IDA

Commercial Aircraft Pricing: Application of Lessons Learned

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Bruce Harmon
Institute For Defense Analyses
bharmon@ida.org

Problem Statement

- How can the USG better estimate the price of commercial aircraft used in weapon systems?
  - Answers to this question have implications for negotiating prices for ongoing programs
- Our research program has evolved to include price negotiation

What Lessons can be Applied to the More General Problem of Pricing Commercial Items?

Approach

- Characterize drivers of commercial aircraft prices
  - Suggested by economic theory
  - Defined by available price and other data
- Price estimating relationships
  - Airline consultant price data: Morten Beyer and Agnew (MBA)
    - Appraised transaction prices for airline-configured aircraft, 1988-2018
  - Cross-section and panel data regression specifications
    - Model price movements over time as well as differences between aircraft
- Analysis of Boeing financial data: 2004-2018
  - Corroboration of MBA data and price estimating relationships
  - Alternative price escalation
  - Estimated sensitivity to production rates

Apply Analyses to 767-2C (KC-46A platform) Pricing

767-2C Program Context

- 767-2C: 767-200ER-derived with FAA Amended Type Certificate; basis of KC-46A tanker
- Not to exceed (NTE) prices set in 2011 as a result of Tanker competition
  - Competition facilitated price-discovery
  - Possible adjustments in out-years by economic price adjustment (EPA) clause
- However, conditions have changed since 2011
  - Data show real commercial aircraft prices continue to fall
    - Nominal prices are rising less than general price indexes
    - Consistent with Boeing financial data
  - Due to added customer interest in the 767-300F freighter, 767 productions rates will be higher than 2011 expectations

Negotiation Below NTEs?

Price Estimating Relationships: Panel Data Regression Approach

- GDP deflator to normalize MBA price data to constant 2018$
- Pooled OLS, log-log; each aircraft model is a panel; aircraft *j* in year *t*
- Static demand drivers
  - **MTOW**$_j$, or Seats and Range (passenger aircraft sample only)
  - 4 engine 1/0 dummy variable;
  - Dummy variables/interaction terms for Wide Body (WB) aircraft
  - Fuel Efficiency (**FE**$_j$) factor
- Dynamic demand drivers
  - World GDP cycles (% delta from trend) lagged 2 years (***WGDPc_L2***$_t$)
  - Real jet fuel price lagged one year (***FuelP_L1***$_t$)
- Dynamic Supply/Cost drivers
  - Cumulative quantity produced by aircraft family lagged 1 year (***CumQ_L1***$_{jt}$)
  - Time trend (***Year***$_t$).

