Using Financial Instruments to Hedge Airline/ANSP Disruption Costs:

From Fuel Hedging to Ops Hedging

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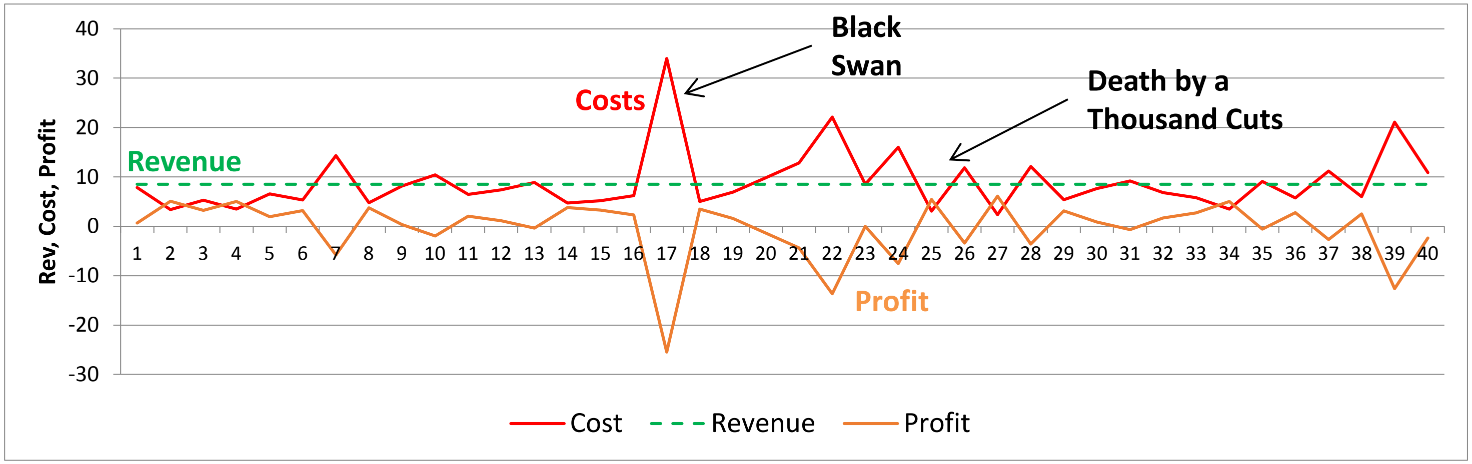
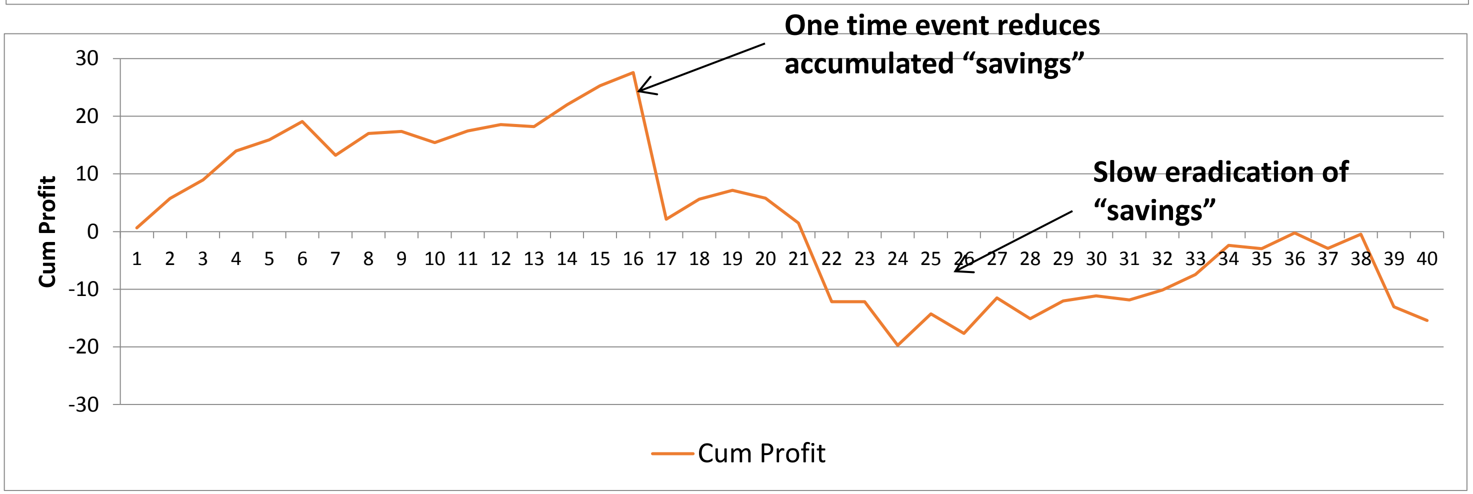
Is this Your Organization’s Financial Profile?

Fixed
Revenue,
but (highly)
Variable
Costs

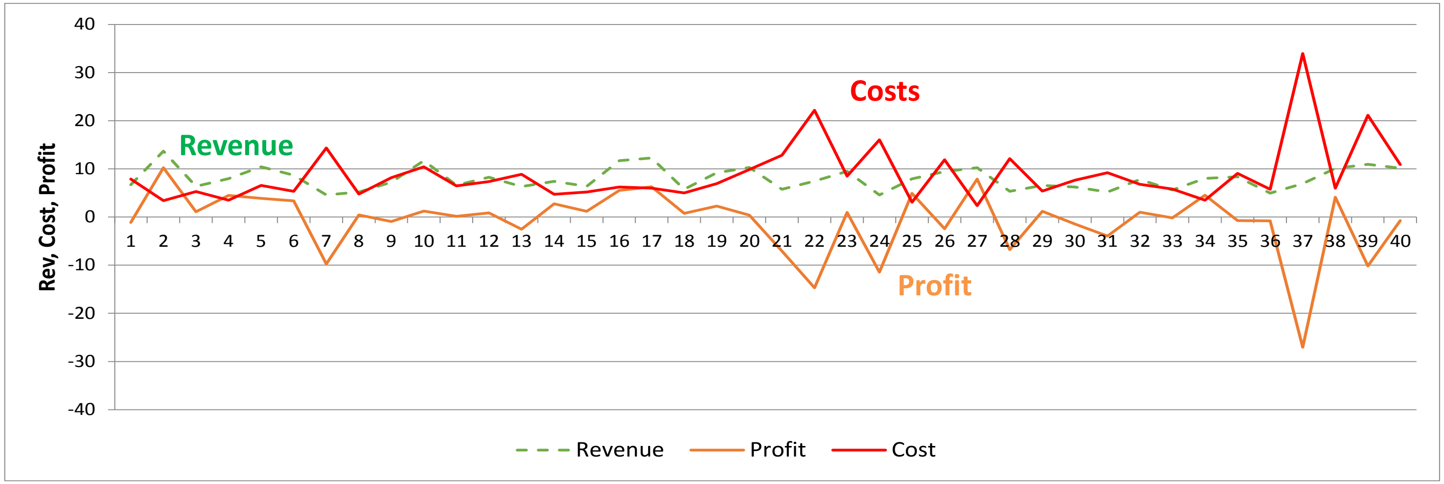


Need to borrow from Corporate/General Fund to make Monthly Obligations



Is this Your Organization's Financial Profile?

