# Synthetic Options: Potential Usefulness and Effectiveness in Agriculture

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# Options Overview

- Useful tool in hedging risk, allows upside and downside potential
  - Numerous payout patterns attainable
- Usefulness is limited in many agricultural settings
  - Options markets are less liquid than futures markets
  - Limited by large contract size trading requirements
- Synthetic options can be used in place of real options in some situations

# Synthetic Options

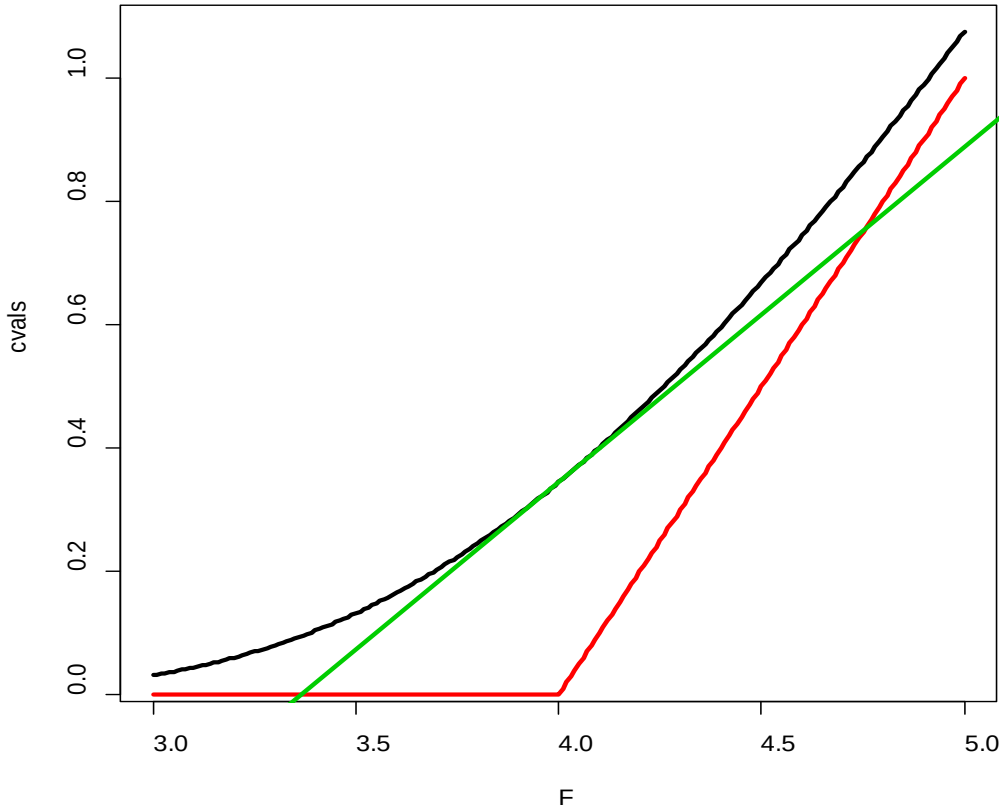
- Constructed using underlying futures
  - Futures markets usually much more liquid
  - Firms already have substantial presence in futures markets
- Allow for more flexibility
  - Contract size
  - Payoff provisions
  - Maturity

# Disadvantages of Synthetic Options

- Constructed by taking the option's "Delta" position in underlying futures market
  - Accurate approximation for small daily changes
  - Less accurate with larger jumps in daily futures prices
- Requires daily rebalancing of delta (Δ)
  - Uses dynamic hedging — More transactions than a single static option purchase
  - Requires daily computation of individual and aggregate delta position

# Constructing a Synthetic Option

- Take Δ-Position in underlying futures




Example:

