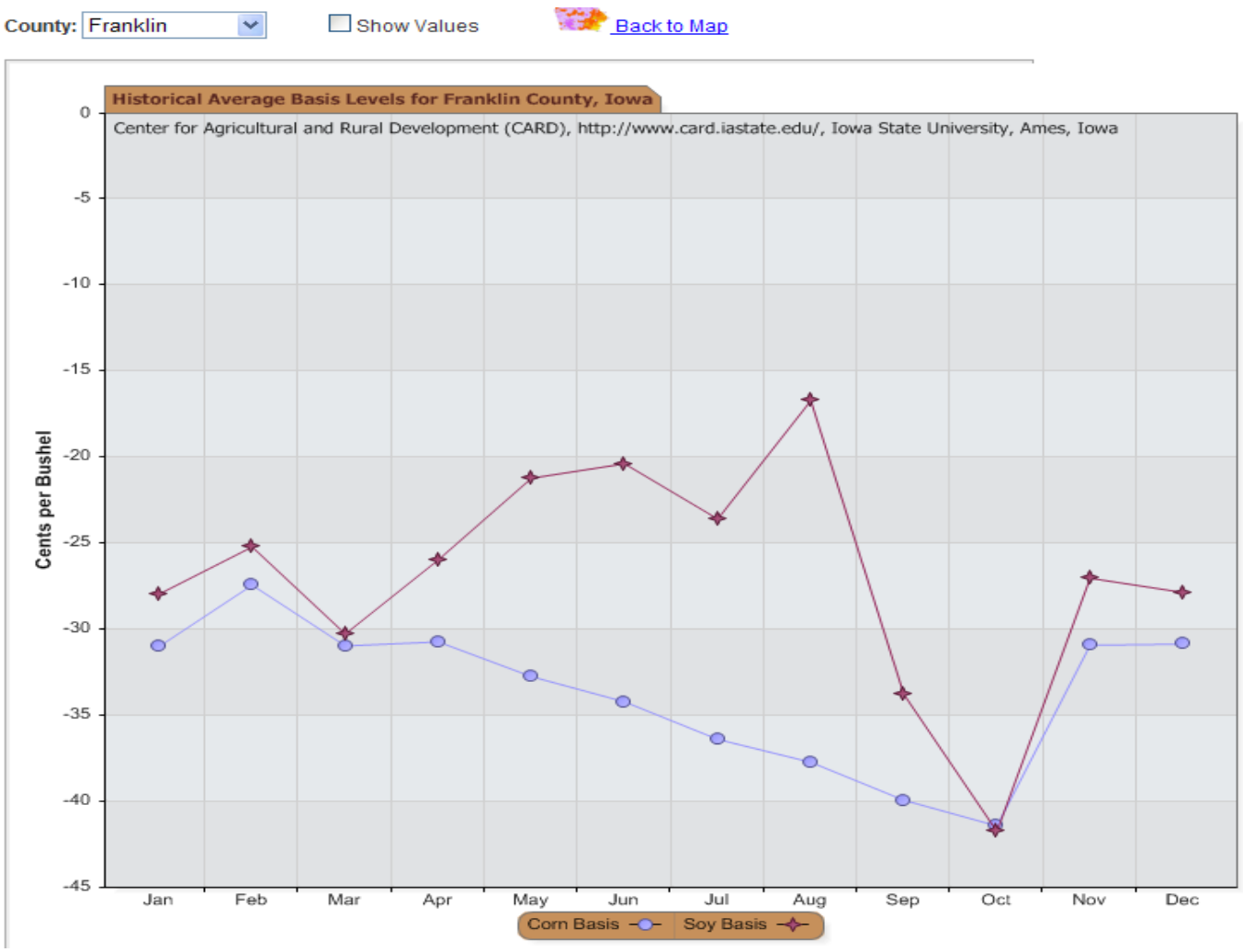
Storable Commodities

- Commodities that can be stored for some period of time
- There is a cost of carrying or holding the physical commodity (cost of carry, or carrying charges)
- Markets for storable commodities are known as carrying charge markets
- Traders can carry the physical instrument from today to the next delivery month, or from one delivery month to a more distant delivery month