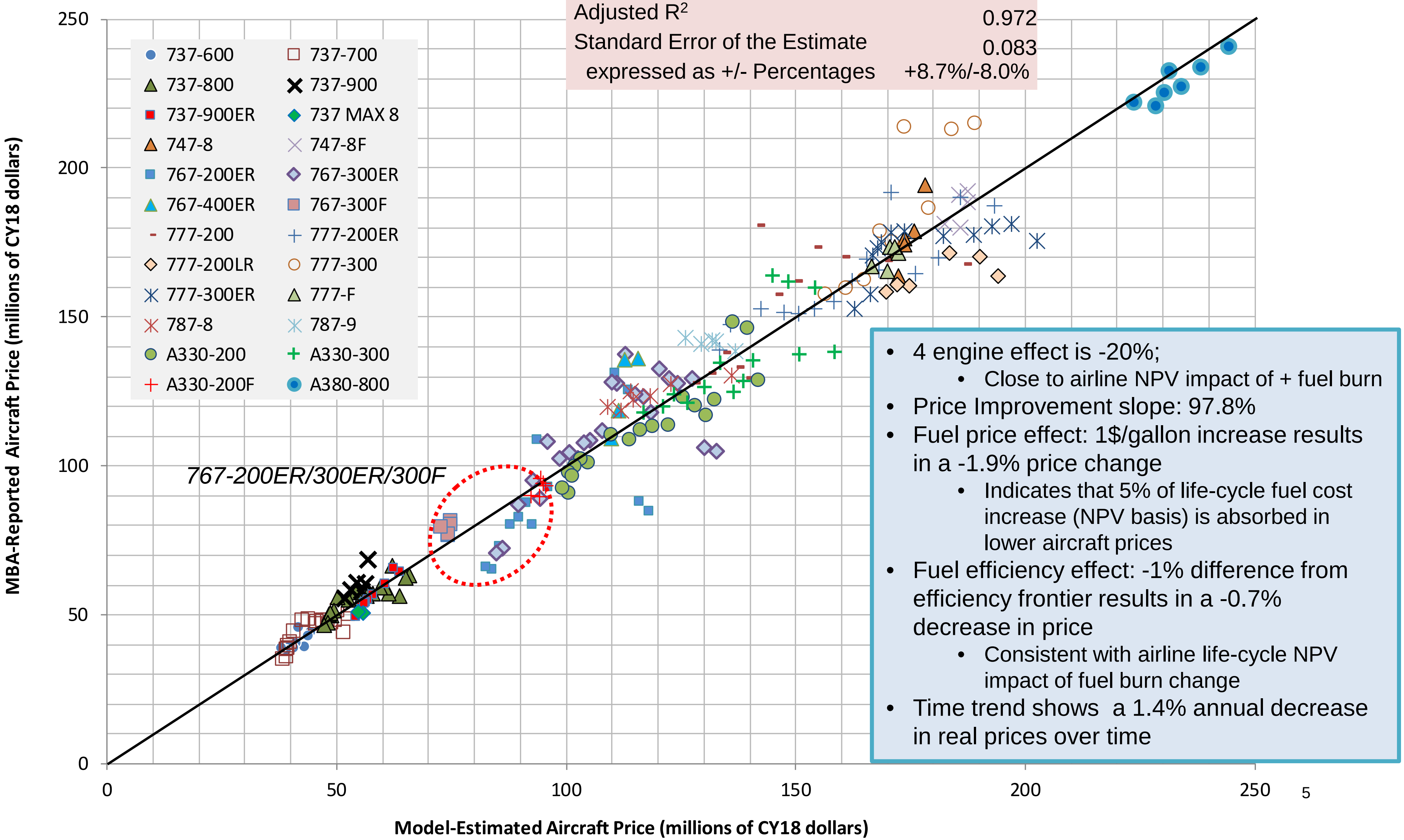
Many Specifications reflecting different combinations of price drivers: Apply preferred MTOW/FE model

Preferred Model

$$p_{WBjt} = 104{,}593{,}510\ MTOW_j^{1.119}\ .799^{4Engines_j}\ 2.004^{FE_j}\ \text{Cum\_Q\_B\_L1}_{jt}^{-0.032}\ .981^{Fuel\_P\_L1_t}\ 0.986^{Year_t}$$