Variable Revenue and Costs



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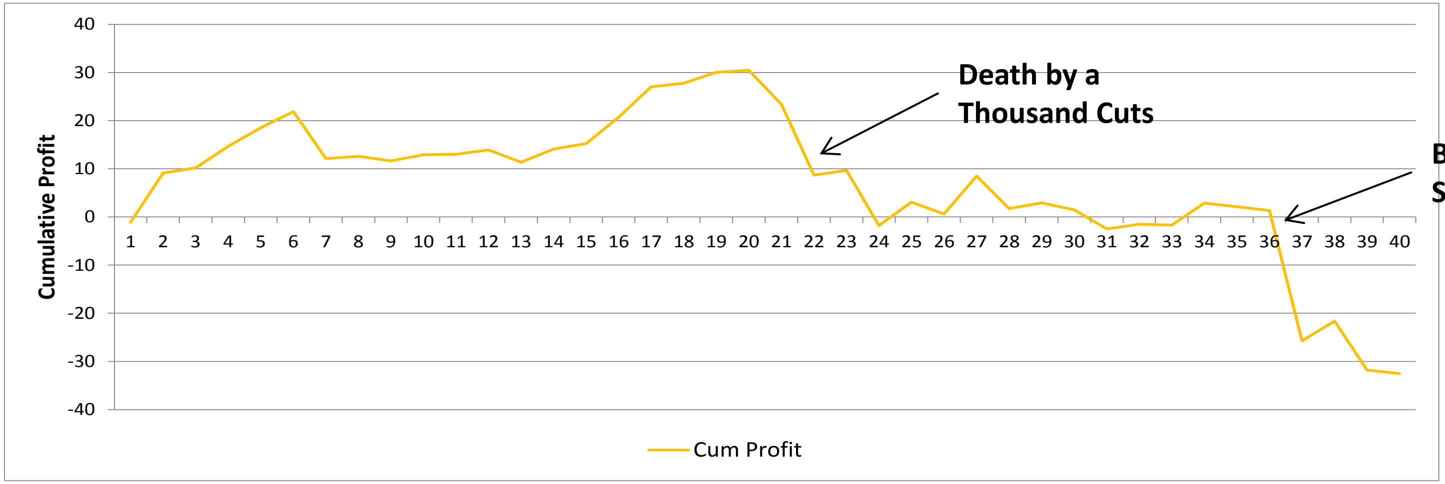
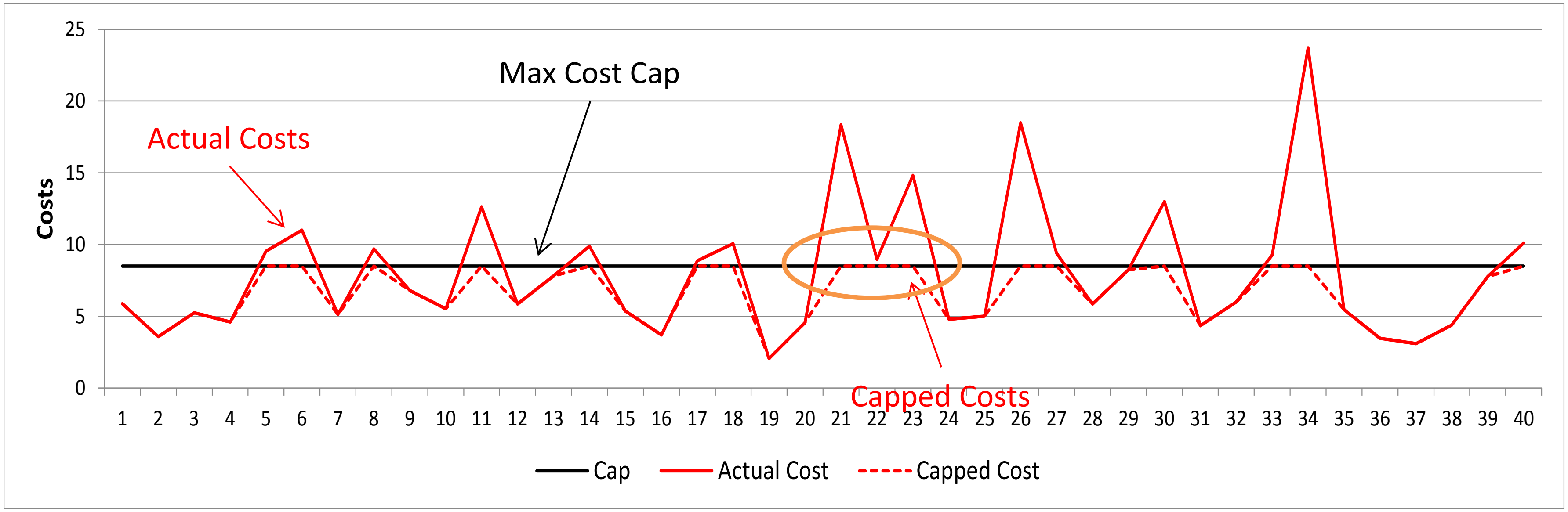


Its about Organizational **Financial Solvency** (not Disruptions)

- Organizations focus on initiatives to:
  - reduce costs
    - may have already cut "low hanging fruit"
  - reduce volatility in costs
    - may be due to external factors
  - increase revenue
    - may be due to external factors
- What about using "financial instruments" to manage financial solvency?
  - Hedge against cost volatility

“Insure” Against Excessive Costs?

Is there a way to use Financial Instruments to avoid Excessive Costs?



Applications for Hedging Financial Instruments

- Airlines
  - Disruption Costs
    - Passenger Bill of Rights
    - Passenger Care Costs
    - Maintenance Costs
    - Flight Crew/Flight Attendant Costs
    - ANSP User-fees
    - …
- ANSP
  - Contractor (Time and Material) Costs
  - Program cost over-runs
  - New program equipment costs
  - Cost analysis for Cost-Benefit Studies
- Airports
  - Concessions
  - Disruption Costs
  - …

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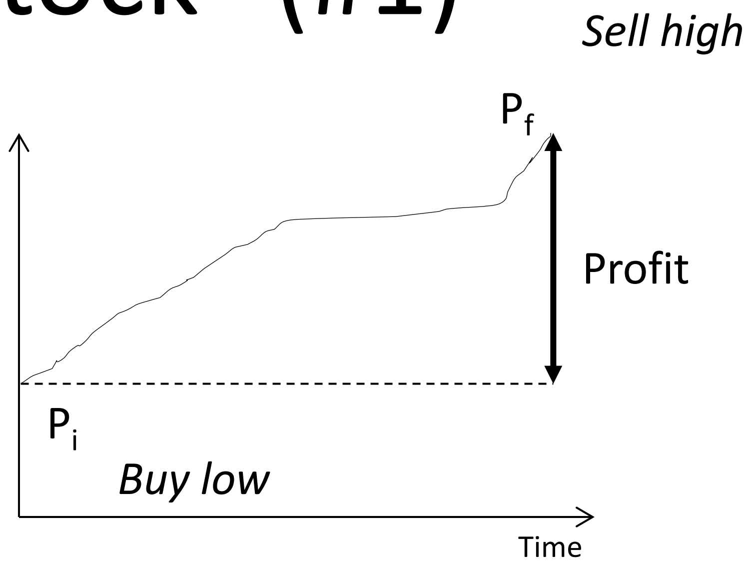
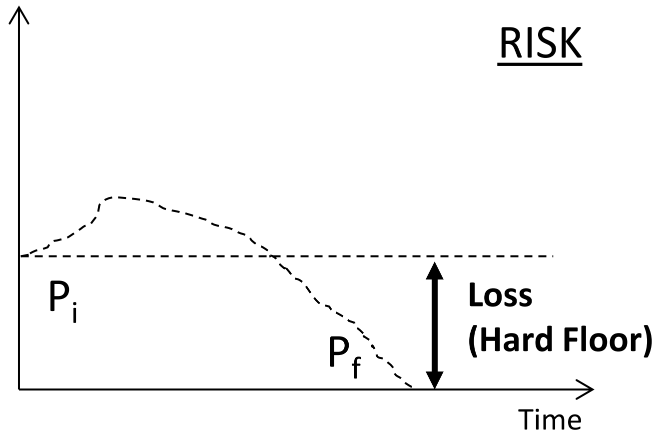
OVERVIEW HEDGING

"Being long the stock" (#1)

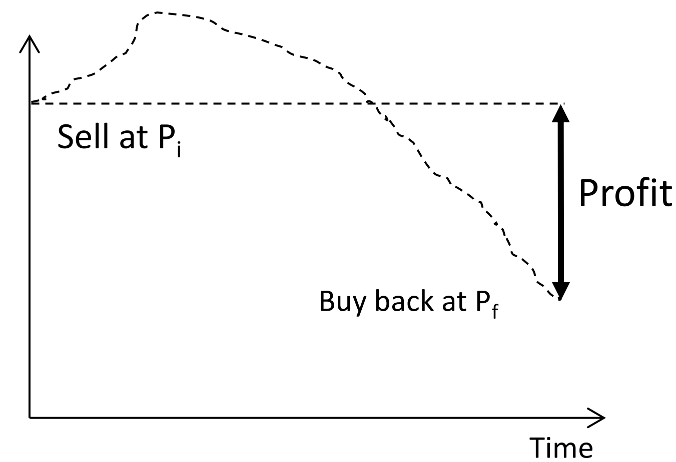
- Strategy: Profit from increase in stock price
  - **Buy low, Sell high**
- Process:
  1. Purchase stocks with the hope of selling at a higher price
  2. Sell stocks at later date
- Profit: Difference between the sales price and the purchase price is profit (or loss)
- Risk exposure:
  - cost of the initial investment
    - stock price drops to zero (e.g. bankruptcy)
    - known quantity, incorporated into risk analysis