Historical Basis Corn and Soybeans Blackhawk County Iowa

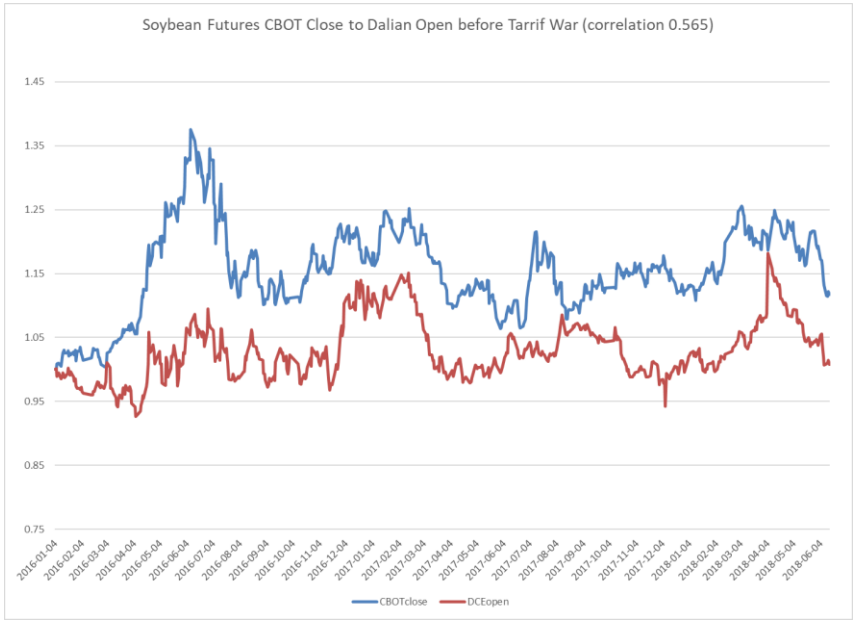


Historical Basis Corn and Soybeans Franklin County Iowa

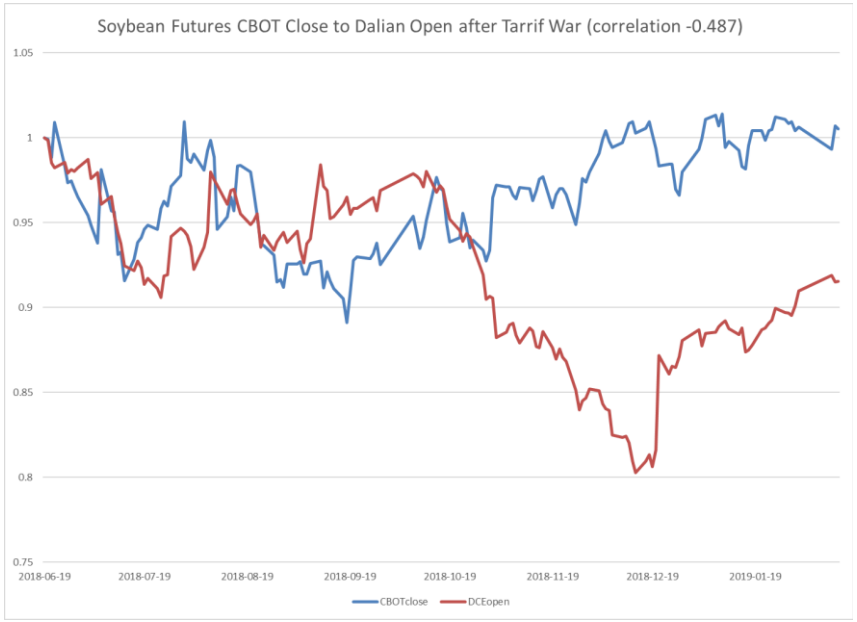


USA – China Soybean Futures and Trade War CBOT-Dalian

CBOT Close-Dalian Open BEFORE

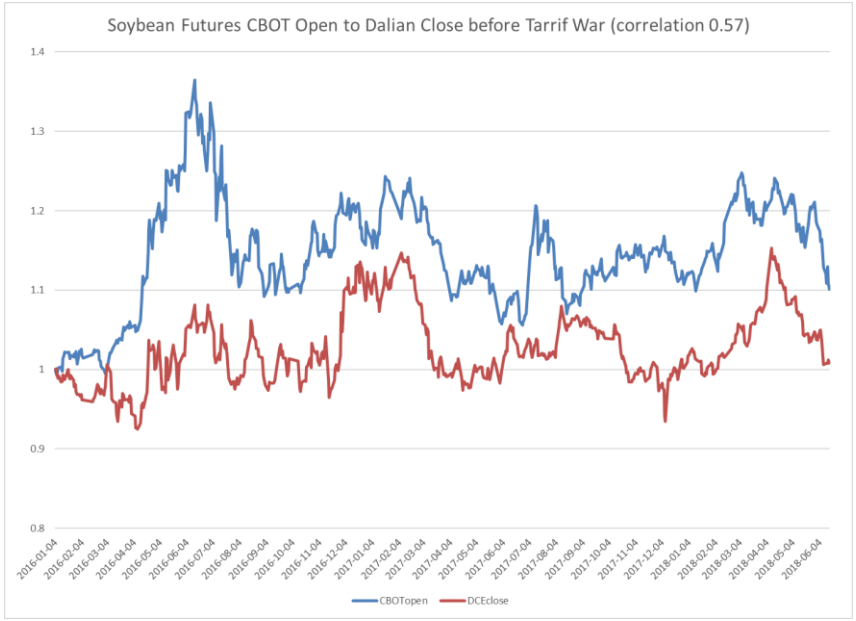


CBOT Close-Dalian Open AFTER

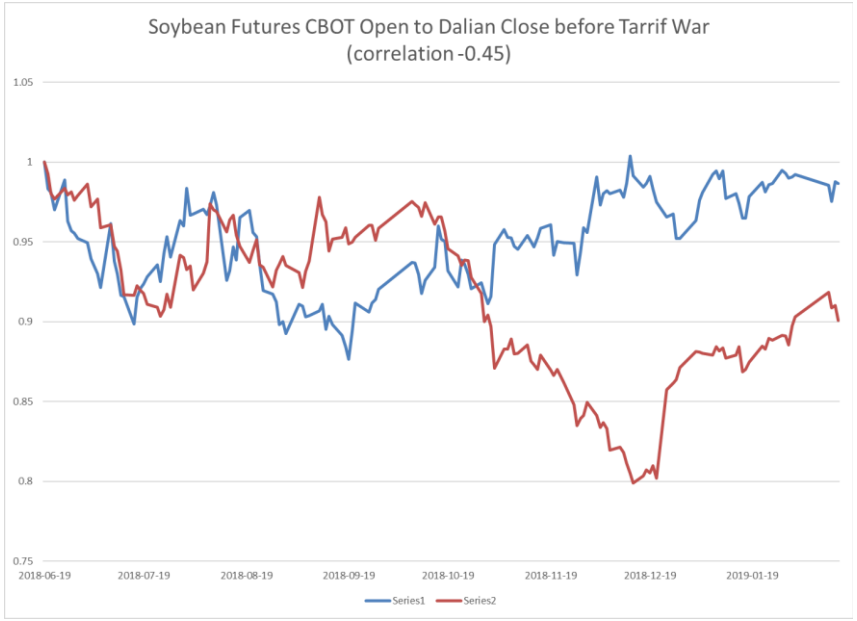


USA – China Soybean Futures and Trade War CBOT-Dalian

Dalian Close-CBOT Open BEFORE



Dalian Close-CBOT Open BEFORE



Basis and Hedging Transactions

- Long in asset (i.e. own asset)
- Gain in hedge
  - = Initial cash/spot price plus change in basis
  - $=S(0) +(B(T)-B(0))$
  - $=S(0)+ (S(T)-f(T))-(S(0)-f(0))$
  - $=S(T) + f(0)-f(T)$
  - =sale of commodity + gain/loss on futures

Hedge Example with Short Futures to hedge Price Decrease. Hedger is 'long' commodity at t=0 (owns commodity) and plans to sell at t=T. In delaying sale, the cash price falls from 290 to 250 resulting in a 40 loss (because selling for less). To protect against price fall a short position in commodity futures is acquired