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# The Role of Inflation and Price Escalation Adjustments in Properly Estimating Program Costs: F-35 Case Study

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Monterey, California. Naval Postgraduate School

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# **The Role of Inflation and Price Escalation Adjustments in Properly Estimating Program Costs: F-35 Case Study**

Bruce R. Harmon  
Stanley A. Horowitz

(presented by David M. Tate)

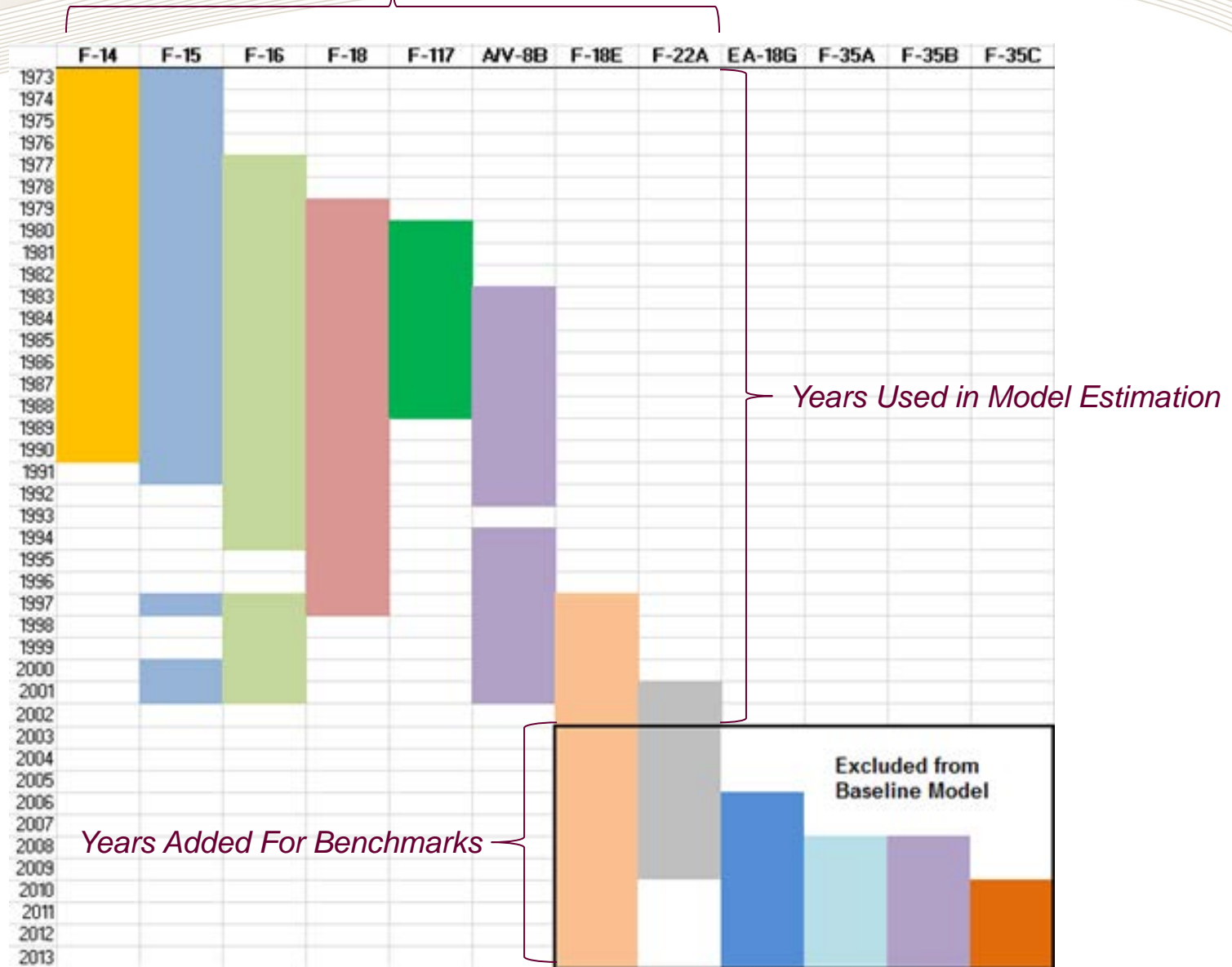
- Using inappropriate price escalation indexes in estimating the costs of future systems can lead to inaccuracies in two ways:
  - Estimating cost-estimating relationships (CERs) and learning curves with constant-dollar prices that don't capture historical price growth
  - Projecting out-year costs using mis-estimates of likely program cost escalation
- We explore these effects by estimating F-35 costs using two different price index approaches
- Purpose is to illuminate issues – How far wrong can we go?

