June 29, 2018

Operating Costs and Aging of Air Force Aircraft

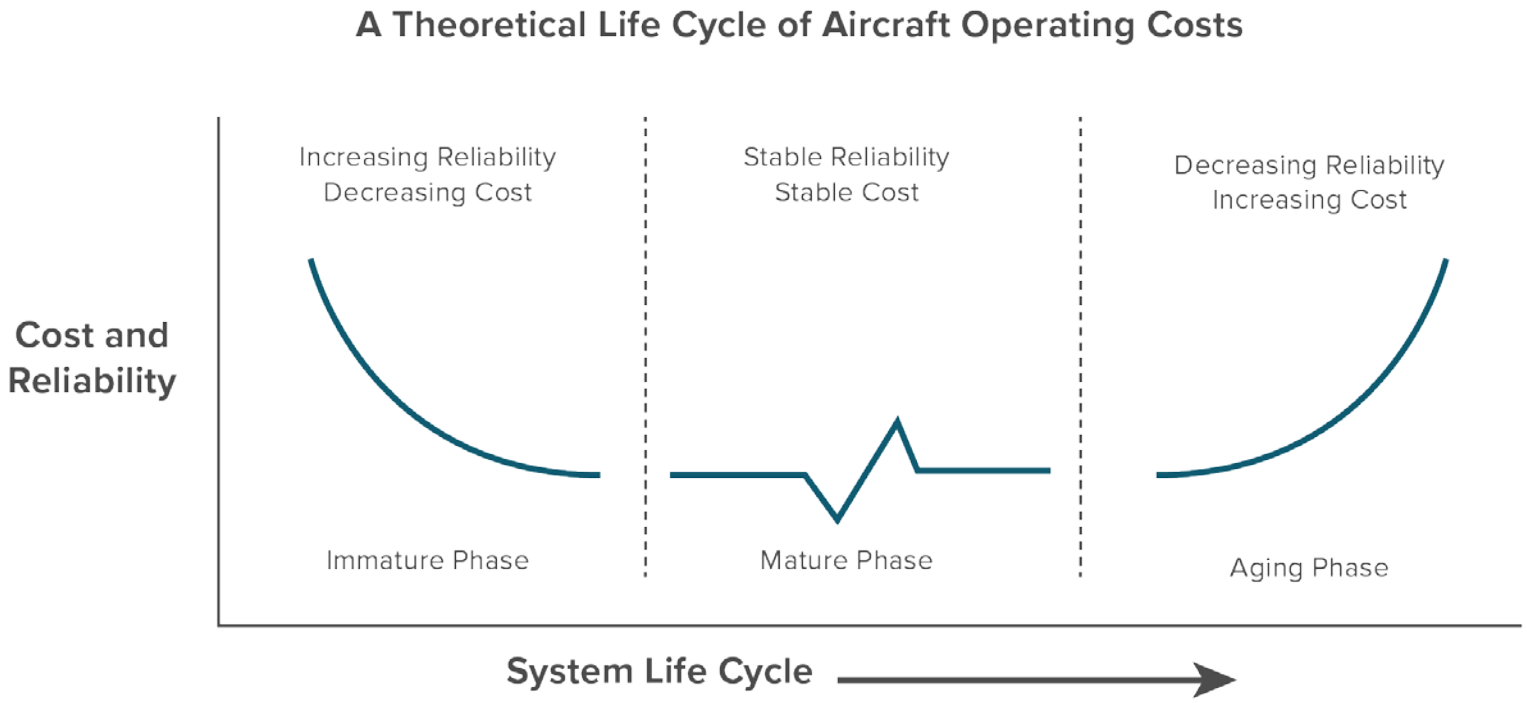
93rd Annual Conference of the
Western Economic Association International
Vancouver, British Columbia

Derek Trunkey

National Security Division

Operating costs are about double acquisition costs and are thought to depend on age.

Aircraft Operating Costs Are Expected to Decline in Initial Years of Operation, to Plateau, and Then to Increase During a Final Phase



Source: K.R. Sperry and K.E. Burns, *Life Cycle Cost Modeling and Simulation to Determine the Economic Service Life of Aging Aircraft* (October 2001).

Estimates of the cost growth associated with age using data from the 1990s found little or no association (0 to 3 percent per year), whereas estimates using data from the 2000s found significant real growth as aircraft age (3 to 8 percent per year).

CBO looked to see if there are factors that could explain the higher growth rates in the recent past.

CBO's Results Explain Divergent Findings From Previous Studies

- Studies based on 1990s' data found little or no growth associated with age
  - LMI (2003) found no age effect
  - CBO (2001) found growth of 1 to 3 percent per year

- Studies based on 2000s' data found larger growth
  - Keating and Arena (2016) found real growth mostly in the 4 to 8 percent per year range
  - Current study found real growth mostly in the 3 to 6 percent per year range (based on a similar model with age as the only explanatory variable)

See Logistics Management Institute, *The Relationship Among Cost, Age, and Usage of Weapon Systems* (January 2003); Congressional Budget Office, *The Effects of Aging on the Costs of Operating and Maintaining Military Equipment* (August 2001), Appendix B, www.cbo.gov/publication/13213; and Edward G. Keating and Mark V. Arena, "Defense Inflation: What Has Happened, Why Has It Happened, and What Can Be Done About It?" *Defense and Peace Economics*, vol. 27, no. 2 (April 2016), pp. 176–183.