at t=0 for 300 with an offsetting long position at t=T at 255 for a gain of 45. Relative to original price of 290 the loss of 40 in cash market is offset by 45 gain in futures, so net is 295.

	Time=0	Time=T	Gain/Loss
Cash	Buy S(0)	Sell S(T)	S(T)-S(0)
Futures	Short F(0,T)	Long F(T,T)	F(0,T)- F(T,T)
Basis	S(0)-F(0,T)	S(T)-F(T,T)	(S(T)-F(T,T))-(S(0)-F(0,T))

	Time=0	Time=T	Gain/Loss
Cash (long at t=0)	(owns) 290	(sells) 250	-40
Futures (Short, sell)	(Short) 300	(long) 255	45
Basis	-10	-5	5
Net Cash Position =	290+5 (change in basis)	Sell at 250+45 gain in futures	=295

Hedge Example with Short Futures to hedge against Price Increase. Hedger is 'long' commodity at t=0 (owns commodity) and plans to sell at t=T. In delaying sale, the cash price increases from 290 to 350 resulting in a 60 gain (because selling for more). To protect against price reduction a short position in commodity futures is acquired at t=0 for 300 with an offsetting long position at t=T at 355 for a loss of 55. Relative to original price of 290 the gain of 60 in cash market is offset by 55 loss in futures, so net is only 295.