# IDA | Methodology – F-35 Case Study

- Use only data available at late 2001 Milestone B – Engineering and Manufacturing Development (FY02 budget)
- Use data on previous tactical aircraft programs to build two cost models for estimating F-35 Unit Recurring Flyaway (URF) costs:
  - “Baseline” model – Uses escalation index based on our own “hedonic” model for tactical aircraft
  - Hedonic model combines CER and escalation estimate
  - “Green Book” model – Uses historical constant-dollar values computed with the Comptroller’s procurement deflator (GDP price index)
- Compare with model results through FY13
- Project price growth based on
  - Published projections from the Green Book
  - Estimate of future escalation based on the historical ratio of earlier hedonic growth rates and the Green Book rates

# IDA | Data for CER and hedonic model development

## Programs Used in Model Estimation



# IDA | General Modeling Approach

- Pooled cross-section/time series panel data regression
  - Quality/characteristics coefficients and learning/production-rate parameters are estimated simultaneously
  - Nonlinear least squares
- Baseline hedonic model
  - Dependent variable is URF cost in nominal (TY) dollars
  - Coefficients on time-dummy variables provide escalation index
- Green Book model
  - Dependent variable is URF cost in FY 2002 dollars
  - Constant dollars obtained using Green Book index
  - CER uses the same predictors as for hedonic model

- Aircraft characteristics (quality variables)
  - Maximum speed
  - Empty weight (by lot)
  - Advanced materials percentage (titanium + composites)
  - Dummy variable for 5<sup>th</sup> generation
  - Dummy variable for Short Take-off and Vertical Landing (STOVL)
- Production context variables
  - Cumulative quantity/learning curve slope, including spillovers
  - Production rate effect: estimated fixed cost divided by lot quantity
  - Case-specific adjustments for Series/Block changes

# IDA | Model Results and Quality Parameters

*Benchmark for Comparison*

Metric	FY 1973–FY 2002		FY 1973–FY 2013
	Baseline	Green Book	Full Information
Price index used	Hedonic	Green Book	Hedonic
Number of data points	117	117	159
Parameters estimated	41	11	54
Adjusted R <sup>2</sup>	.97	.84	.97
Standard error	.09	.20	.09
Quality coefficients			
Empty Weight <sup>a</sup>	0.78	0.75	0.84
Maximum Speed <sup>a</sup>	0.29	0.08	0.28
Advanced Materials <sup>b</sup>	1.95	1.86	1.63
5th-Generation <sup>b</sup>	1.24	1.44	1.16
STOVL Capability <sup>b</sup>	1.00	1.00	1.05