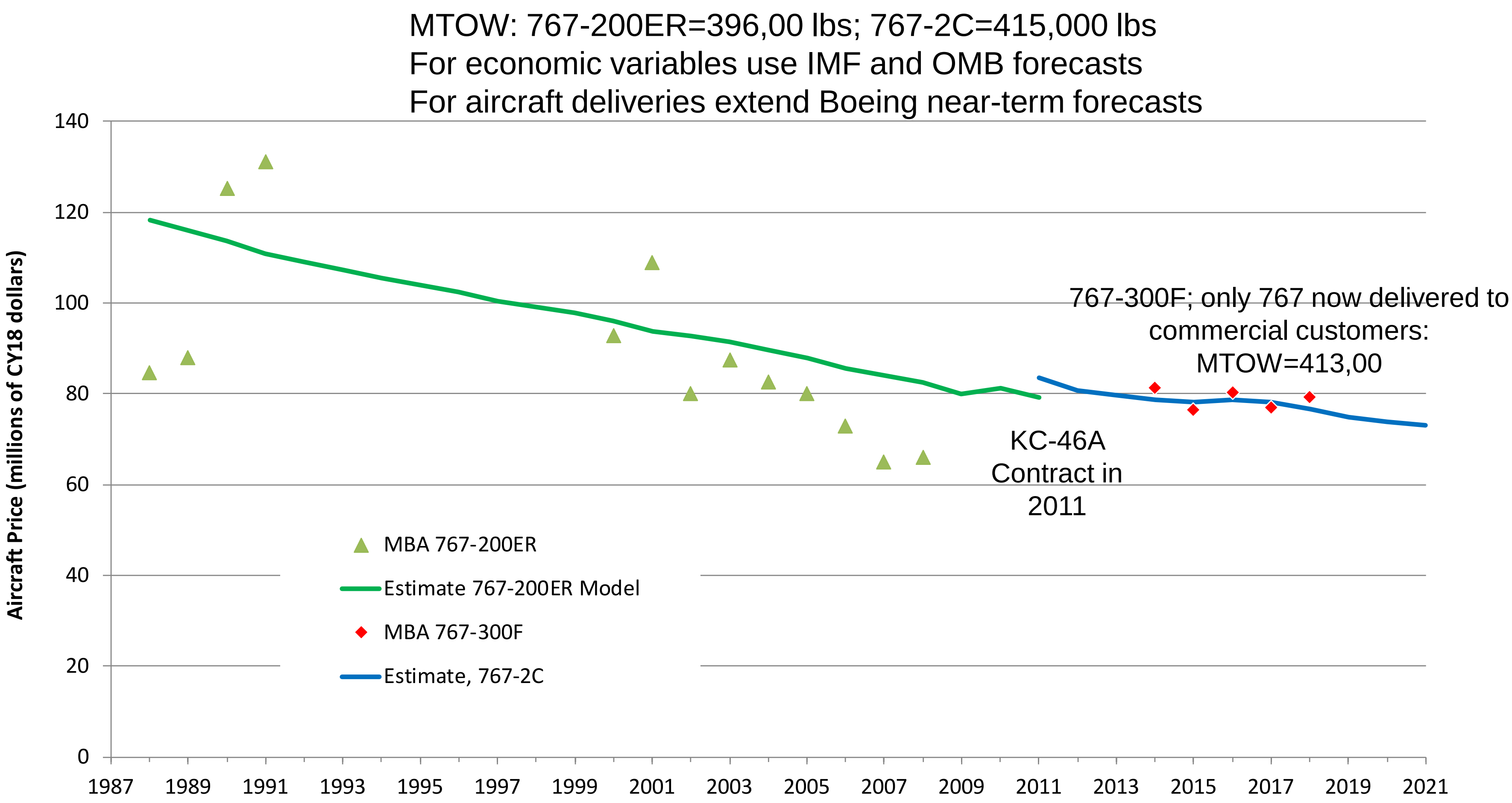
$$(p_{NBjt} = 1{,}221{,}410\ MTOW_j^{1.533})$$

R^2	0.973
Adjusted R^2	0.972
Standard Error of the Estimate	0.083
expressed as +/- Percentages	+8.7%/-8.0%



- 4 engine effect is -20%;
  - Close to airline NPV impact of + fuel burn
- Price Improvement slope: 97.8%
- Fuel price effect: 1$/gallon increase results in a -1.9% price change
  - Indicates that 5% of life-cycle fuel cost increase (NPV basis) is absorbed in lower aircraft prices
- Fuel efficiency effect: -1% difference from efficiency frontier results in a -0.7% decrease in price
  - Consistent with airline life-cycle NPV impact of fuel burn change
- Time trend shows a 1.4% annual decrease in real prices over time

Apply Preferred Model to 767-2C



767-2C estimates do not include additional value of combi and tanker provisions not captured in MTOW