	Time=0	Time=T	Gain/Loss
Cash	Buy S(0)	Sell S(T)	S(T)-S(0)
Futures	Short F(0,T)	Long F(T,T)	F(0,T)- F(T,T)
Basis	S(0)-F(0,T)	S(T)-F(T,T)	(S(T)-F(T,T))-(S(0)-F(0,T))

	Time=0	Time=T	Gain/Loss
Cash (long at t=0)	(owns) 290	(sells) 350	+60
Futures (Short, sell)	Short 300	Long 355	-55
Basis	-10	-5	+5
Net Cash Position =	290+5 (change in basis)	350 – 55 (loss from futures)	= 295

Hedge Example with Long Futures to hedge Price Increase. Hedger is 'short' commodity at t=0 (e.g. does not own commodity) but needs to purchase by t=T. In delaying purchase, cash price decreases from 290 to 250 resulting in a 40 gain (because buying for less). To protect against price rise take out long position in commodity futures at t=0 for 300 and sell at time T at 255 for a loss of 45. Relative to original price of 290 the gain of 40 in cash market is offset by 45 loss in futures, so net cost is only 295.

	Time=0	Time=T	Gain/Loss
Cash	S(0)	Buy S(T)	S(T)-S(0)
Futures	Long F(0,T)	Short F(T,T)	F(T,T)- F(0,T)
Basis	S(0)-F(0,T)	S(T)-F(T,T)	(S(T)-F(T,T))-(S(0)-F(0,T))

	Time=0	Time=T	Gain/Loss
Cash (long at t=T)	290	Buy 250	40
Futures (Long, buy)	Long 300	Short 255	-45
Basis	-10	-5	5
Net Cash Position =	290+ 5 (change in basis)	250 + 45 (loss in futures)	=295

Hedge Example with Long Futures to Hedge Price Increase. Hedger is 'short' commodity at t=0 but needs to purchase by t=T. In delaying purchase, cash price increases from 290 to 350 costing 60 more. To protect against price rise take out long position in commodity futures at t=0 for 300 and sell at time T at 355 for a gain of 55. Relative to initial price of 290 the loss of 60 in cash market is offset by 55 gain in futures, so net cost is only 295.

	Time=0	Time=T	Gain/Loss
Cash	S(0)	Buy S(T)	S(T)-S(0)
Futures	Long F(0,T)	Short F(T,T)	F(T,T)- F(0,T)
Basis	S(0)-F(0,T)	S(T)-F(T,T)	(S(T)-F(T,T))-(S(0)-F(0,T))

	Time=0	Time=T	Gain/Loss
Cash (long at t=T)	290	Buy 350	-60
Futures (Long, buy)	Long 300	Short 355	+55
Basis	-10	-5	5
Net Cash Position =	290+5 (change in basis)	350-55 (gain in futures)	+5=295

Minimum Variance Hedge

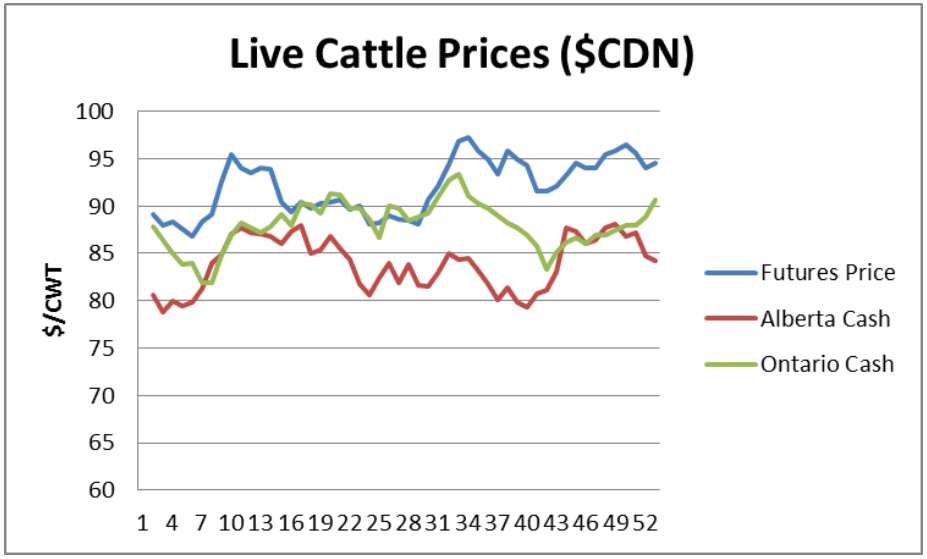
- When cash and futures are not perfectly correlated it may not be optimal to hedge 100% of cash position (e.g. crop in field or crop in storage)
- H = Covariance(S(t,T),f(t,T)) / Variance(f(t,T))
- Proof provided on board and also in Chapter 6