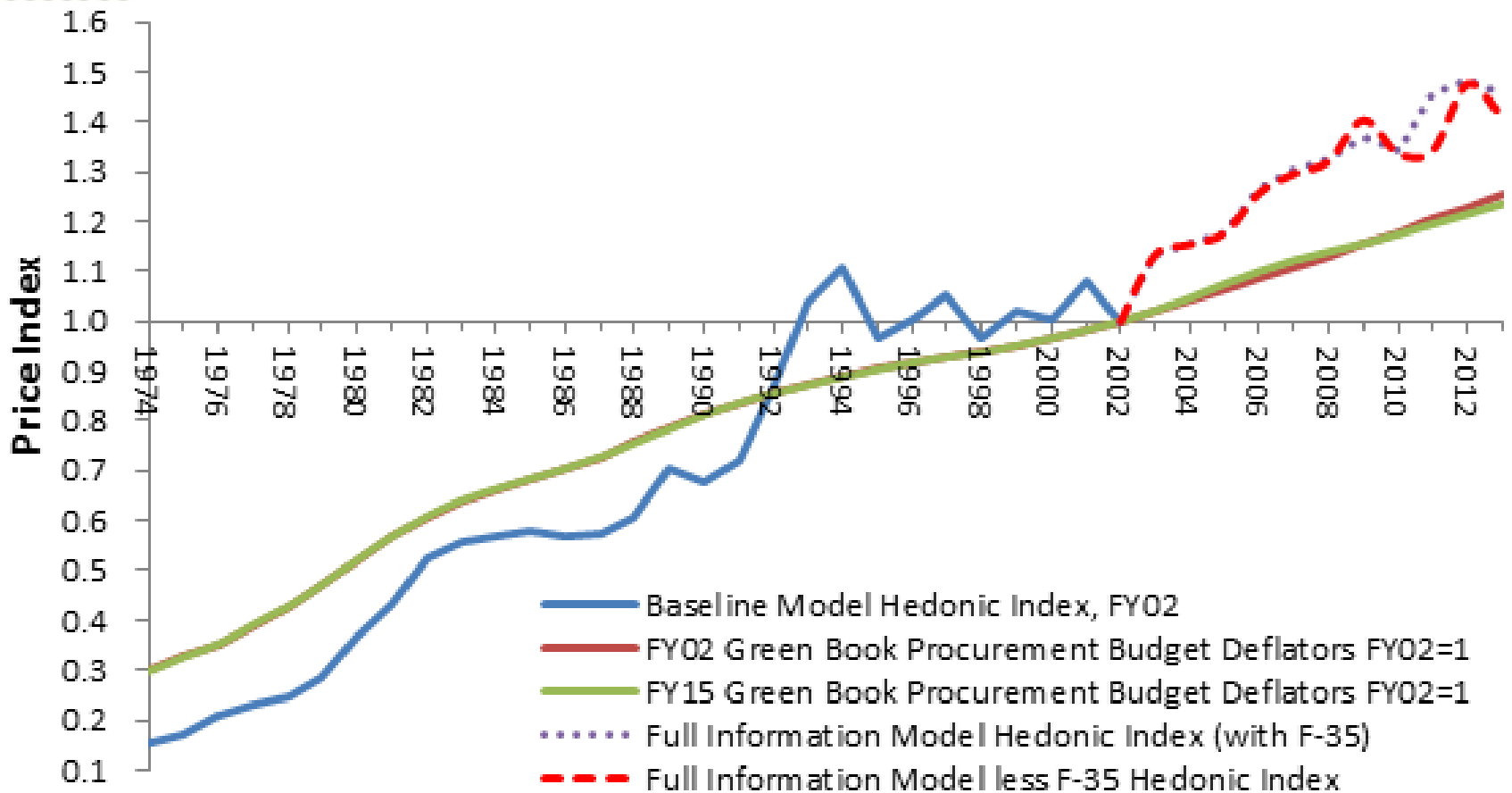
<sup>a</sup> The coefficients on these variables enter the model in the form  $x^b$ .

<sup>b</sup> The coefficients on these variables enter the model in the form  $b^x$ .