F = $4

K = $4

Volatility = 0.25

r = 0.01, dT = ¾

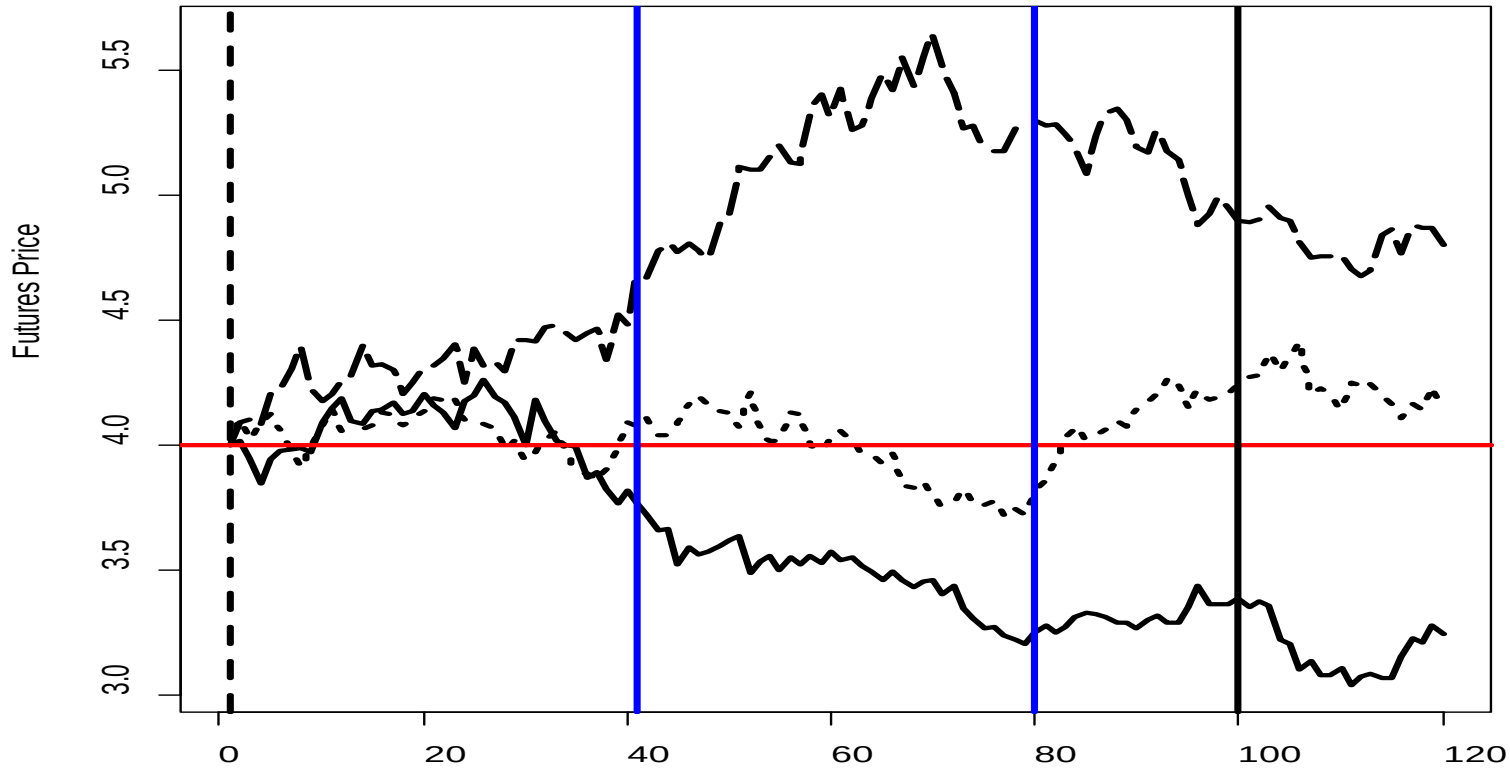
BSM ⇒ cval ~ $0.342

Δ ~ 0.539

# Contract Specifications

- On day zero → $F_0$ = $4.00
  - Producer agrees to deliver Q bushels on delivery date $t_D$ = 100.
- Pricing window → $(t_1, t_2)$ = (41,80)
  - nwin = $(t_2 - t_1) + 1$ days in window.
- Producer selects a price floor K = $4.00 (strike price)
- Truncated price computed as $\underline{F_t}$ = max$(F_t, K)$
- Producer can "call out" on any day $t_c$ in $[t_1, t_2]$
  - All remaining $\underline{F_t}$ set at $F_{t_c}$ for t in $[t_c, t_2]$
- The price received by producer PR is average of $\underline{F_t}$ over the days $(t_1, t_2)$ = (41,80)
- Producer charged the market price of call option with strike price K on day $t_0$ .
  - If K > $F_0$, the producer's option charge is increased by $(K - F_0)$
  - If K<$F_0$, the producer's option charge is reduced by $(F_0 - K)$

# Elevator “Upside” Forward Contract




- Explained to producer as “selling” bushels each day of the averaging window

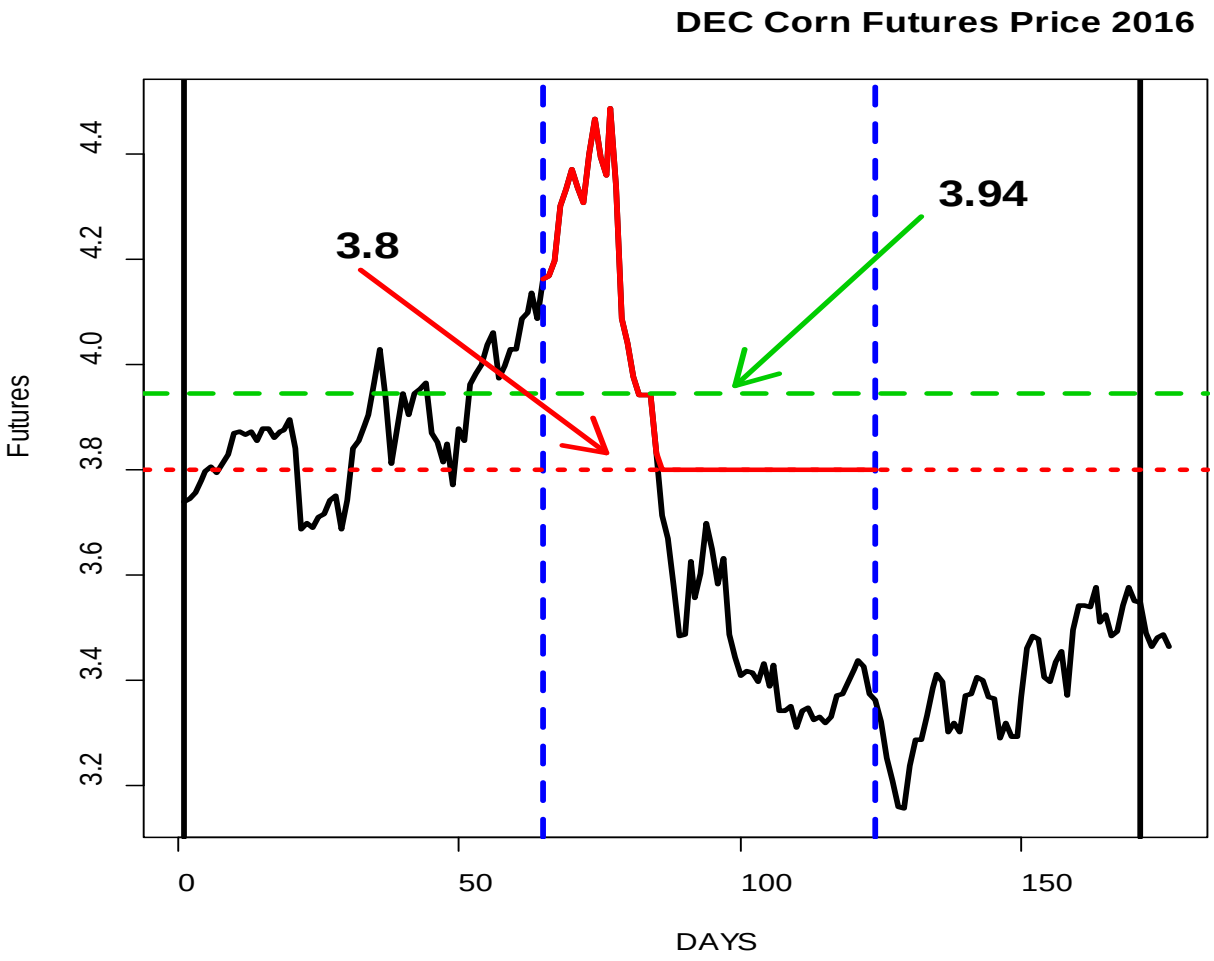
# Buyer's Hedging Process

- Buyer can construct riskless hedge with following process
  - Short Q futures bushels on day $t_0$
  - Long Q call options on day $t_0$
- Charge producer for Q call options on day $t_0$
- Close out q bushel of options each day of pricing window —selling q options each day
  - Note:  for all t  Commonly a "profit" for buyer
- Close out Q short futures position on delivery date

# March 1, 2016 Example

- $T_0$ = March 1, 2016
- Producer agrees to deliver Q = 12000 bushels of corn on October 31, 2016.
  - Contract priced using DEC 2016 corn futures contract.
- = $3.7375, K = $3.80, = $0.2525, In/Out-of-money adjustment = $3.80 - $3.7375 = $0.0625
  - Producer charged $0.3125 per bushel
- Producer selects averaging window
  - 6/1/2016 – 8/24/2016 giving a 60 day window
  - Options to sell off daily during window → q = 200