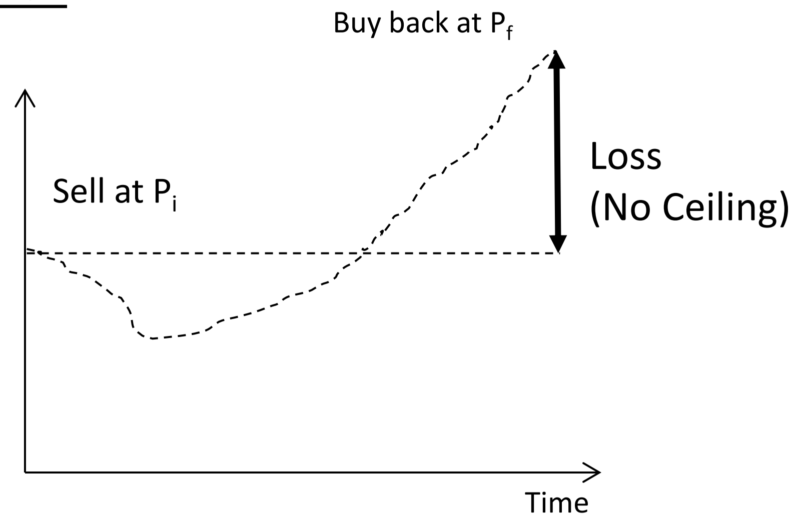


“*Short-sell* a stock” (#2)

- Strategy: Profit from decline in a stock's price
  - **Sell high, Buy low**
- Process:
  1. borrow a stock which they do not own
  2. immediately sell it at the current market price of P1
  3. wait for the price to decay to P2 (i.e. P2 < P1)
  4. repurchase purchase the stock and return it to the party they borrowed
- Profit = P1 –P2
- Risk Exposure: Very High
  - stock price (P2) can increase without limits
  - expose the investor to costs well beyond the initial purchase price (P1)



RISK



Call Options Protect Short Sellers (#2-1)

- *Short Sellers* protect themselves to increases in a stock's price (i.e. limit losses)
- **Call Option** gives them the right to buy the stock for a predetermined *price (i.e. the strike price)*
- Losses limited to difference between the initial purchase price (P1) and the Strike price

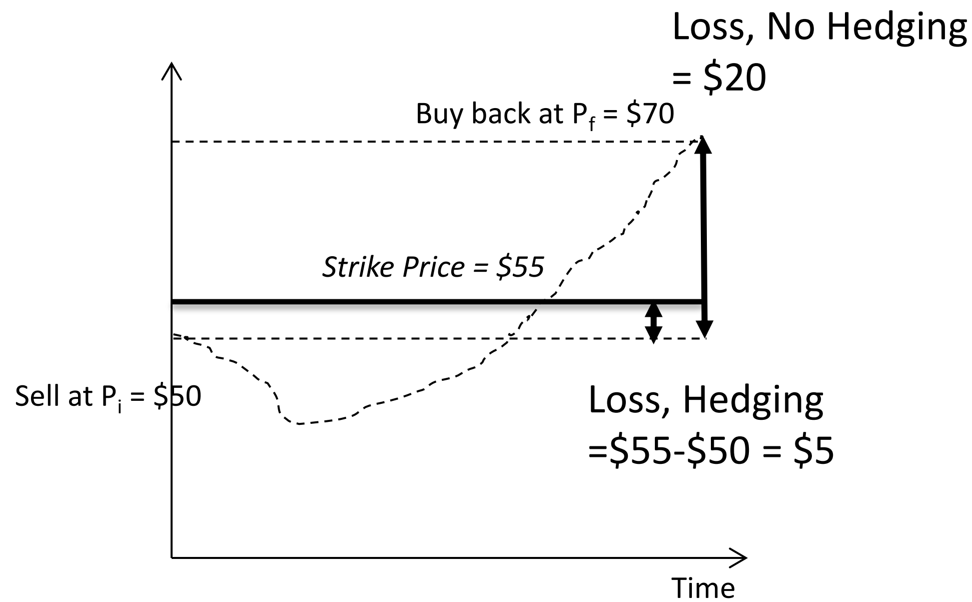
Example Short Sell with Call Option

- Trader can protect against "No Ceiling" Losses with Call Option

- Short Sell, No Hedging:
  - trader borrows stock then sell for $50
  - buy the stock back at $70
  - Loss of $20

- Short Sell, Hedging:
  - trader borrows stock then sell for $50
  - purchases a call option with a strike price of $55
  - buy the stock back at $70
  - Loss = $55-$50 = $5

  - Note: total cost to trader is $5 plus the cost of the call option, say $2.



How Much Should Call Option Cost

- How to set “fair” price for Call Options
  – Ensure Provider of Call Option does not lose money

- Black Scholes Model (Black, Merton, Scholes, 1973)
  – assumes stock prices follow a lognormal distribution
    - asset prices cannot be negative
  – Model assumes there are no transaction costs or taxes
    - the risk-free interest rate is constant for all maturities
    - short selling of securities with use of proceeds is permitted
    - no riskless arbitrage opportunities

Idea?

- Use Call Option to “insure” against high costs in operation with high volatility

- Already used widely in Airline Fuel Hedging
  – Why not use in other areas of Airline /ANSP / Airport operations?

Black-Sholes Model

- $Call\ Price = S_0 \cdot \Phi(d_1) - K \cdot e^{-rT} \cdot \Phi(d_2)$

- $\Phi(\cdot)$ - standard Normal distribution function
- S_0 - current stock price
- $K \cdot e^{-rT}$ – Net Present Value
  - K -strike price
  - T - term of the call option
    - the time the option holder has to decide whether to use the option to purchase the stock at the strike price
  - r - riskless interest rate (e.g. US Treasury rate)

- $d_1 = \frac{\log(S_0/K) + \left(r + \sigma^2/2\right) \cdot T}{\sigma\sqrt{T}}$
  - stock's price, the strike price, volatility, time, and the interest rate
- $d_2 = d_1 - \sigma\sqrt{T}$
  - **σ is the *volatility* of the stock price, defined as the standard deviation of stock returns**

Black-Sholes Model

- Critical parameter in BS model is volatility of stock prices - σ
  - measures level of uncertainty in prices
  - insures against large upward movements
    - When volatility is high → call option will be expensive
    - When volatility is low →call will be relatively less expensive

ADAPTING BLACK-SHOLES MODEL FOR OPERATIONAL COST "INSURANCE"

Airlines, ANSPs, ….Experience Volatility

- No end of enterprises/ operations/ departments that experience volatility (e. g. weather, network effects, labor, ….)

- Use Black-Sholes to hedge against volatility in costs
  - Improves budget accuracy
  - Avoids insolvency

“Operational Insurance Model” using B-S

- “Insurance Model”
  - Enable enterprise to hedge against the unexpected costs
  - Pay a monthly “insurance premium”
  - For a given “deductible”

- Call Price is the premium for insurance
- S_0 is the expected value of costs
- σ is the volatility of costs
- K is a deductible on the costs before the insurance contract becomes active

“Operational Insurance Model” using B-S

$$Premium = E[discounted\ quarterly\ costs] \cdot \Phi(d_1) - Deductible \cdot e^{-r \cdot T_{PMT}} \cdot \Phi(d_2)$$

- $d_1 = \frac{\log\left(\frac{E[discounted\ quarterly\ costs]}{Deductible}\right) + r \cdot T_{PMT} + (\sigma^2/2) \cdot T}{\sigma\sqrt{T}}$
- $d_2 = d_1 - \sigma\sqrt{T}$, and
- $T = 1$

* valid iff. costs are lognormally distributed

CASE STUDY – AIRLINE PASSENGER BILL OF RIGHTS (PBR) COMPENSATION

Example Airline application

Could be used by ANSP, Airports, etc …

Passenger Bill of Rights (PBR) Compensation

- European Union "Passenger Bill of Rights" EC-261
- Airlines pay passengers when flights experience:
  - a flight arrival delay in excess of 3 hours
  - flights are cancelled with less than 24 hours notice