Minimum Variance Hedge Derived

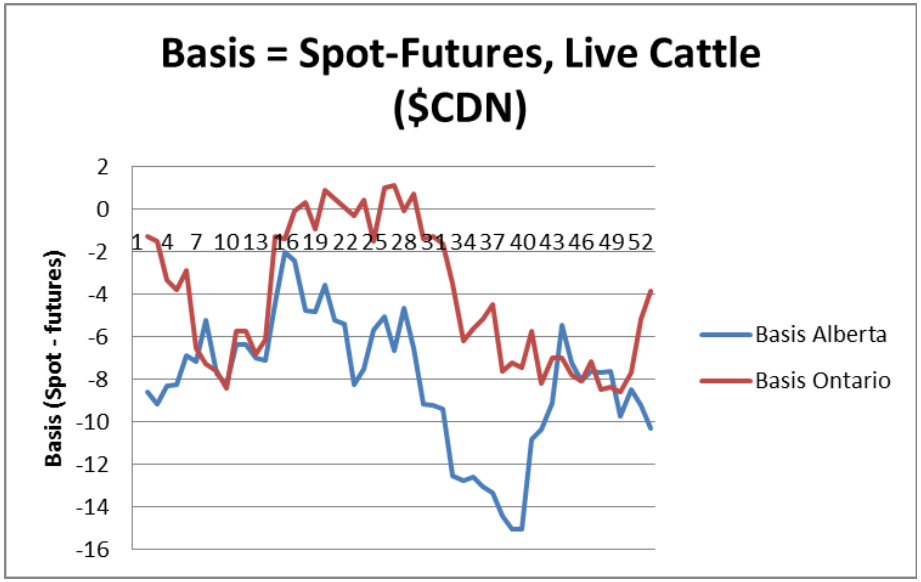
- Profits for firm with output Q, price P, hedge ratio h, and futures f are
- $\pi = PQ + hQ\left(f_0 - f_T\right)$
- With variance $\sigma_\pi^2 = Q^2\sigma_P^2 + h^2Q^2\sigma_f^2 - 2hQ^2\rho_{Pf}\sigma_p\sigma_f$
- Taking derivative $\frac{\partial\sigma_\pi^2}{\partial h} = 2Q^2\left(h\sigma_f^2 - Cov\left(P, f\right)\right) = 0$
- Solving for hedge ratio $h = \frac{Cov\left(P, f\right)}{\sigma_f^2}$
- Obtain h from simple regression $P_t = a + hf_t + e$
  - Note $Cov\left(P, f\right) = \rho_{Pf}\sigma_p\sigma_f$