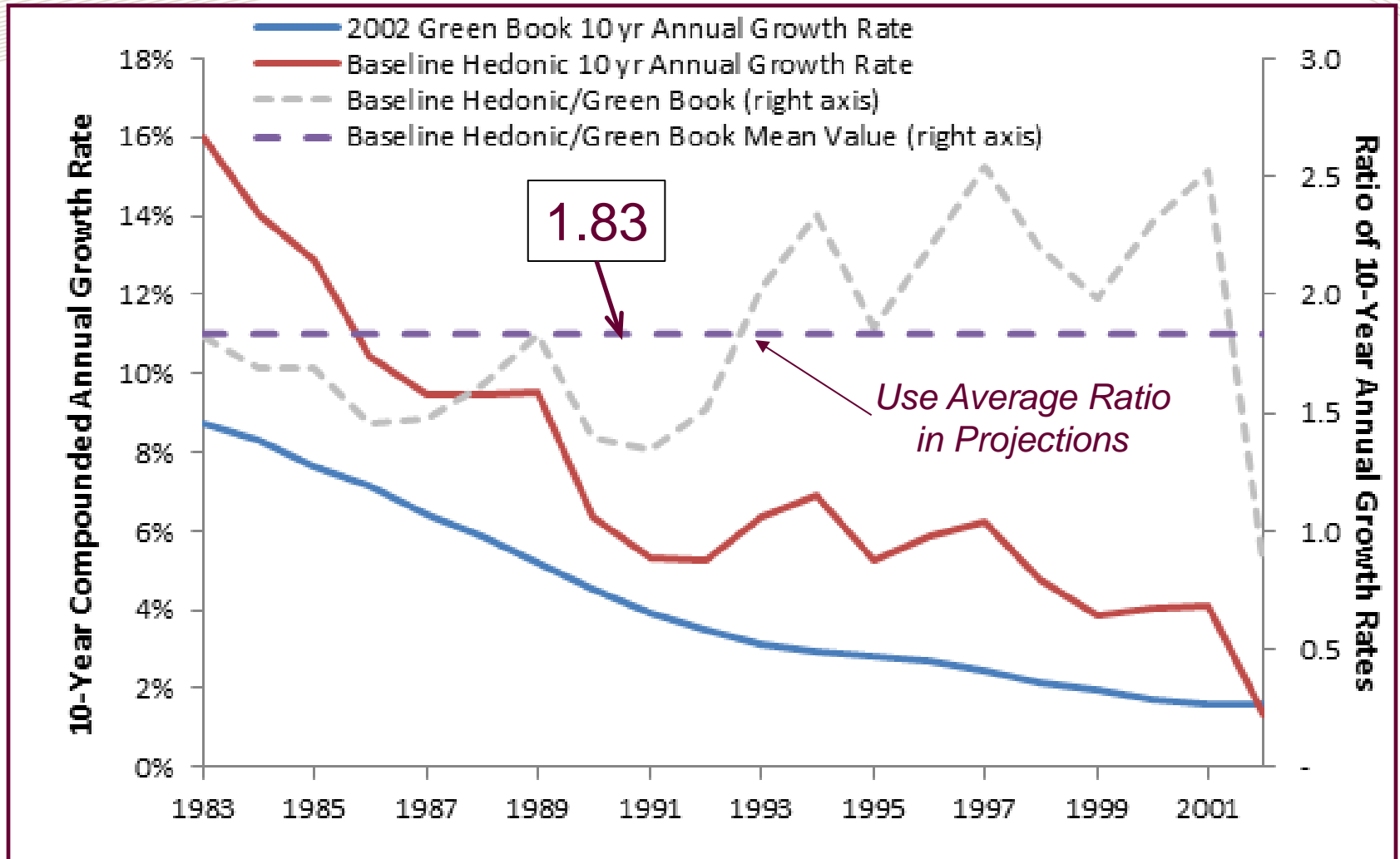
Parameters on variables that are systematically related to time are most distorted in Green Book model