# DEC Corn Futures Price 2016



# Payout to Buyer and Producer

- Assume that Buyer sells delivered grain of day  for 10/31/2016 futures price of = $3.5475.
- Buyer closes out short futures position on day .
  - Buyer gains amount
- Examine two days in pricing window 6/1/2016 and 8/24/2016
  - ,  = $0.510  Producer price
  - ,  = $0.03375  Producer price =

# Buyer's Gains on 6/1/2016 and 8/24/2016

| | | DATE | |
|---|---|---|---|
| | 6/1/2016 | | 8/24/2016 |
| Initial futures price | 3.73750 | | 3.73750 |
| Price floor | 3.80000 | | 3.80000 |
| Initial option price | 0.25250 | | 0.25250 |
| "Moneyness" charge | 0.06250 | | 0.06250 |
| Initial producer charge | 0.31500 | | 0.31500 |
| | | | |
| Ending sales price | 3.54750 | | 3.54750 |
| Less Price paid producer | -4.16200 | | -3.80000 |
| Plus initial producer charge | 0.31500 | | 0.31500 |
| Less initial cost of option | -0.25250 | | -0.25250 |
| Plus price received for option sale | 0.51000 | | 0.03375 |
| Plus gain on short futures position | 0.19000 | | 0.19000 |
| | | | |
| Net Gain on Given Day | 0.14800 | | 0.03375 |
| | | | |
| Price received from option sale | 0.51000 | | 0.03375 |
| Less max( Ft-K) | -0.36200 | | 0.00000 |
| | | | |
| Net Gain on Given Day | 0.14800 | | 0.03375 |

# Buyer's Profits

- Over the time period 6/1/2016 – 8/24/2016
- Average call price $0.2551
- Average $\max(F_t - K)$ = $3.94 - $3.80 = $0.14
- ⇒ Buyer profit (ignoring transaction costs) of $0.2551 - $0.14 = $0.1151
- Zero probability of having  a loss

# Problems and Complications

- Actually using calls to hedge this contract may not be possible
  - Insufficient liquidity in options markets
    - Especially when “strike price” is far in or out of the money on a given day
  - Buyer may have insufficient scale to aggregate q units across contracts to be able to sell q options each day.

# Problems and Complications

Consider synthetic options

– Usually more liquid futures markets

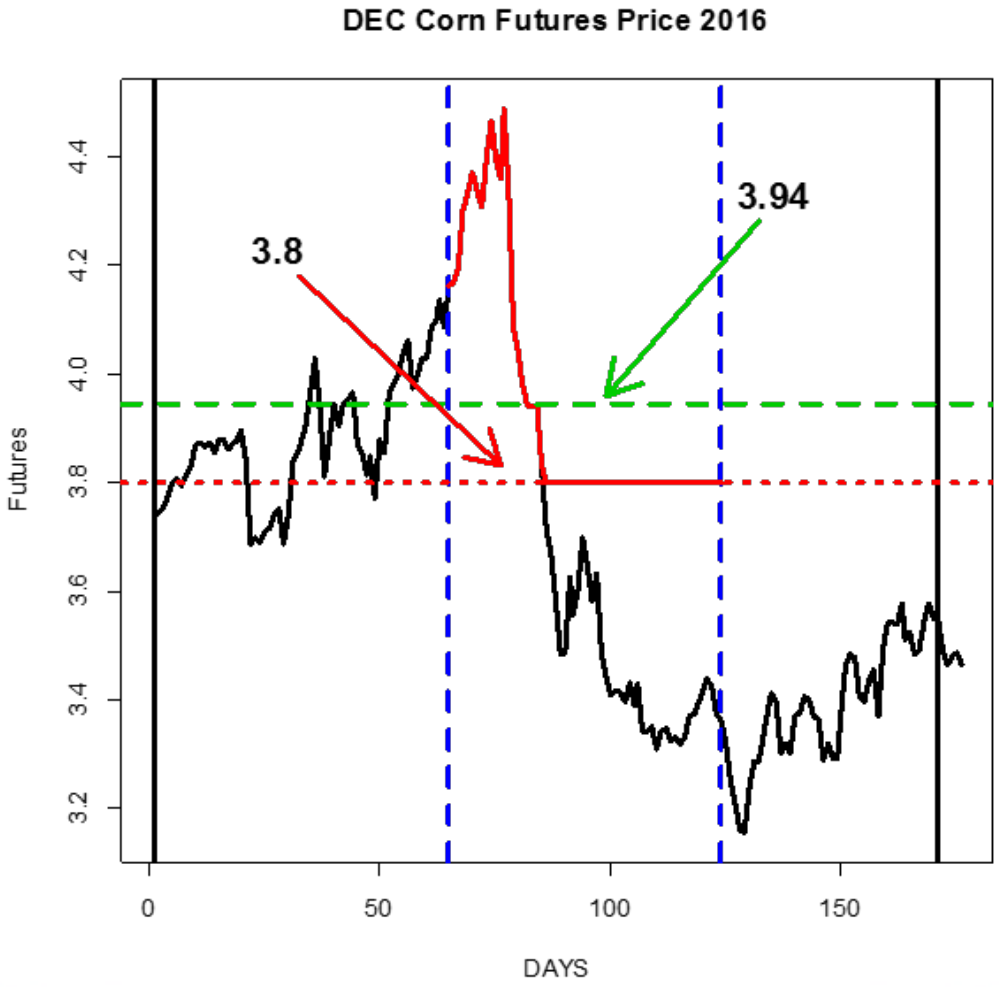
– Many elevators have substantial futures positions across portfolio of forward contracts enabling a pooling of delta's and short futures

  - Less likely to be constrained by integer (i.e. 5000 bushel) futures contract constraints.