Spot, Futures and Basis

Spot and Futures Prices



Basis = Spot - Futures



Calculating Minimum Variance Hedge Ratio for Alberta Live Cattle in Excel

$$P_t = a + hf_t + e$$

SUMMARY OUTPUT

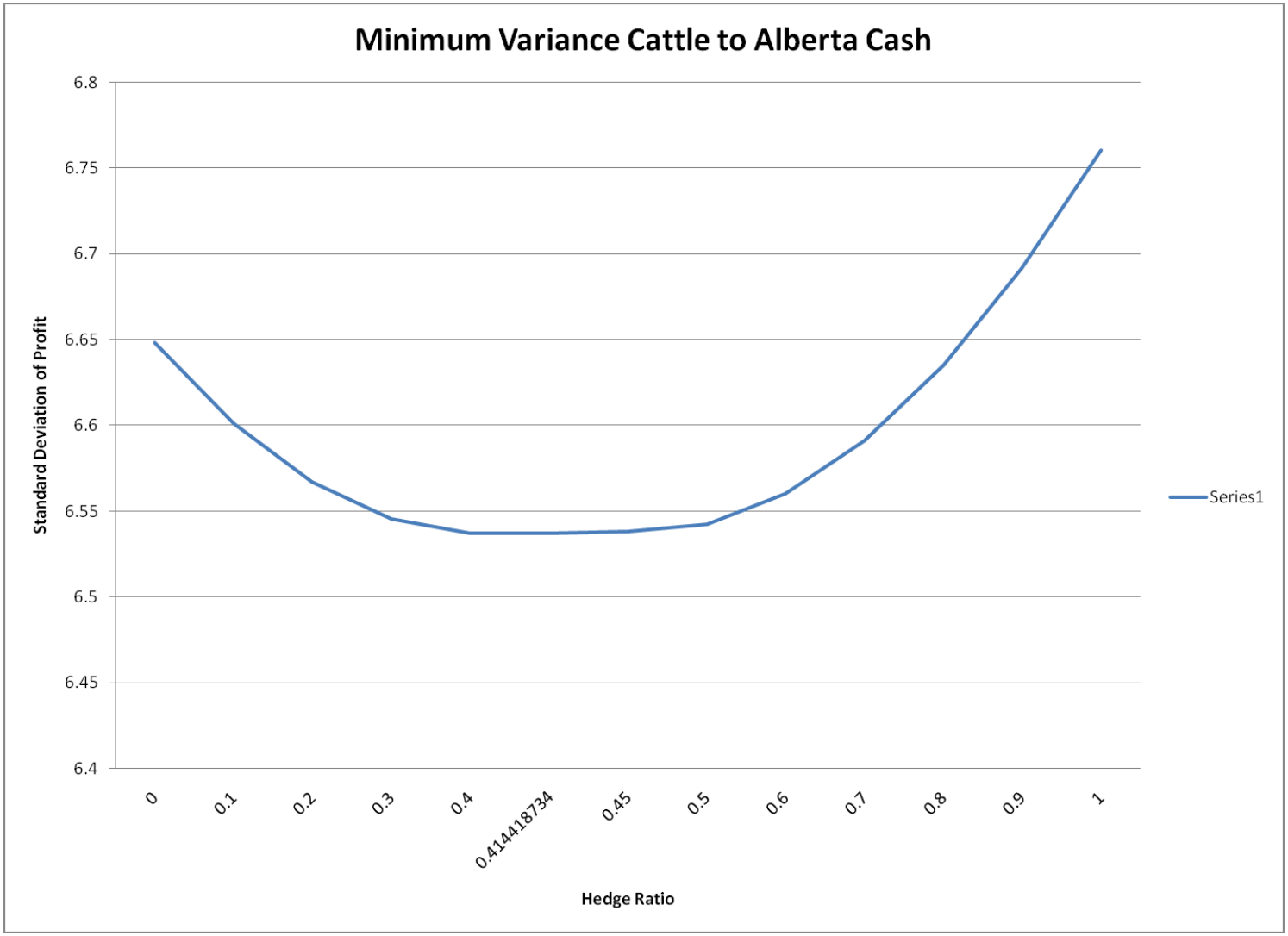
Regression Statistics	
Multiple R	0.433351
R Square	0.187793
Adjusted F	0.171549
Standard E	2.556806
Observatio	52

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	75.57523	75.57523	11.5607	0.001331
Residual	50	326.8628	6.537256		
Total	51	402.438			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	45.78617	11.22347	4.079502	0.000162	23.24316	68.32919	23.24316	68.32919
X Variable	0.414419	0.121884	3.400102	0.001331	0.169607	0.65923	0.169607	0.65923

Minimum Variance Hedge



Additional Considerations

- If no futures available on good or commodity then find futures contract that is highly correlated with good or commodity and institute a cross-hedge (e.g. Sohrgum and corn; oil and airplane fuel; oil engineering firm and oil etc)
  - Basis defined by 'difference of form' – imperfect subtitutions
- Use of index futures to hedge portfolio risk for pension funds and mutual funds and asset managers… CAPM Beta is good proxy for hedge ratio
- Tax loss carryforwards may encourage hedging to lock in a sure profit against which accumulated tax loss carryforwards can be applied.
- Hedge swap positions with interest or foreign exchange futures