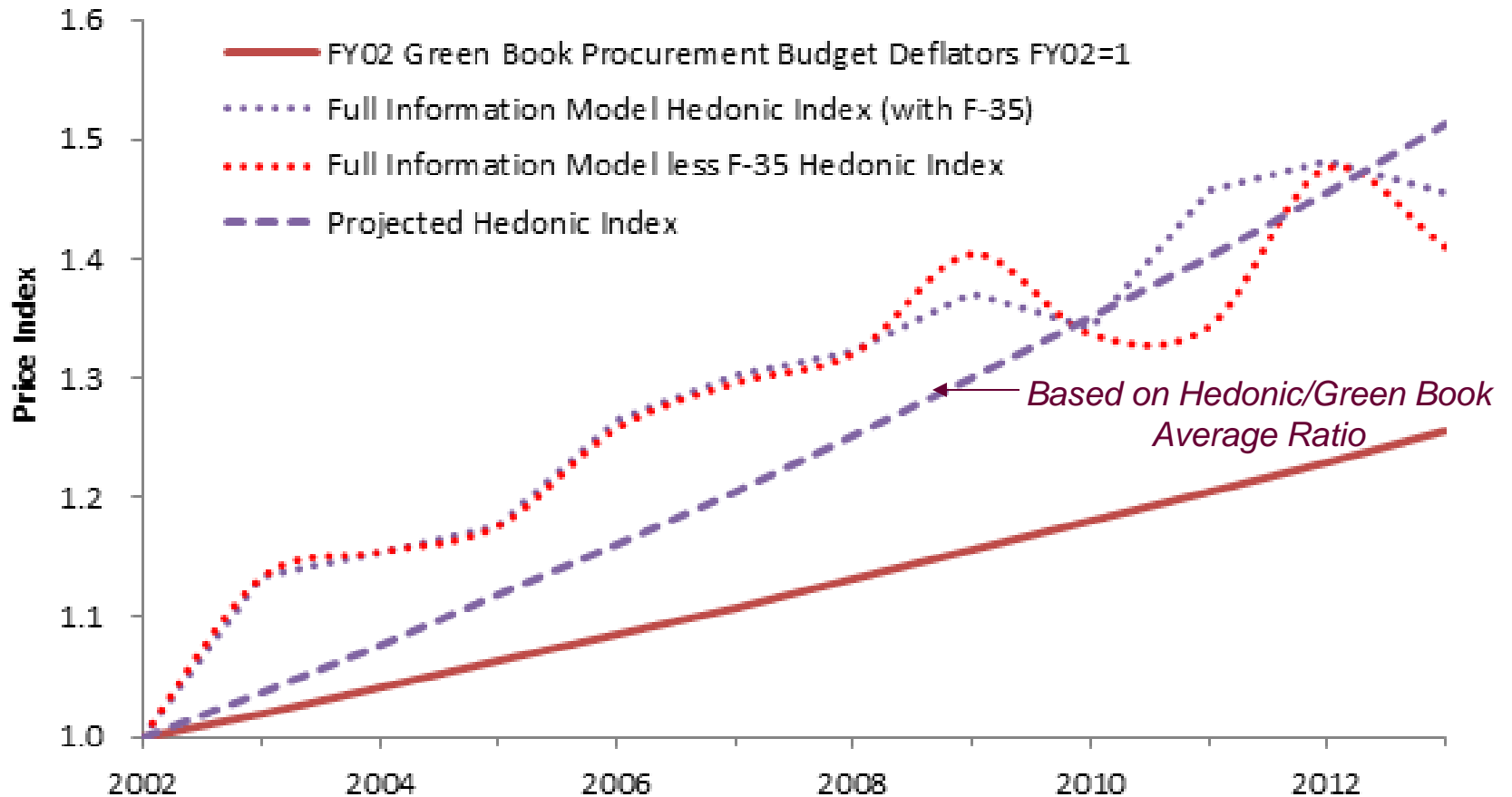
# IDA | Index Comparisons



# IDA | Basis of Hedonic Escalation Projection



# IDA | Index Comparisons with Projected Hedonic



# IDA | T1, Learning Curve and Escalation Estimates

Metric	FY 1973–FY 2002		FY 1973–FY 2013
	Baseline	Green Book	Full Information
1st unit cost (T1), FY02\$M			
F-14A	240	119	261
F-15A	196	94	207
F-16A	97	50	104
F/A-18A	140	73	153
F-117A	187	128	192
A/V-8B	81	49	88
F/A-18E	197	101	210
F-22A	370	212	367
F-35A	235 <sup>c</sup>	144 <sup>c</sup>	234
F-35B	246 <sup>c</sup>	154 <sup>c</sup>	259
F-35C	278 <sup>c</sup>	169 <sup>c</sup>	277
Learning curve slope	84.5%	88.1%	84.1%
Average escalation 73–02	7.4%	4.5%	7.5%
Average escalation 02–13	1.83*GB	2.1% <sup>d</sup>	3.5%

<sup>c</sup> Out-of-sample estimates.