- Airline's Obligation – Payout to Passengers
  - 250 EUR for flights with stage-length < 1,500 KM (932 miles) – Type 1
  - 400 EUR for flights with stage-length between 1,500 KM (932 nautical miles) and 3,500 KM (2,174 nautical miles) – Type 2
  - 600 EUR for flights with a stage-length > 3,500 KM (2,174 nautical miles) – Type 3

- No Payout for Extra-Ordinary Circumstances:
  - circumstances beyond the airline's control :
    - weather related airport closures
    - aircraft mechanical problems
    - labor actions, security closures

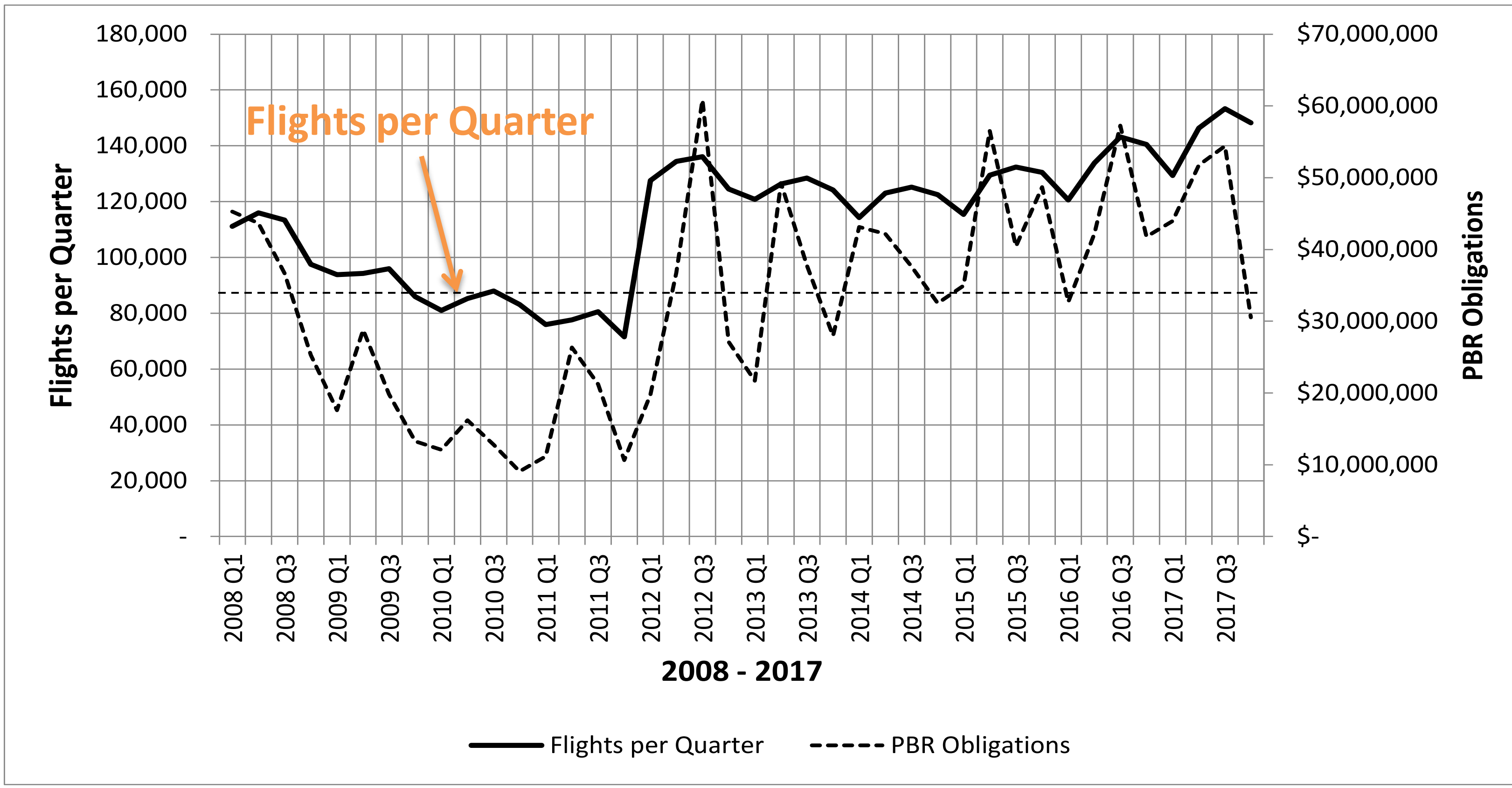
PBR for U.S. Airlines

- Financial impact of EC-261 applied to U.S. domestic and international flights (2016)
  - 0.4% of the flights meet the EC-216 compensation criteria
  - Compensation to passengers averaged $299 per disrupted passenger
    - $1.08 across all passengers
  - Airlines total obligation **$955.7M**
    - ***4%*** of pre-tax net income
    - $109 per flight
    - Assumes every eligible passenger is compensated (i.e. no “breakage”)

Case Study – Hedging EC-261 Obligations

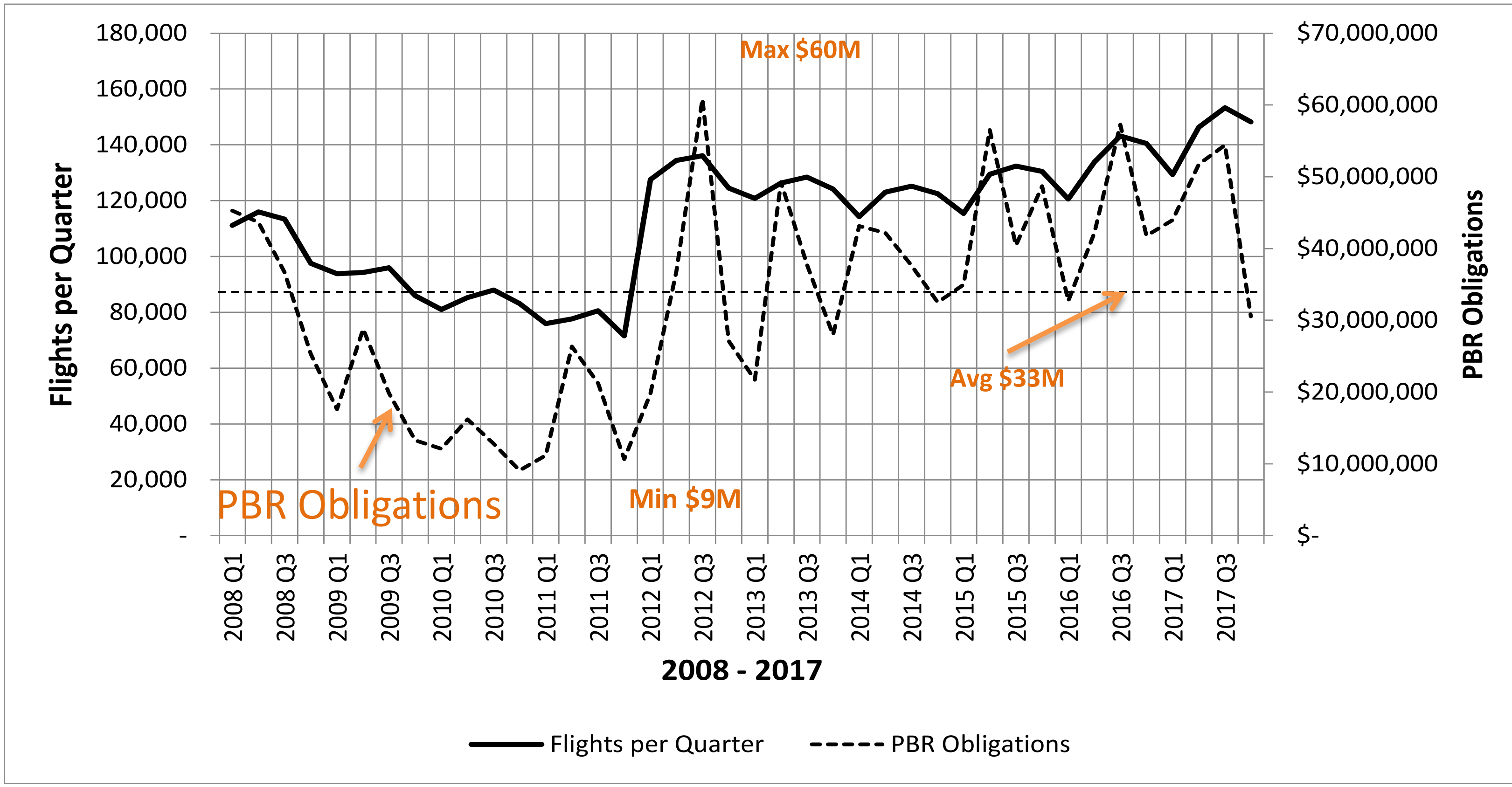
- US-based International Carrier
- Domestic Flights only
- Quarterly periods (2008- 2017)