Boeing Financial Data: Comparisons and Trends

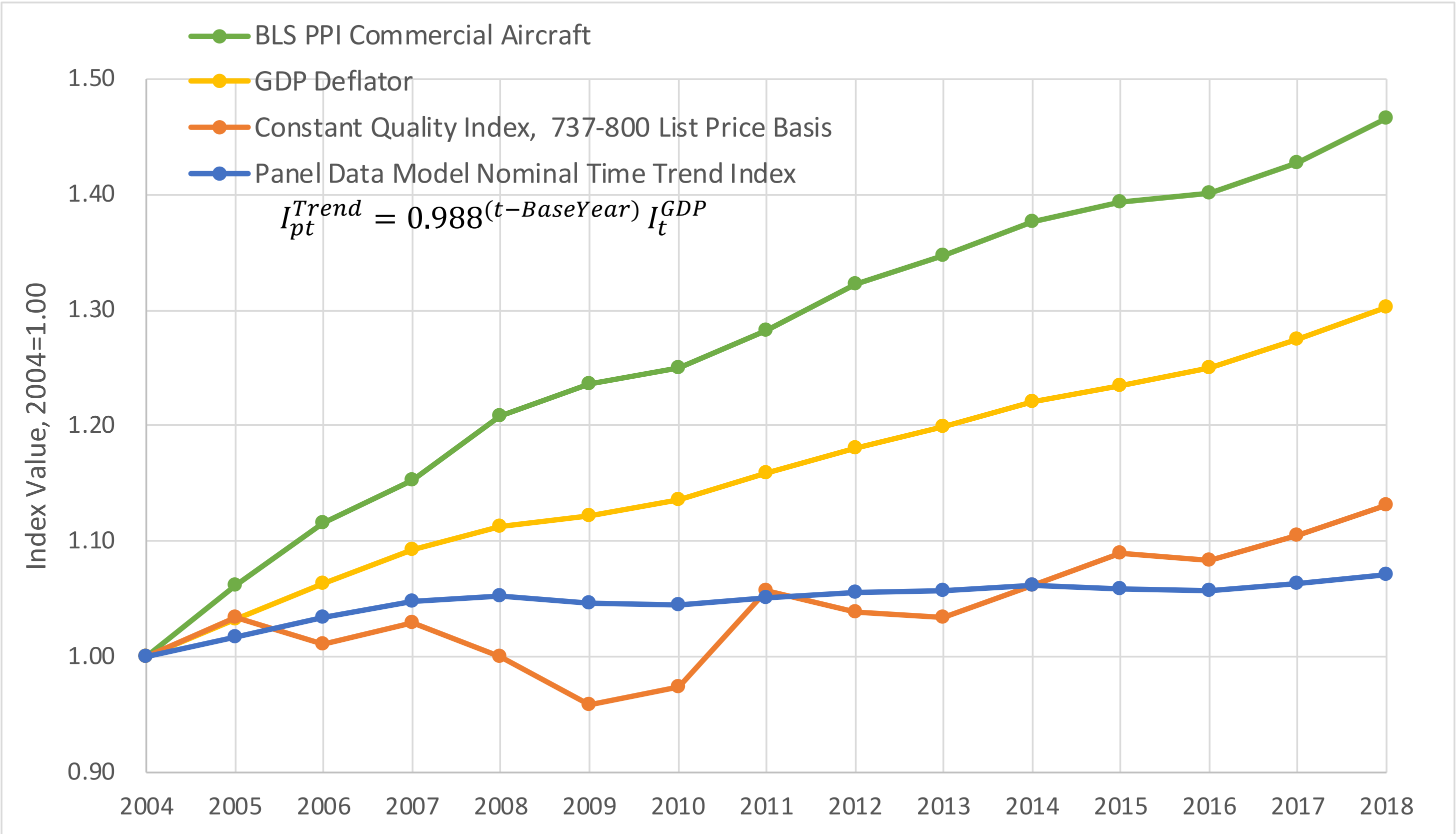
- Boeing Commercial Airplanes (BCA) annual revenue
  - Aircraft sales revenues (R_t) are booked when aircraft are delivered
  - Annual delivery quantities available by aircraft model (q_{jt})
  - Aircraft list prices $(\bar{p}_{jt})$ by aircraft model are published annually
- Compare with MBA and model-estimated prices, 2018 data
  - Weighted discount (D_t) from list prices; BCA revenue: $D_t = \frac{R_t}{\sum_j \bar{p}_{jt} q_{jt}} - 1 = \frac{60{,}715}{129{,}617} - 1 =$ 53.2%
  - Replace R_t using MBA and model estimates ($\hat{p}$);

$$\hat{D}_t = \frac{\sum_j \hat{p} q_{jt}}{\sum_j \bar{p}_{jt} q_{jt}} - 1 = \frac{59{,}528}{129{,}617} - 1 = 54.1\% \text{ (MBA)}, \quad \frac{58{,}857}{129{,}617} - 1 = 54.6\% \text{ (model estimates)}$$

- Create quality-adjusted price index using 2004-2018 data
  - Relative list prices define “737-800 equivalent Index”: $I_{jt}^{737-800_L} = \frac{\bar{p}_{jt}}{\bar{p}_{(737-800)t}}$
  - Calculate equivalent quantities: $Q_t^{737-800_L} = \sum_j q_{jt} I_{jt}^{737-800_L}$
  - A constant-quality price index is:

$$I_{pt}^{737-800_L} = \frac{R_t}{Q_t^{737-800_L}} \Bigg/ \frac{R_{BaseYear}}{Q_{BaseYear}^{737-800_L}}$$