# Buyer's Hedging Process with Synthetic Options

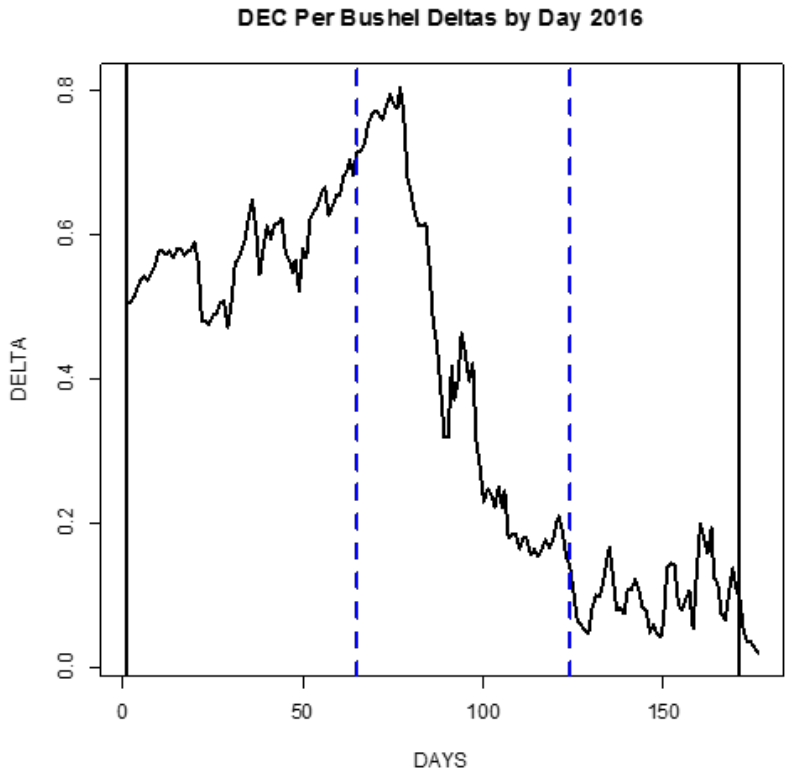
- Short Q futures bushels on day $t_0$
- Long Q synthetic call options on day $t_0$ by acquiring $\Delta_c$ Q futures on that day
  - Note the buyer actually takes the net position $\Delta_c$Q – Q futures on day $t_0$
- Charge producer for Q call options at market option price for strike price K on day $t_0$
- Recompute $\Delta_c$ each day t and adjust the net $\Delta_c$Q – Q futures position each day
  - "Close out" q bushel of options each day of pricing window by changing futures positions
- Close out Q short futures position on delivery date $t_D$