Flights per Quarter (2008 – 2017)



Note: Change in flight schedule Q3 2012 distorts volatility measure

PBR Obligations (2008 – 2017)



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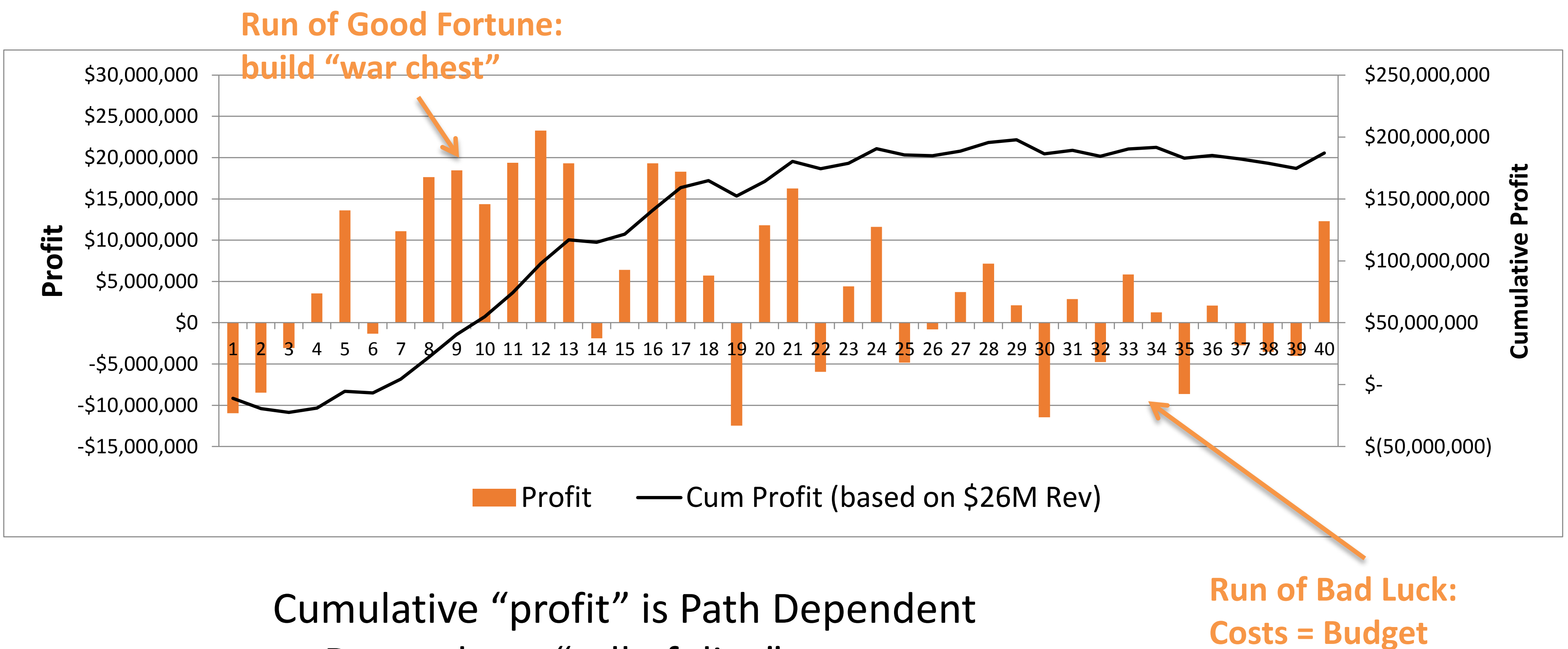
Cumulative "Profit" (2008 – 2017)