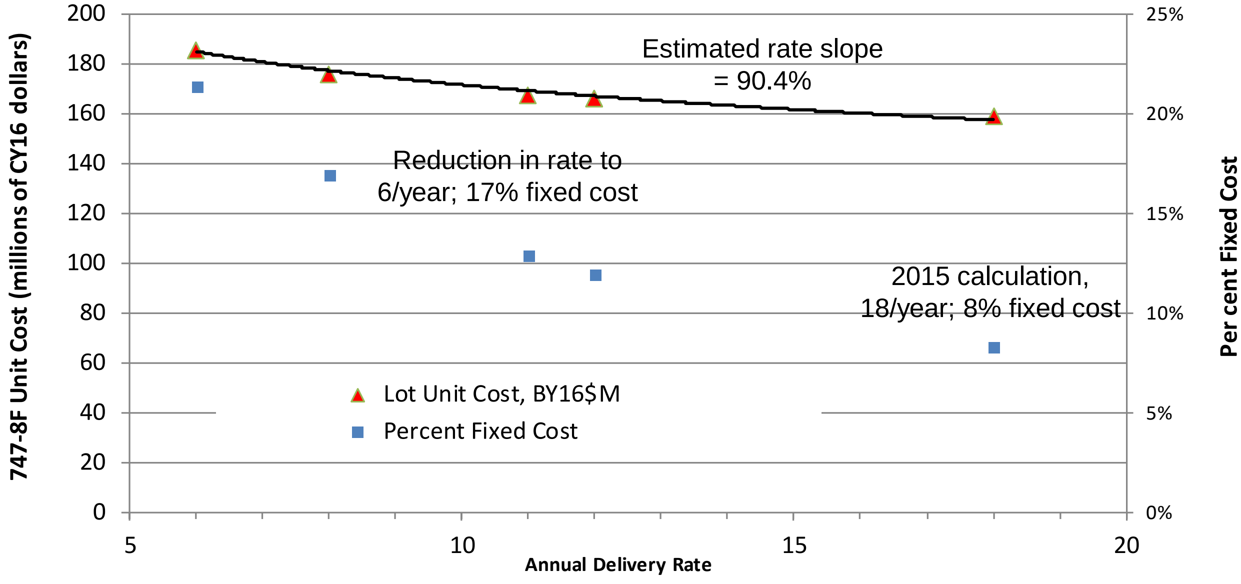
Comparison of Price Indexes



BCA revenue* and model-derived Indexes are below others

Boeing Financial Data: Production Rate Analyses

- Equilibrium condition (Cournot game) for Airbus/ Boeing duopoly: price is a mark-up on cost for mature program*
- Estimate rate effect on cost using analogous program
  - 747 2015 $850M reach-forward loss; +2 years for same program quantity
  - Given this, estimated annual fixed cost is $230M, CY16$.
    - $520M 2 yr delay effect; remainder is estimated pricing delta



- Apply these findings to increased 767 production rates
  - Cost/price effects can be estimated using rate slope