# March 1, 2016 Example

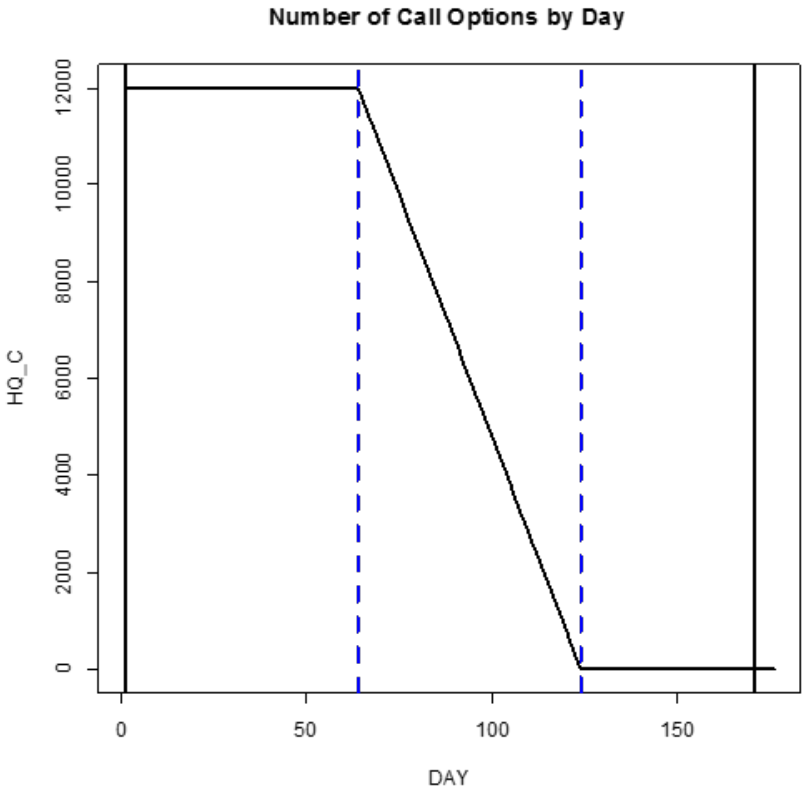


# March 1, 2016 Example

Daily Per Bushel Delta Positions 2016

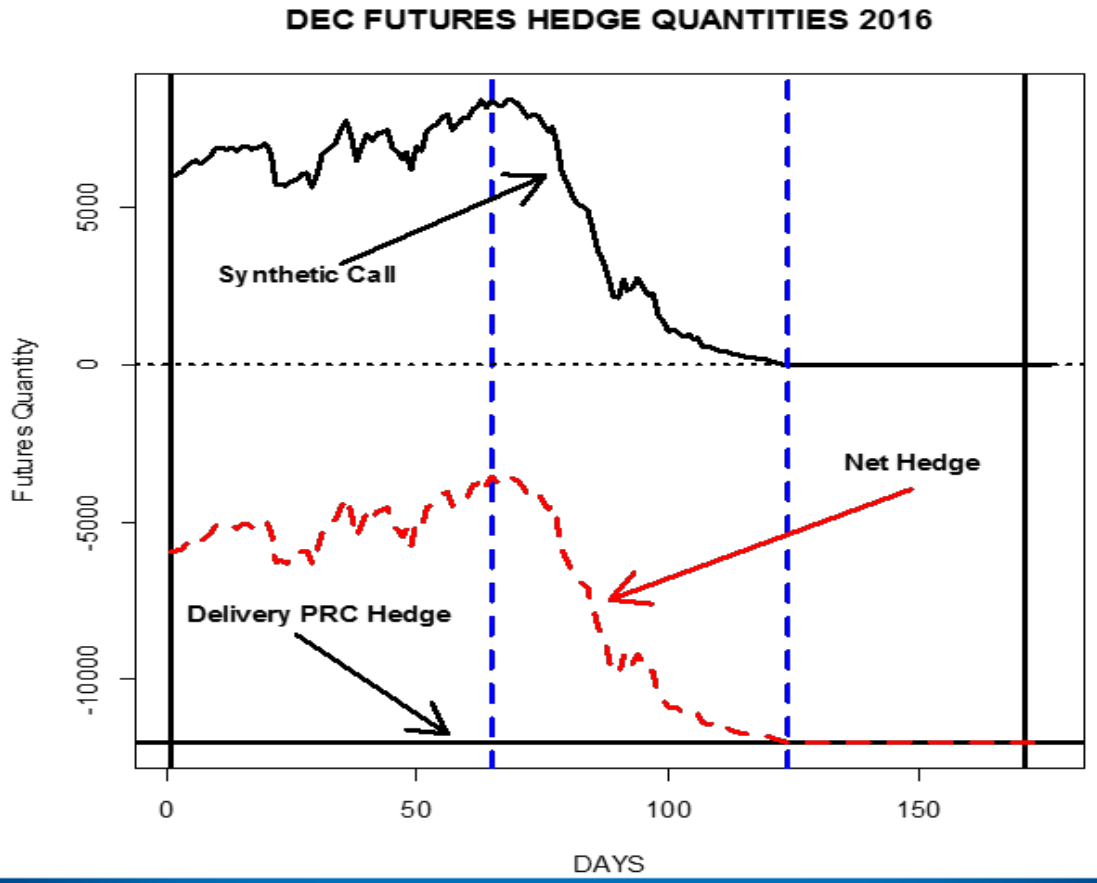



Daily "Option Positions" 2016



# March 1, 2016 Example

## Futures Daily Hedge Positions 2016

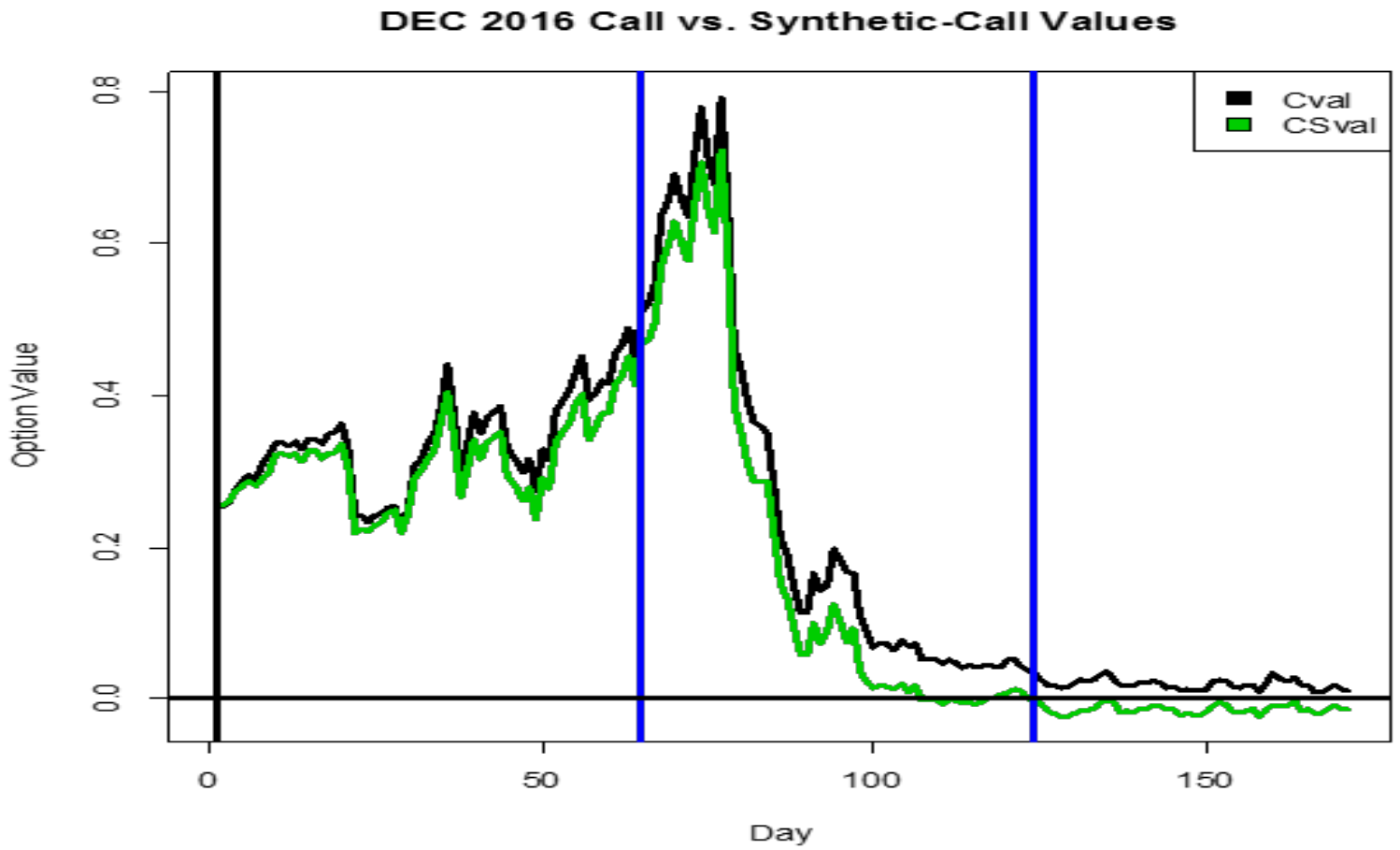


# March 1, 2016 Example

## EVOLUTION OF SYNTHETIC HEDGE POSITION

| DATE | 1-Mar | 2-Mar | 3-Mar | 31-May | 1-Jun | 2-Jun | 23-Aug | 24-Aug | 25-Aug | 28-Oct | 31-Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| F | 3.74 | 3.75 | 3.76 | 4.09 | 4.16 | 4.17 | 3.37 | 3.36 | 3.32 | 3.55 | 3.55 |
| K | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| delta | 0.497 | 0.501 | 0.507 | 0.700 | 0.740 | 0.743 | 0.158 | 0.150 | 0.123 | 0.133 | 0.124 |
| | | | | | | | | | | | |
| EXval(K) | 0.000 | 0.000 | 0.000 | 0.285 | 0.363 | 0.368 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| cval | 0.253 | 0.255 | 0.260 | 0.450 | 0.510 | 0.520 | 0.039 | 0.034 | 0.026 | 0.014 | 0.011 |
| csval | 0.253 | 0.256 | 0.261 | 0.414 | 0.469 | 0.472 | 0.001 | -0.001 | -0.007 | -0.013 | -0.013 |
| | | | | | | | | | | | |
| Cprof | 0.253 | 0.255 | 0.260 | 0.165 | 0.148 | 0.152 | 0.039 | 0.034 | 0.026 | 0.014 | 0.011 |
| CSprof | 0.253 | 0.256 | 0.261 | 0.129 | 0.106 | 0.105 | 0.001 | -0.001 | -0.007 | -0.013 | -0.013 |
| | | | | | | | | | | | |
| QC | 12000 | 12000 | 12000 | 12000 | 11800 | 11600 | 200 | 0 | 0 | 0 | 0 |
| QCSF | 5970 | 6018 | 6082 | 8402 | 8736 | 8624 | 32 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | |
| HB_C | 0 | 0 | 0 | 0 | 102 | 206 | 3055 | 3061 | 3061 | 3061 | 3061 |
| HB_CS | 3030 | 3075 | 3135 | 4974 | 5625 | 5669 | 2363 | 2363 | 2363 | 2363 | 2363 |