Based on $26M per Quarter "Budget" for PBR

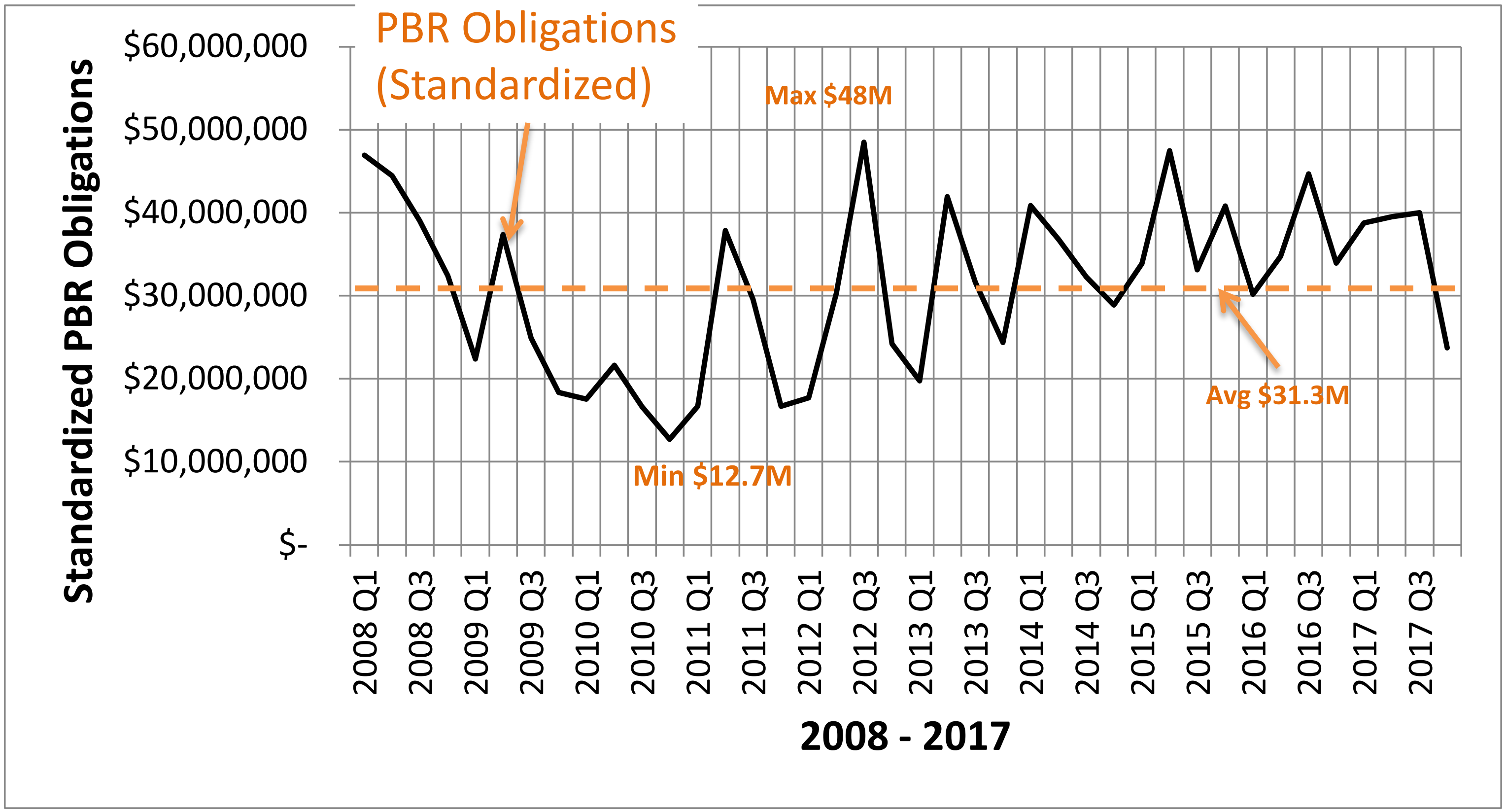


Cumulative "profit" is Path Dependent

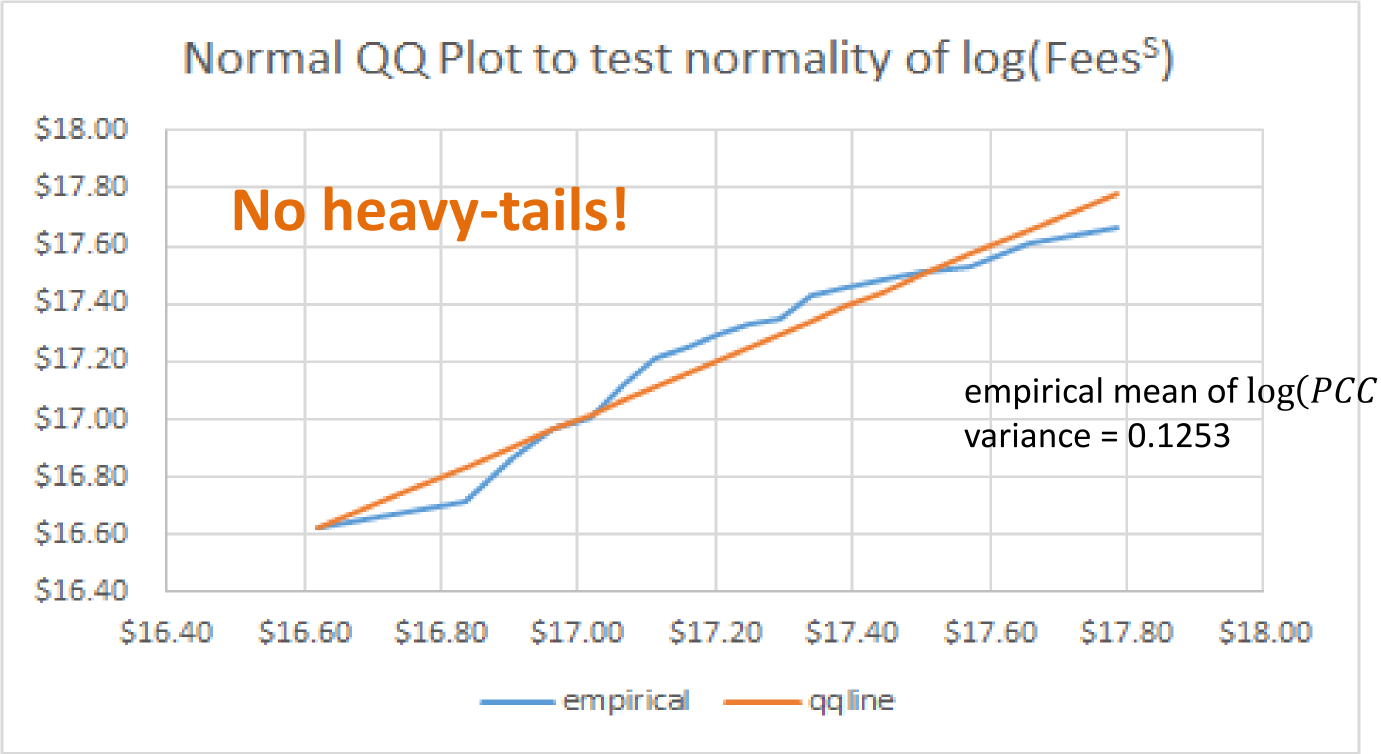
- Depends on "roll of dice"
- Above sequence could have been reversed

Standardized PBR Obligations (2008 – 2017)

σ = $9.9M
Range $36M



PBR Obligations are LogNormal

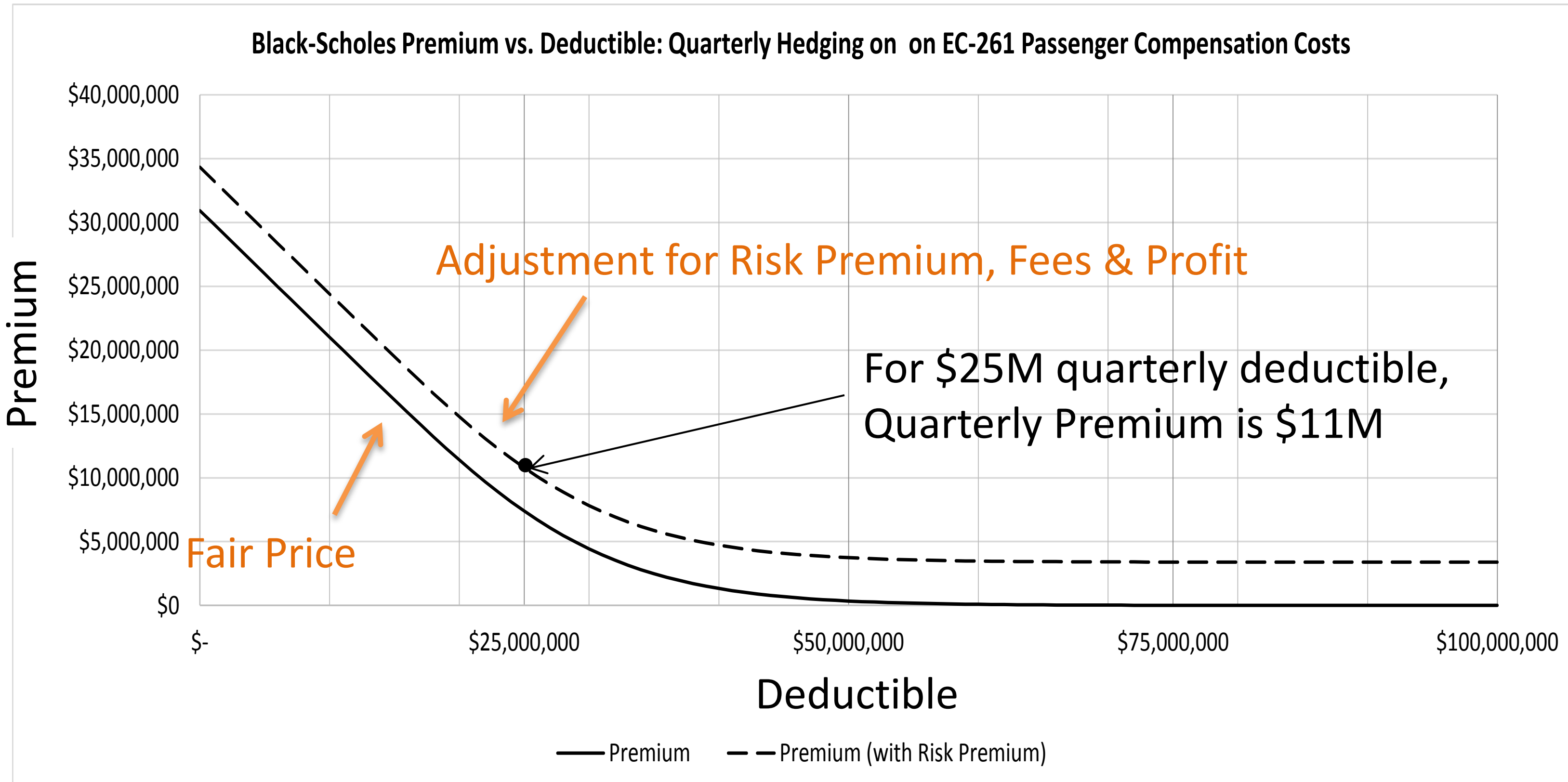


empirical mean of $\log(PCC^S)$ = $17.20
variance = 0.1253

Black-Sholes Model Assumptions

- Quarterly interest rate = 1.25%
- Expected value of $Passenger\ Compensation\ Costs^S$ $E[PCC^S] = \$31{,}326{,}092.45.$
- Expected discounted value of PCC is $E[PCC^S] \cdot e^{-.0125} = \$30{,}936{,}953.48.$
- Empirically calculated variance is $Var[PCC^S] = 99{,}696{,}139{,}272{,}068.90$
- Volatility of PCC^S, σ, can be calculated as follows:
- $Var[PCC^S] = (E[PCC^S])^2 \cdot \left(e^{\sigma^2} - 1\right) \rightarrow \sigma = \sqrt{\log\left(\frac{Var[PCC^S]}{\left(E[PCC^S]\right)^2} + 1\right)} = 31.11\%$