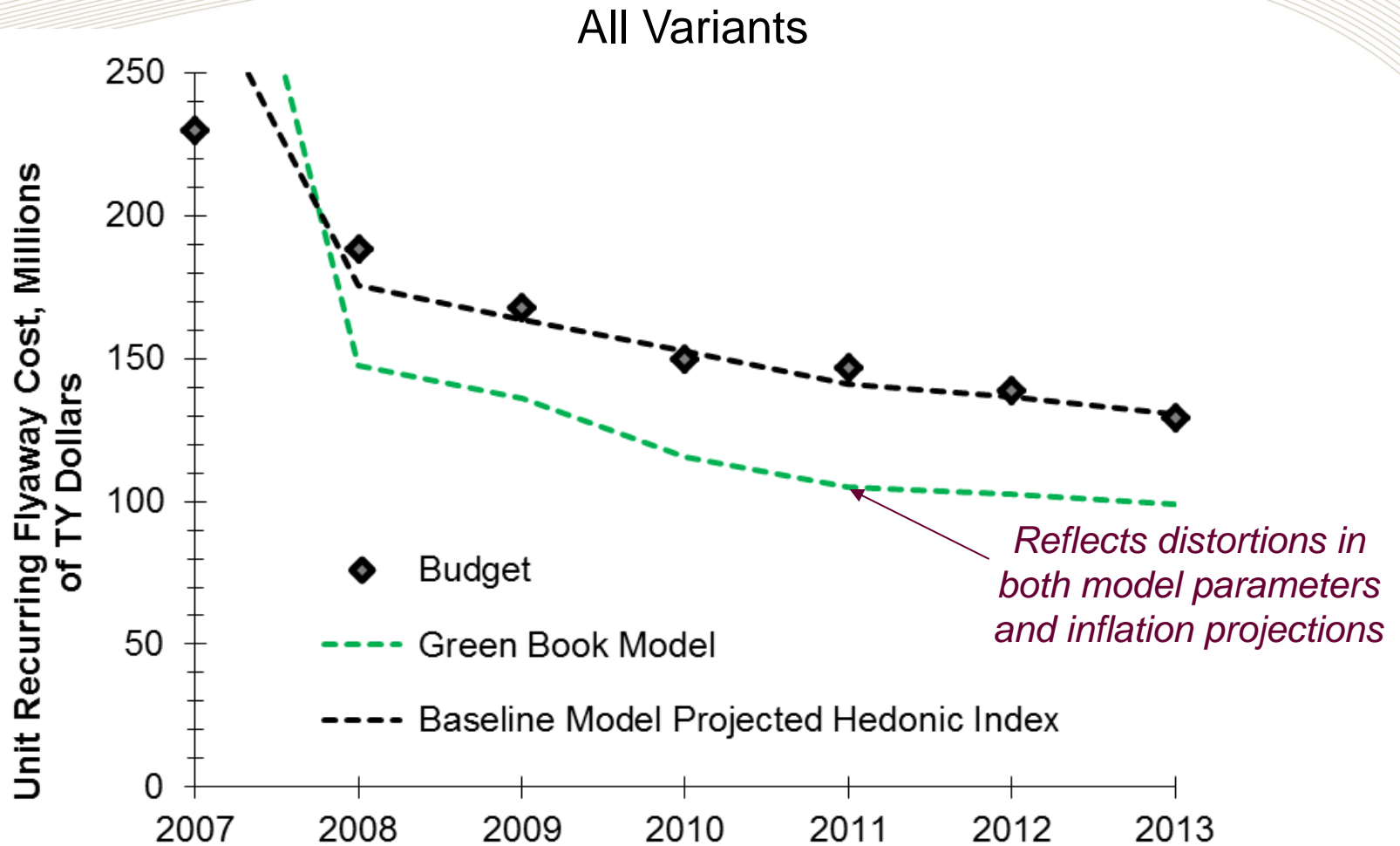
<sup>d</sup> Extrapolated from projections in the FY 2002 Green Book.