# March 1, 2016 Example



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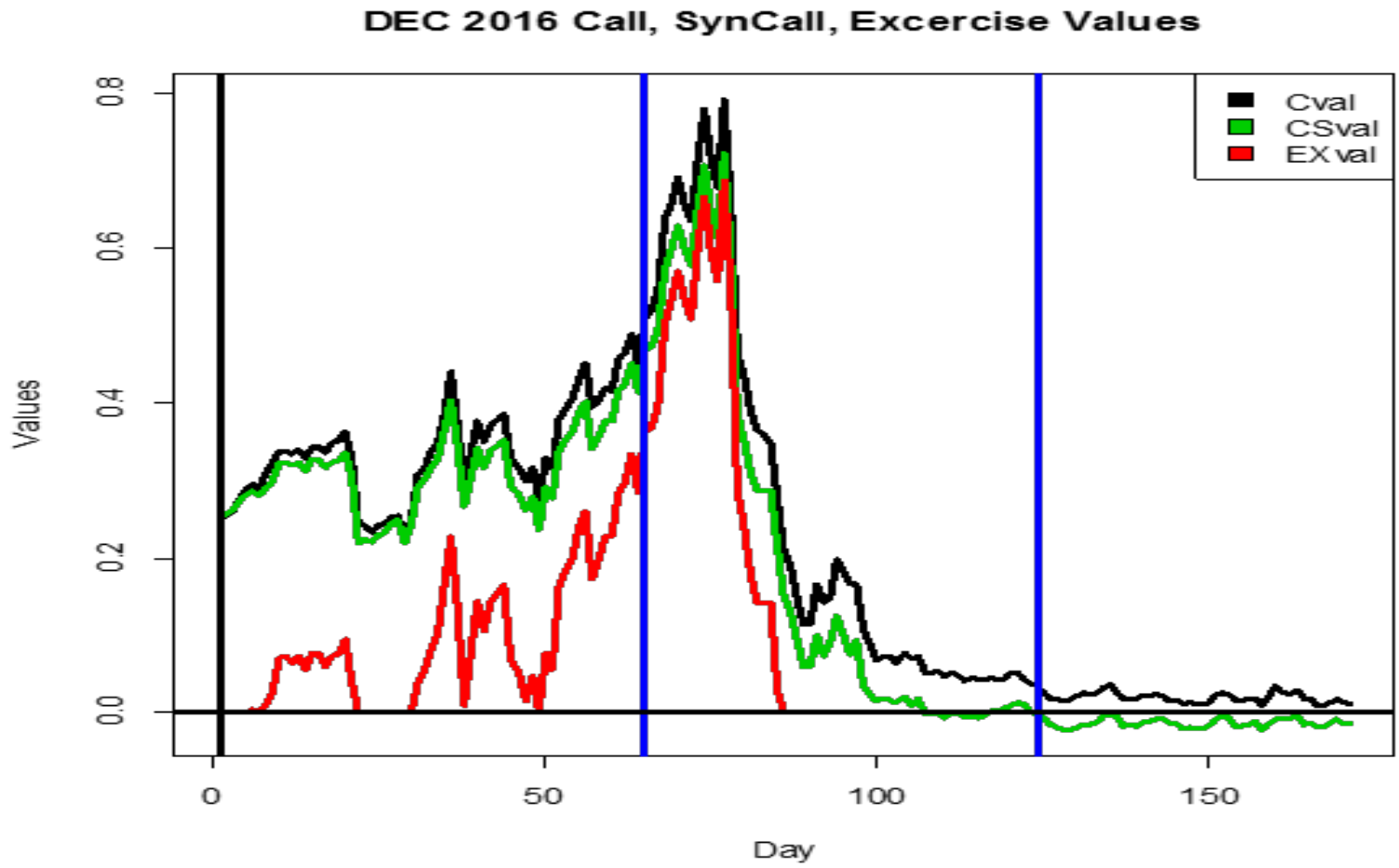