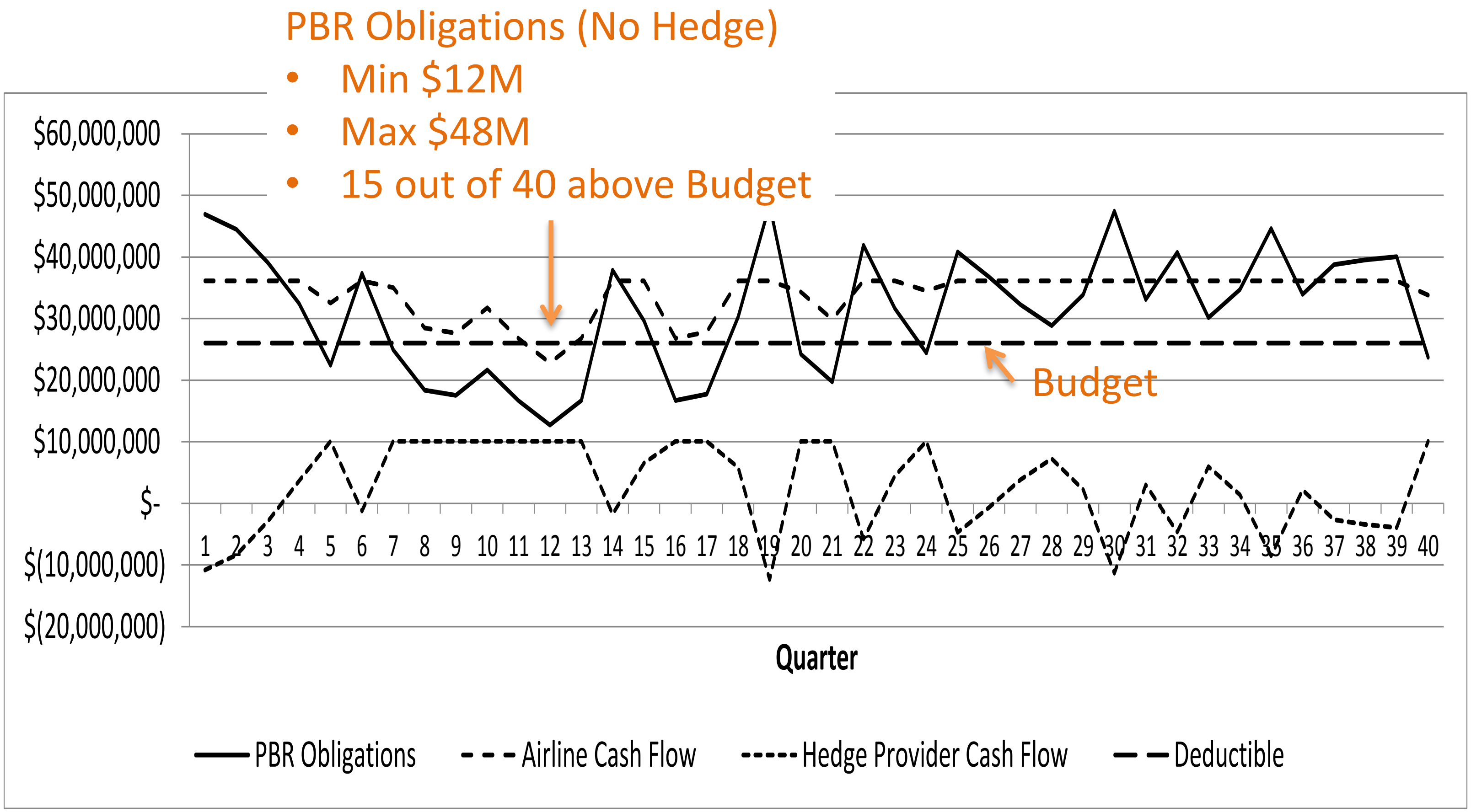
Premium vs Deductible for PBR Obligations



2008 – 2017 PBR Obligations

	No Hedge	**Hedge** • **deductible $26M** • **quarterly premium payment $10.1M**
Total airline liability for PBR Obligations	$1,253M	$1,444M
Range	**$12M** to **$48M**	**$22M** to **$36M**
Average Quarterly Payment	$31.3M	$32.9M
	15 Quarters over Revenue	15 quarters capped at $26M deductible

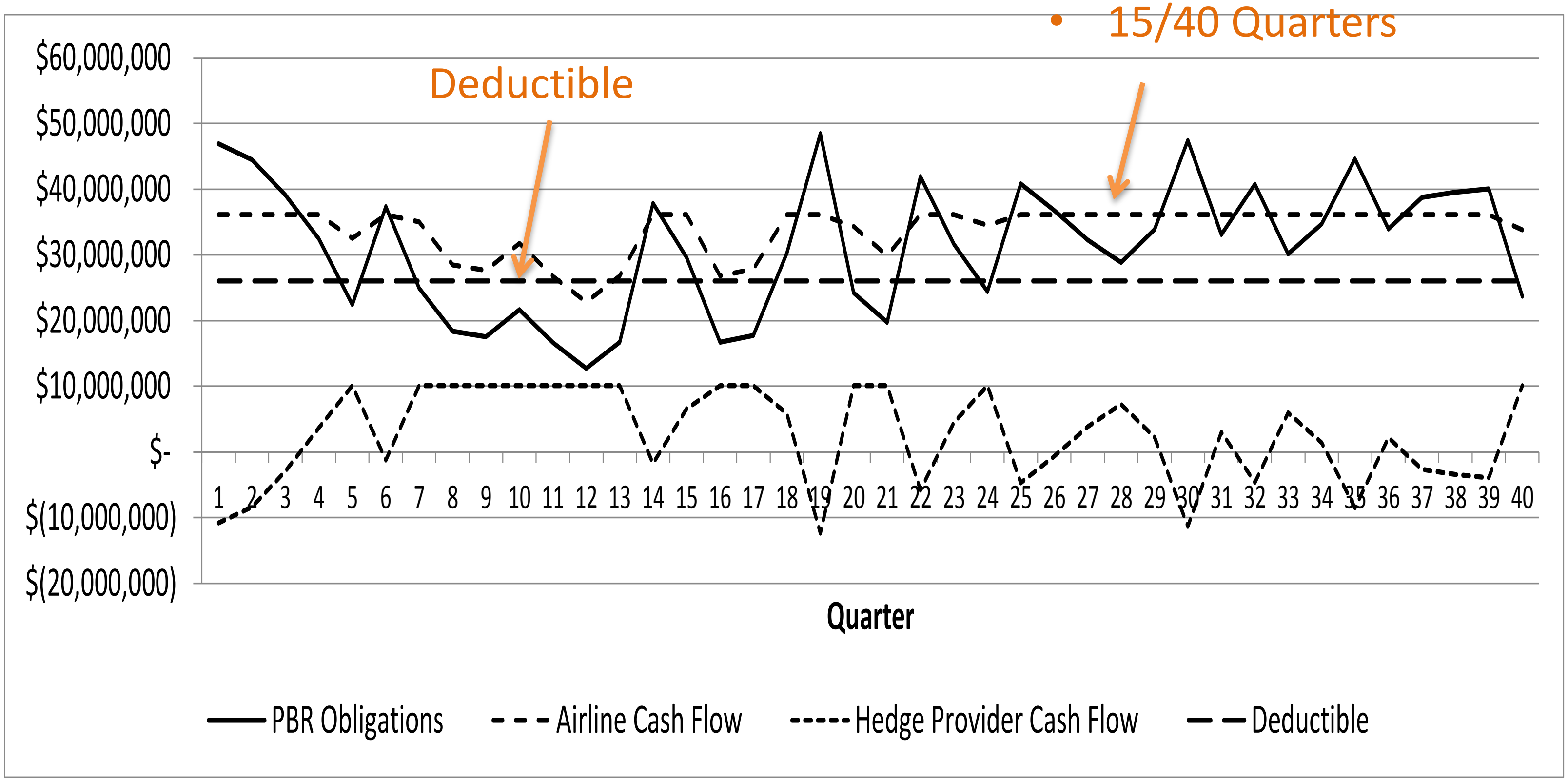
PRB Obligations – No Hedge (2008 – 2017)