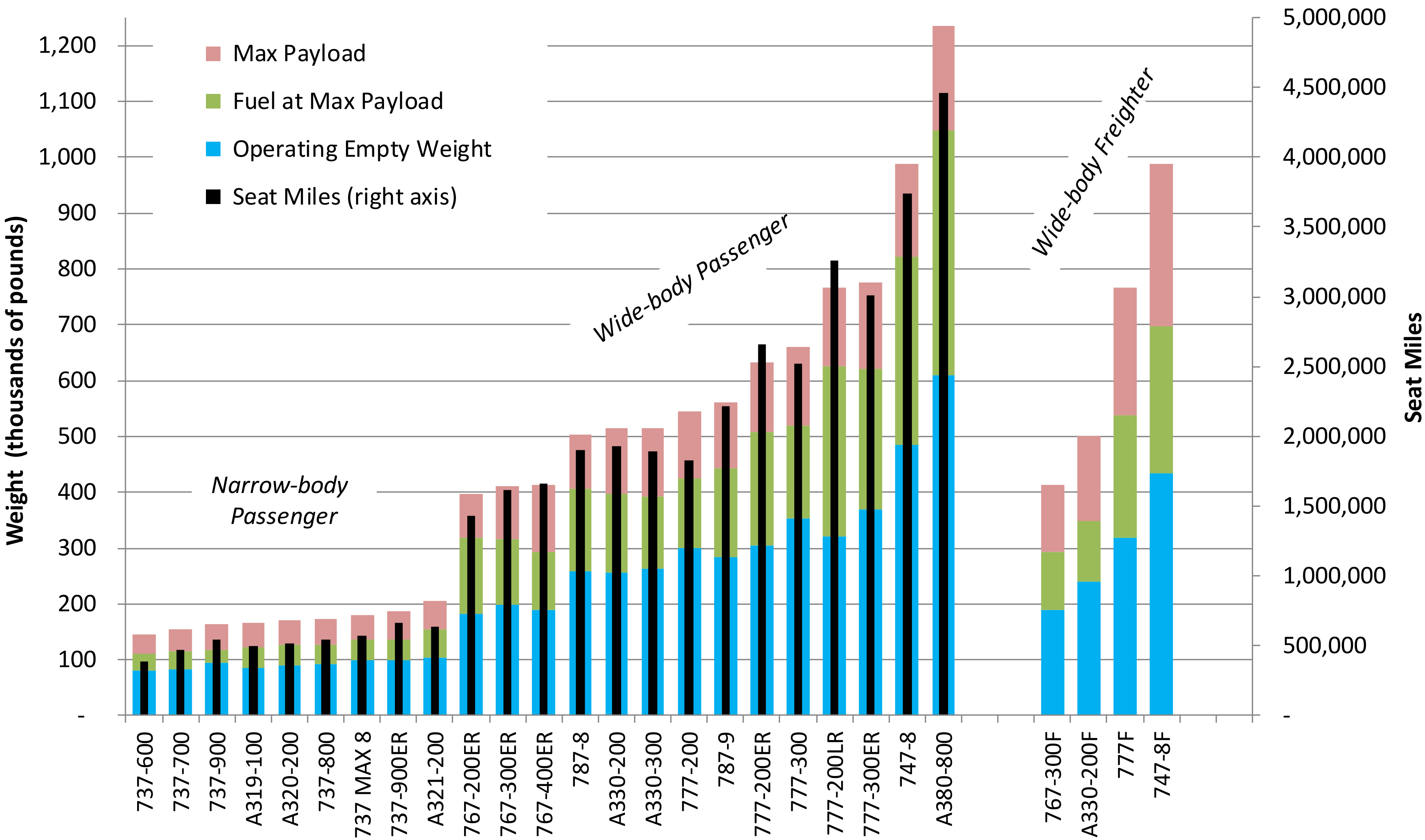
* R Baldwin and P. Krugman. “Industrial Policy and International Competition in Wide-Bodied Jet Aircraft” 2004

Implications for Pricing Commercial Items

- Understand the market in which the seller operates. This would go beyond "market research" and should address market dynamics as described by economic theory.
- Model market prices as they relate to both supply (cost) and demand (utility) side drivers.
  - This will be challenging in that most commercial items bought by DoD and subject to price negotiation will not be as homogenous as commercial aircraft.
- Make use of the seller's publicly available financial data to put available pricing data into perspective, and to better understand the seller's business model.