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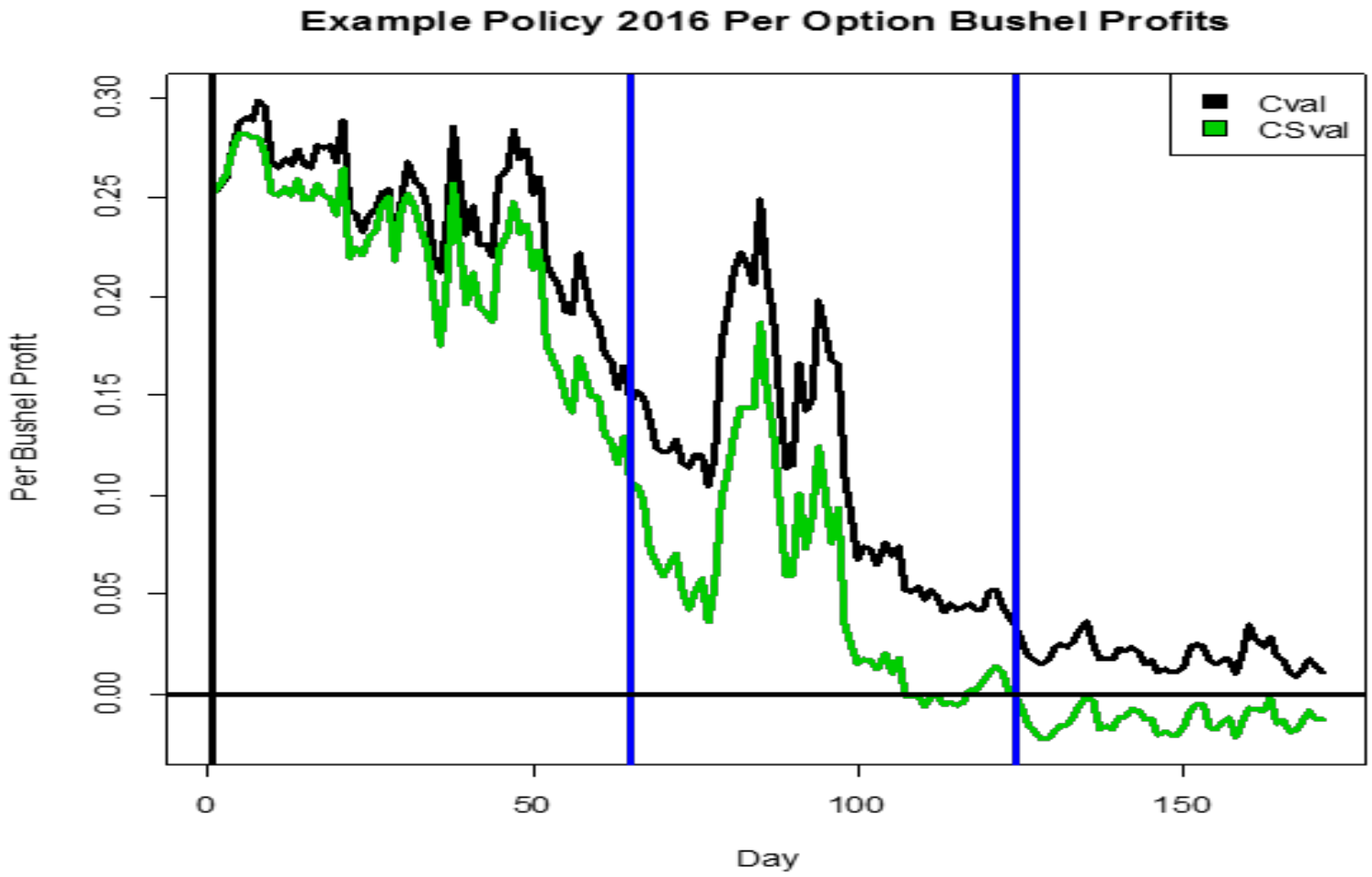
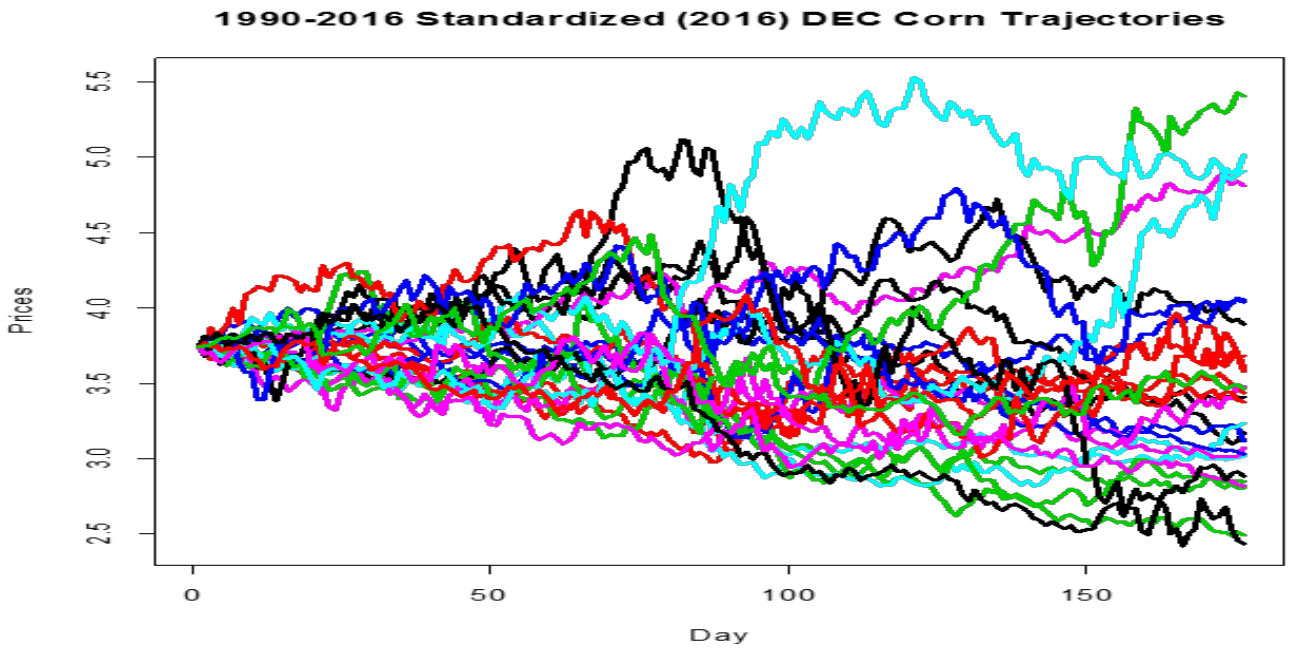
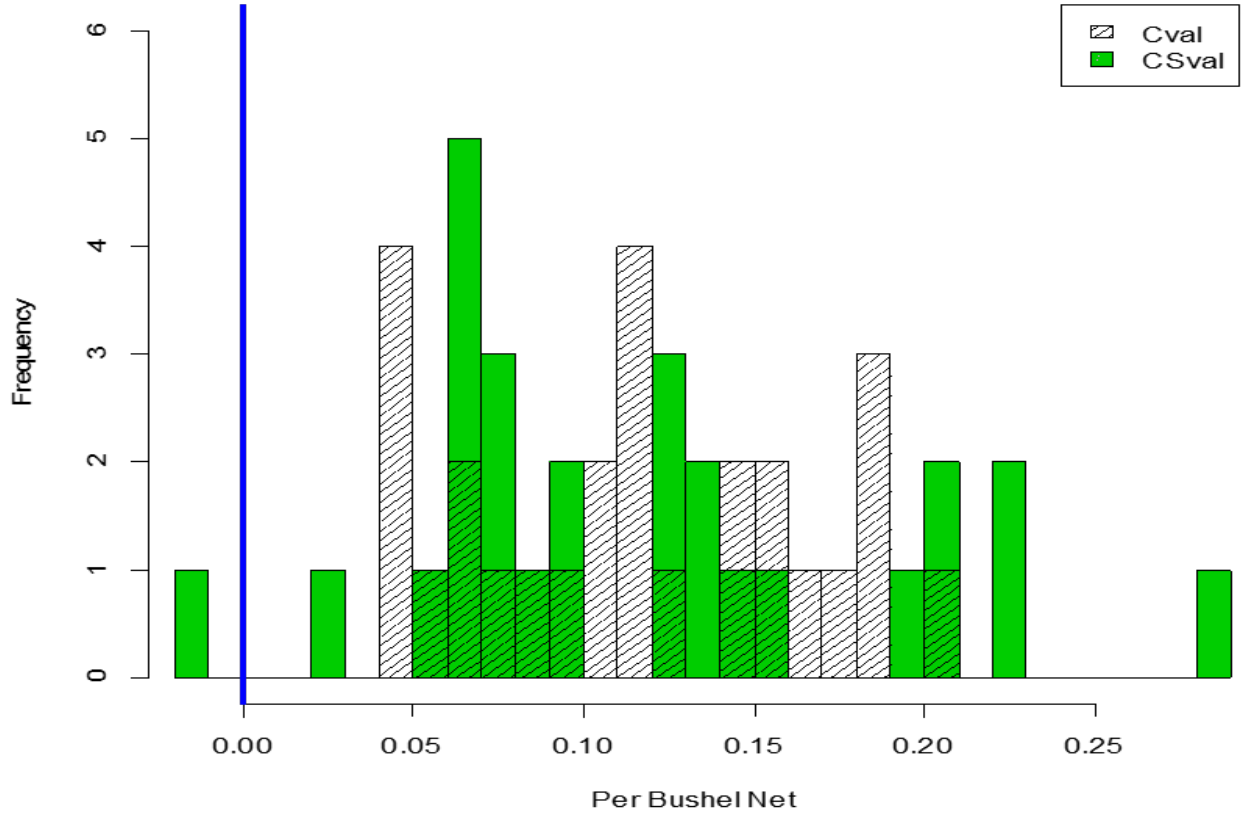