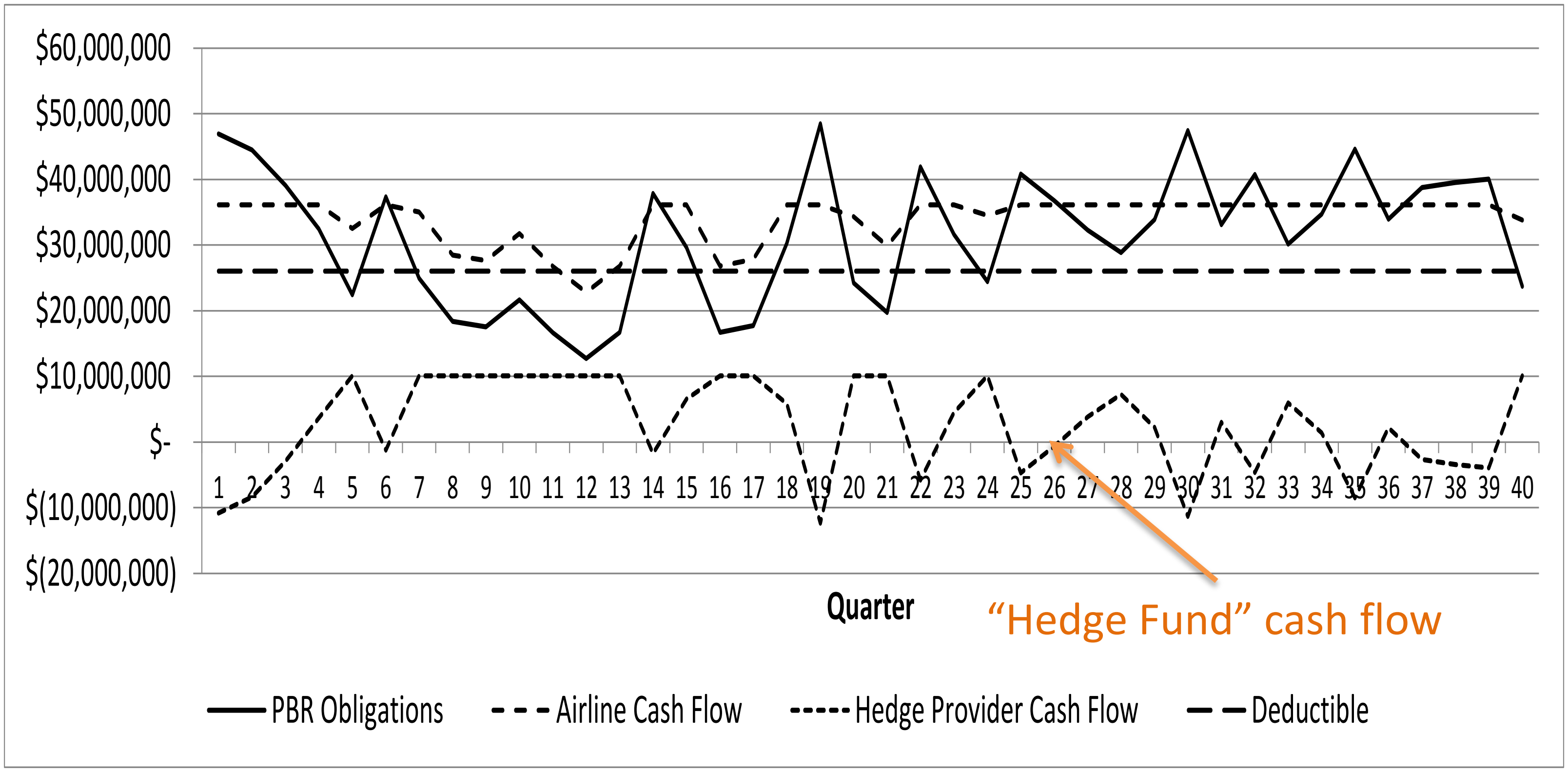
PBR Obligations Hedged (2008 – 2017)

Airline Cash Flow with Hedge

- Min $22M
- Max $36M
- 15/40 Quarters



Hedge Fund Solvency (2008 – 2017)

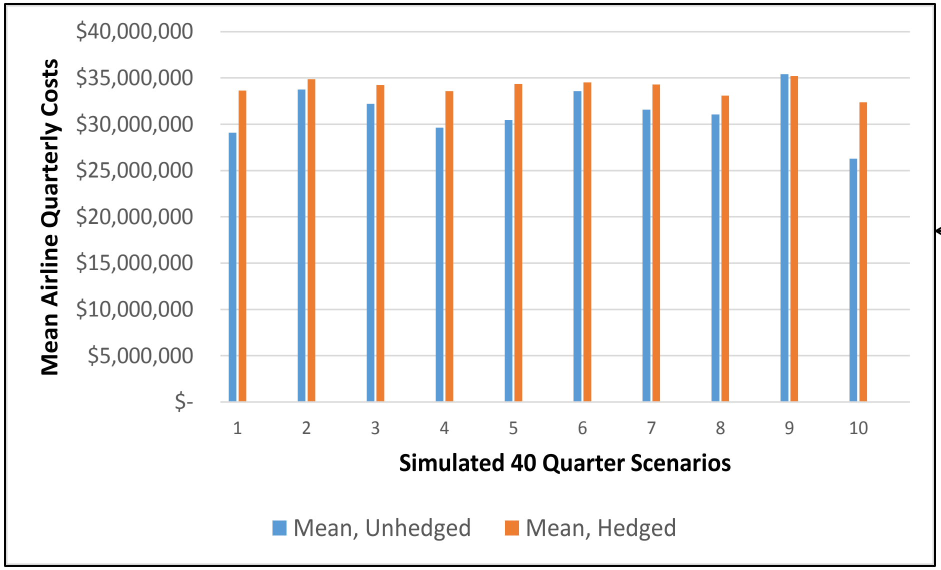


"Hedge Fund" profitable $2.6M (95% Confidence Interval)

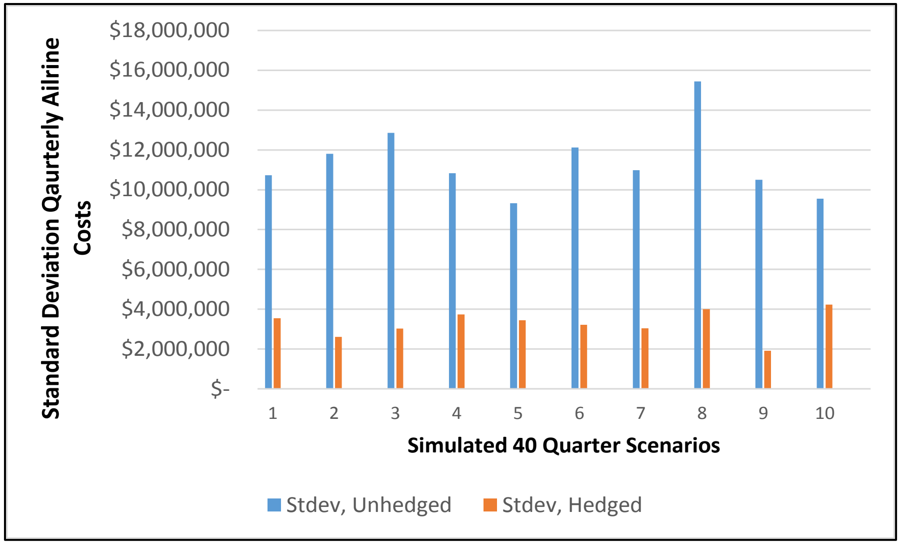
Summary (2008 – 2017)

- Trade-off addition cost for reduced volatility
  - Hedging reduced the standard deviation in quarterly PCCs from $9.9M (No Hedge) to $3.7M (Hedge)
  - Airline was never liable for more than $36M in costs per quarter
  - Total airlines costs over the 40 quarters
    - No hedge $1,253M
    - Hedge $1,357M
      - PCCs up to the deductible **plus** premiums
  - Airline paid an additional $2.6M per quarter for the benefit of reducing the standard deviation of payments by $6.2M

Monte Carlo Simulation (40 Qs)



- Mean quarterly airline costs higher for the hedged positions
  - average $1.2M over the unhedged position



Standard Deviation Hedged position reduced **2.7 times** from the No Hedge position

- Hedged Min/Max $22M/$36M
- NO Hedge Min/Max $12.7M/$48.4M

Conclusions

- Objective – manage financial risk by reducing volatility
  - Use financial instrument
- Applied at Airline's
  - PBR
  - Maintenance
  - Passenger Care
- How can we use at ANSP?

Conclusions - Implementation

- External
  - Third Party
    - State-certified Insurance Company
  - Premiums higher
    - Costs include
      - Profit
      - Management Fees

- Internal
  - "Rainy-day fund"
  - "Premiums" lower
    - No profits
    - No Management Fees
  - Prevent others from "borrowing" or "stealing" from fund