Backups

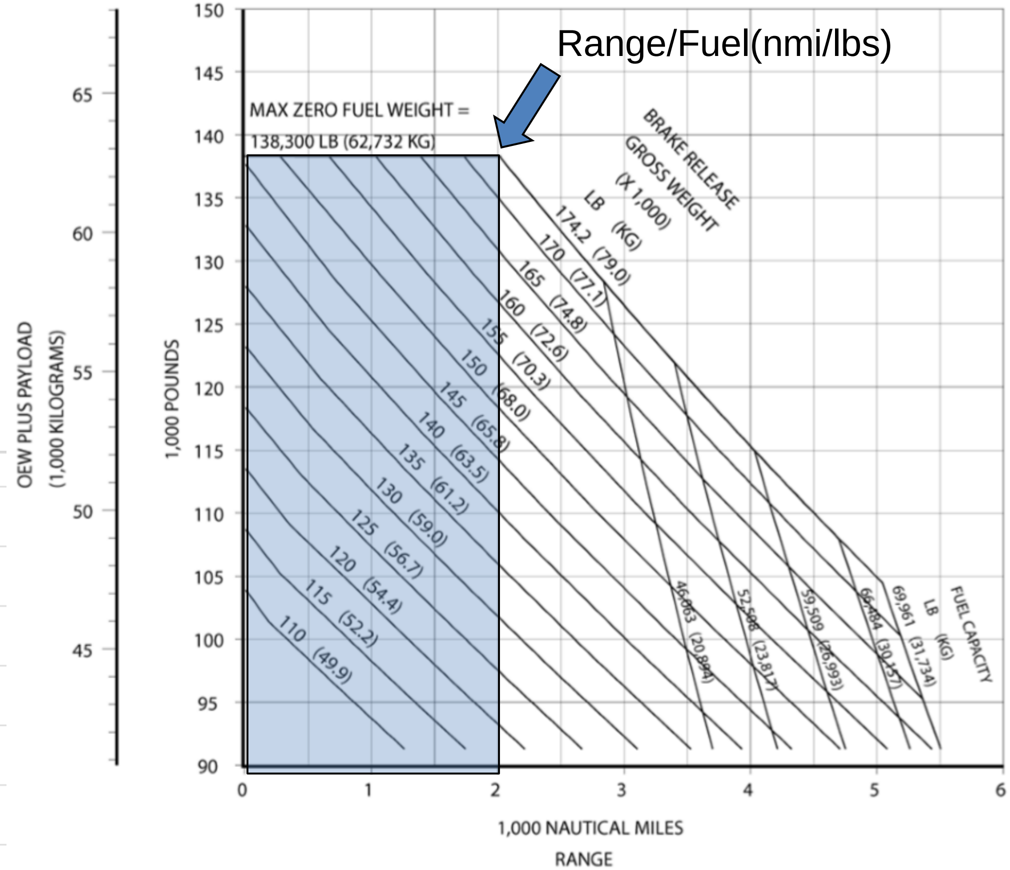
Aircraft Data Sample: Maximum Take off Weight (MTOW) and Seat-Miles

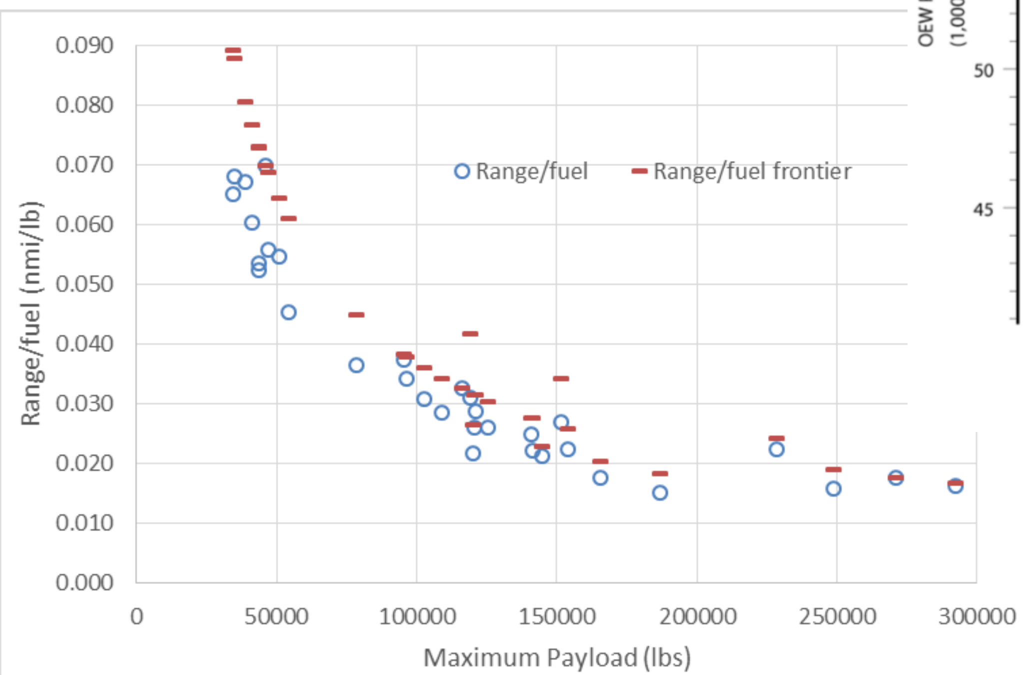


MTOW and Seat-Miles are key price drivers

Fuel Efficiency Factor

- Define aircraft technology frontier with respect to fuel efficiently
  - Range(nmi)/Fuel(lbs) at Max Payload and MTOW
  - Technological frontier defined for a given Max Payload
    - Reflects economies of scale
    - Additional variables adjust for 4 engine and freighter payload effects
    - Non-linear programming solution