# Simulating Standardized Historical Synthetic Options




- Historical price trajectories standardized to initial 3/1/2016 initial prices  normalized as:
- Previous process applied each day  along each trajectory.
- Net per bushel position computed for each trajectory for call and syncall hedging

# Example Contract: Historical Standardized Net Per Bushel Contrast - Call vs. SynCall Hedge



# Example Contract: Historical Standardized Net Per Bushel Contrast - Call vs. SynCall Hedge

CALL HEDGE PER BUSHEL PROFIT

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
|---|---|---|---|---|---|
| 0.042 | 0.070 | 0.111 | 0.115 | 0.153 | 0.203 |

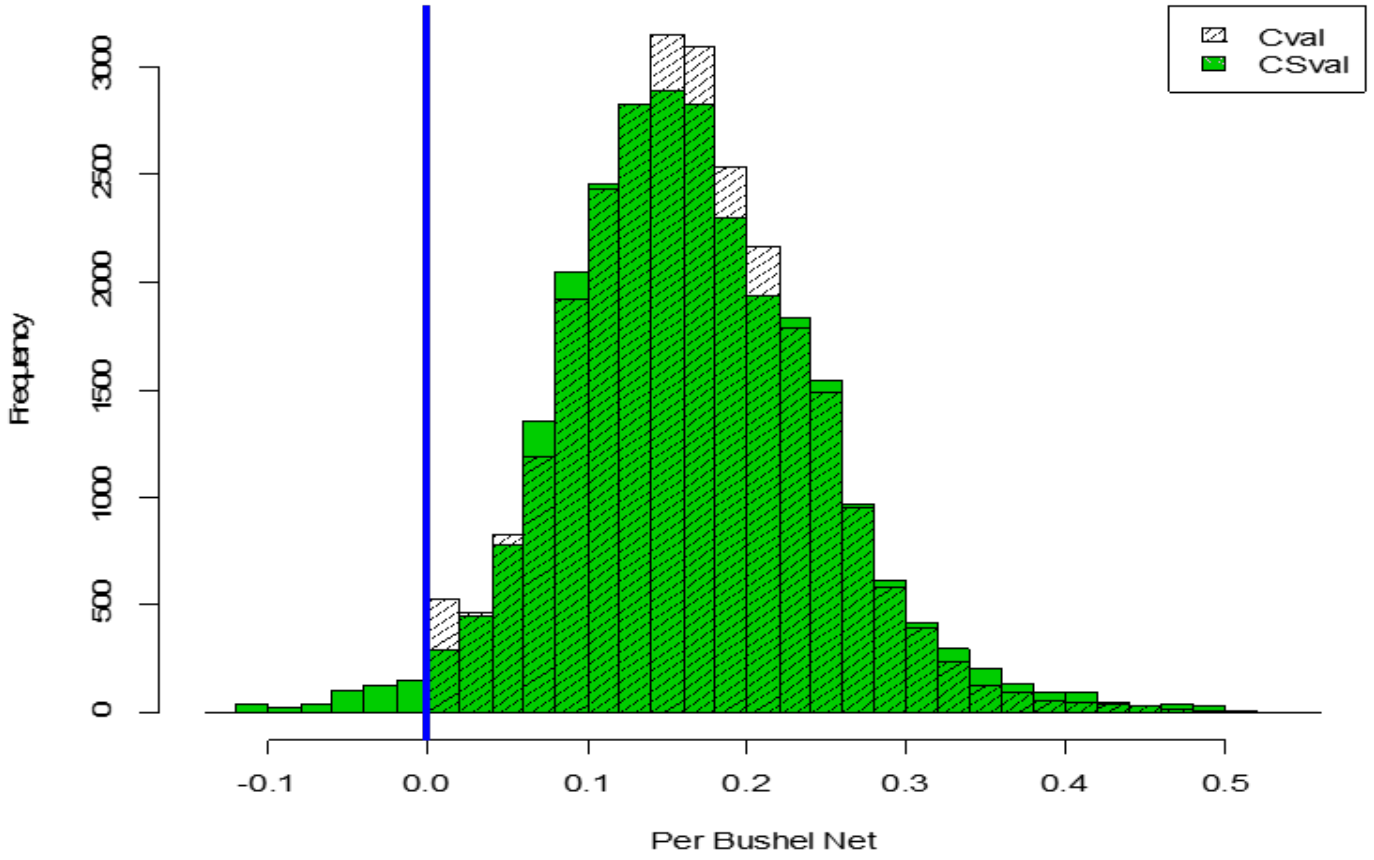
SYNCALL HEDGE PER BUSHEL PROFIT

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
|---|---|---|---|---|---|
| -0.016 | 0.068 | 0.096 | 0.118 | 0.148 | 0.281 |

PROPORTION OF YEARS WITH PER BUSHEL LOSSES

0.037

# Historical Standardized Net Per Bushel Contrast -
## 1000 Randomly Constructed Contracts



# Historical Standardized Net Per Bushel Contrast -

## 1000 Randomly Constructed Contracts

### CALL HEDGE PER BUSHEL PROFIT

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
|---|---|---|---|---|---|
| 0.0002 | 0.116 | 0.161 | 0.165 | 0.211 | 0.511 |

### SYNCALL HEDGE PER BUSHEL PROFIT

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
|---|---|---|---|---|---|
| -0.122 | 0.111 | 0.160 | 0.165 | 0.216 | 0.548 |

### PROPORTION OF YEARS WITH PER BUSHEL LOSSES

0.018

# Conclusions

- Synthetic options appear to be useful alternative when options may not be feasible
- Slightly more risky than traditional options