Shallower Learning and Lower T1s for Green Book model

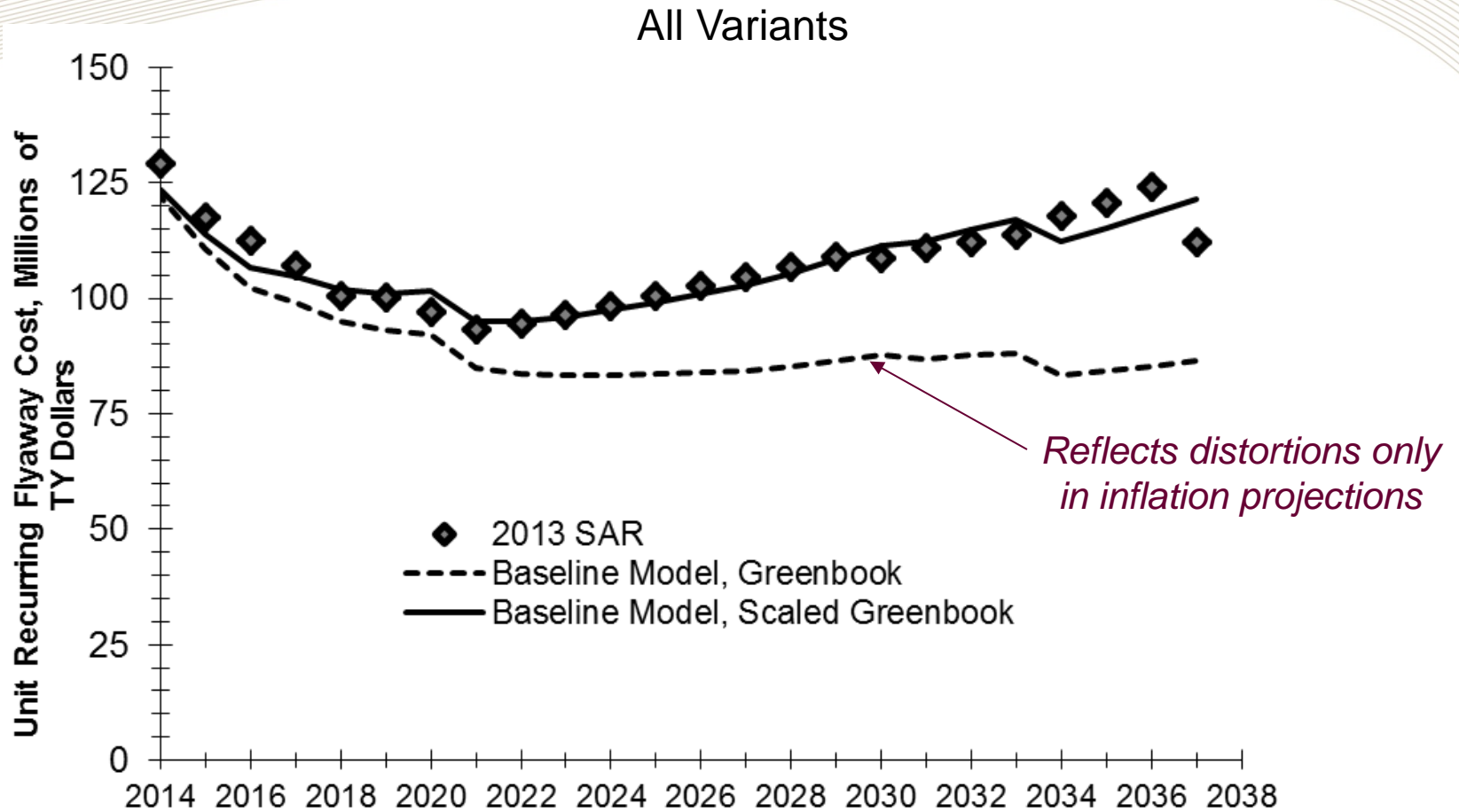
# **IDA | Inputs to F-35 Program Cost Estimation**

- Parallel inputs for Baseline and Green Book models
- Quality variables
  - Contemporary values used in program projections, vice later actual values
- Learning and production rates
  - Use quantities in SAR 13/PB 15, including international buys
  - Use contemporary commonality to capture learning spillovers
- Escalation
  - Projected hedonic index for Baseline model application
  - Green Book index and model; include case with Baseline BY02 estimates and Green Book projections.

# IDA | FY 2008 – FY 2013 F-35 Budget Projections



# IDA | F-35 Program Acquisition Cost Projections



- Built estimates of FY 2008–13 budgets
  - Baseline hedonic-based projection is surprisingly accurate
  - Green Book-based projection underestimates requirement by 30%
- Built estimates of total program cost through 2037
  - Hedonic projection tracks the 2013 SAR very well
  - Projection using the Green Book deflator is 17% below SAR
- Demonstrated the importance of using appropriate price indexes
  - Accurate estimates of cost model structural parameters – CER and learning curve
  - Feasibility of using past price escalation to create improved index series for projecting forward