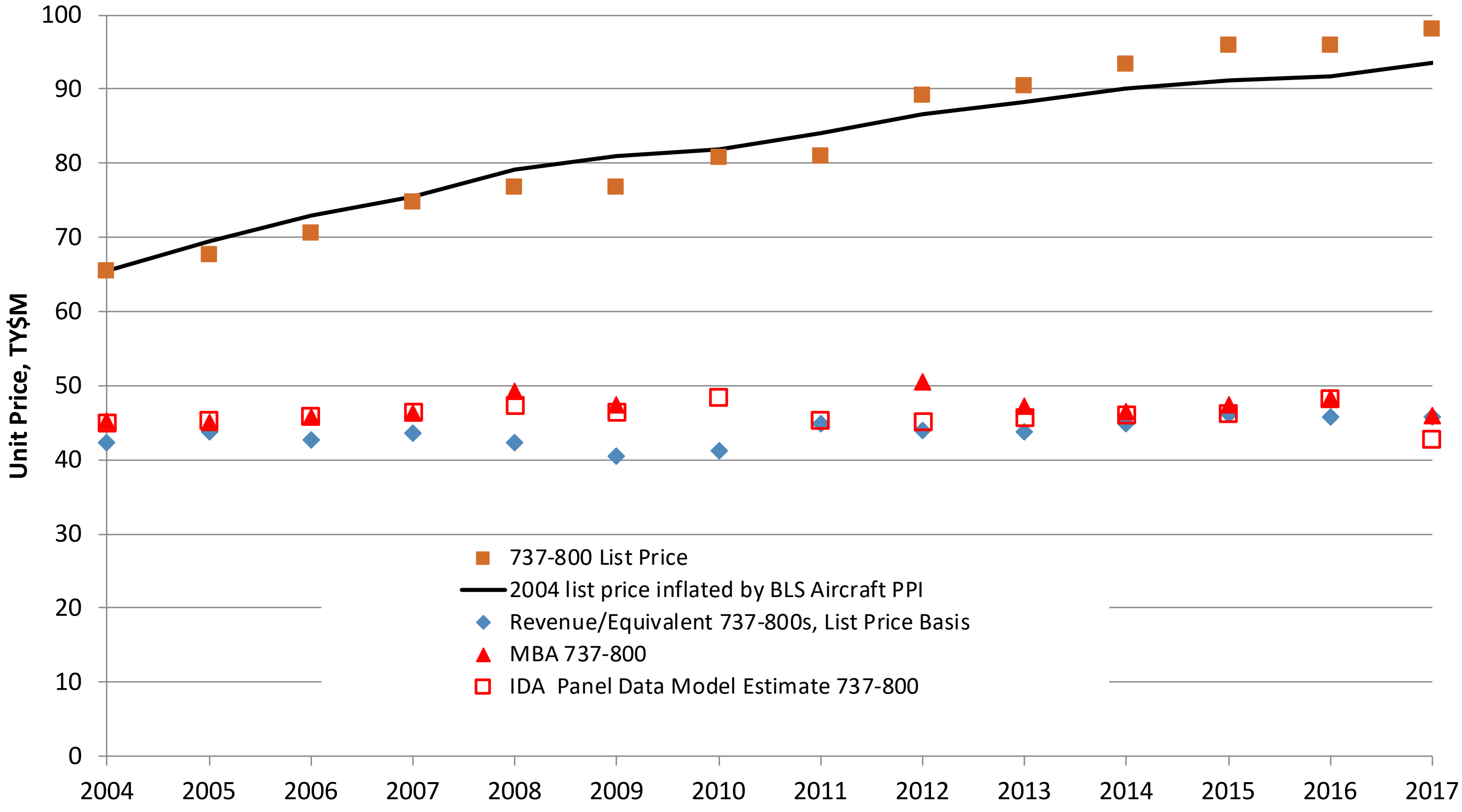




- Fuel Efficiency (FE) factor: percentage difference between observed values and frontier: range is 0% to – 28%
- Newest aircraft (787-9 and Max 8) are on the frontier (FE=0%)

737-800 Side Bar

- Compare unit prices for equivalent 737-800, $\frac{R_t}{Q_t^{737-800_L}}$, with 737-800 prices from other sources



- Transaction price values track one another well
- BLS PPI inflation aligns more closely with list price inflation