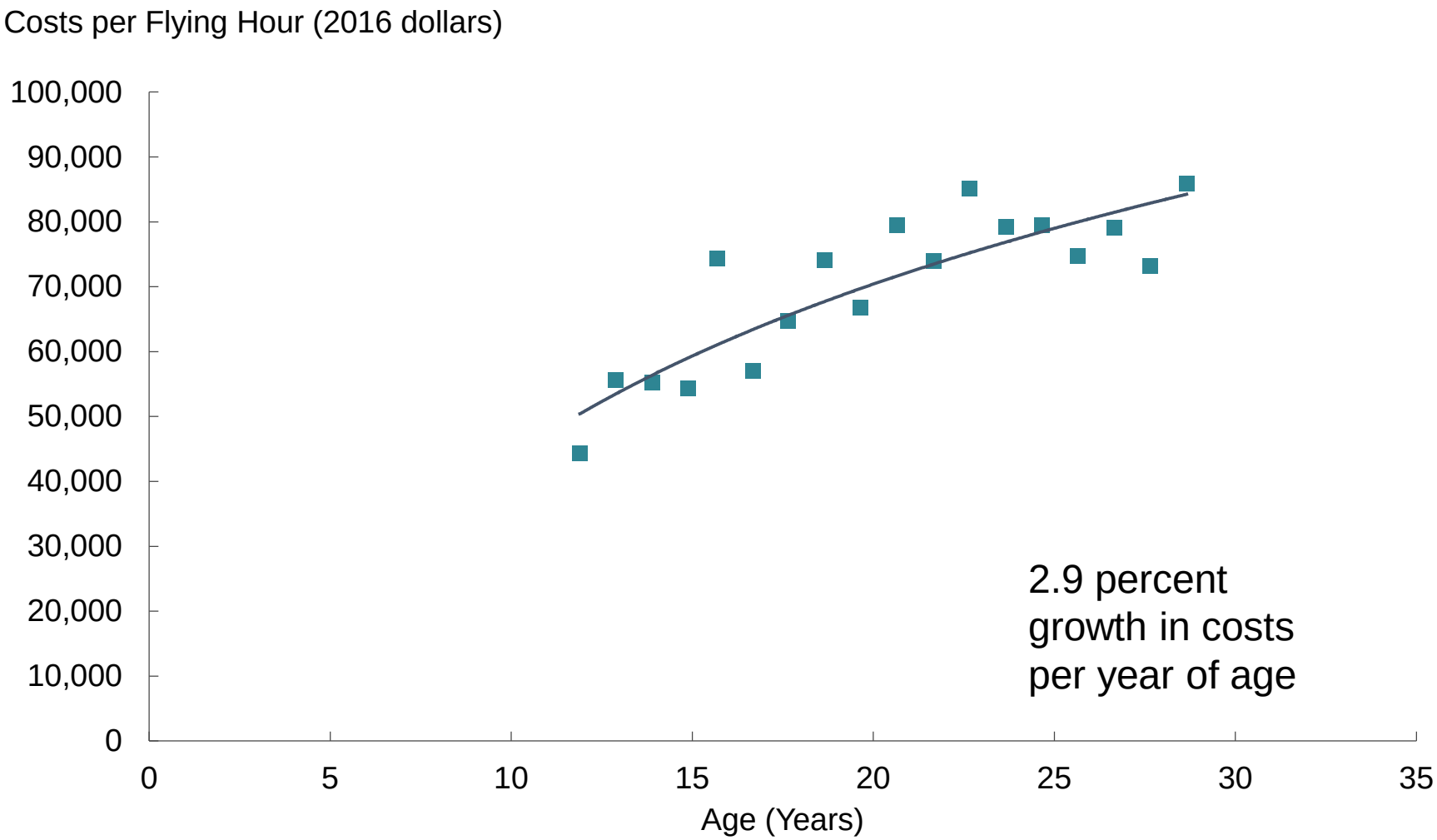
CBO’s current study reconciles past studies from different eras by using the size of the Air Force’s budget as an additional explanatory variable.

CBO Explored Factors That Could Explain the High Recent Growth in Operating Costs

- CBO used linear regression models to explain the costs per flying hour (semi log form)
- The first model used only age of aircraft as an explanatory variable
- The second model used both age of aircraft and the size of the Air Force's budget as explanatory variables
- CBO used annual AFTOC data from 1999 to 2016 for B-1B, B-52, C-130, C-17, C-5, F-15 A-D, F-15E, F-16, F-22A, HH-60G, KC-135, RQ-4, and U-2
  - Most data are from the midpoint of an aircraft's life

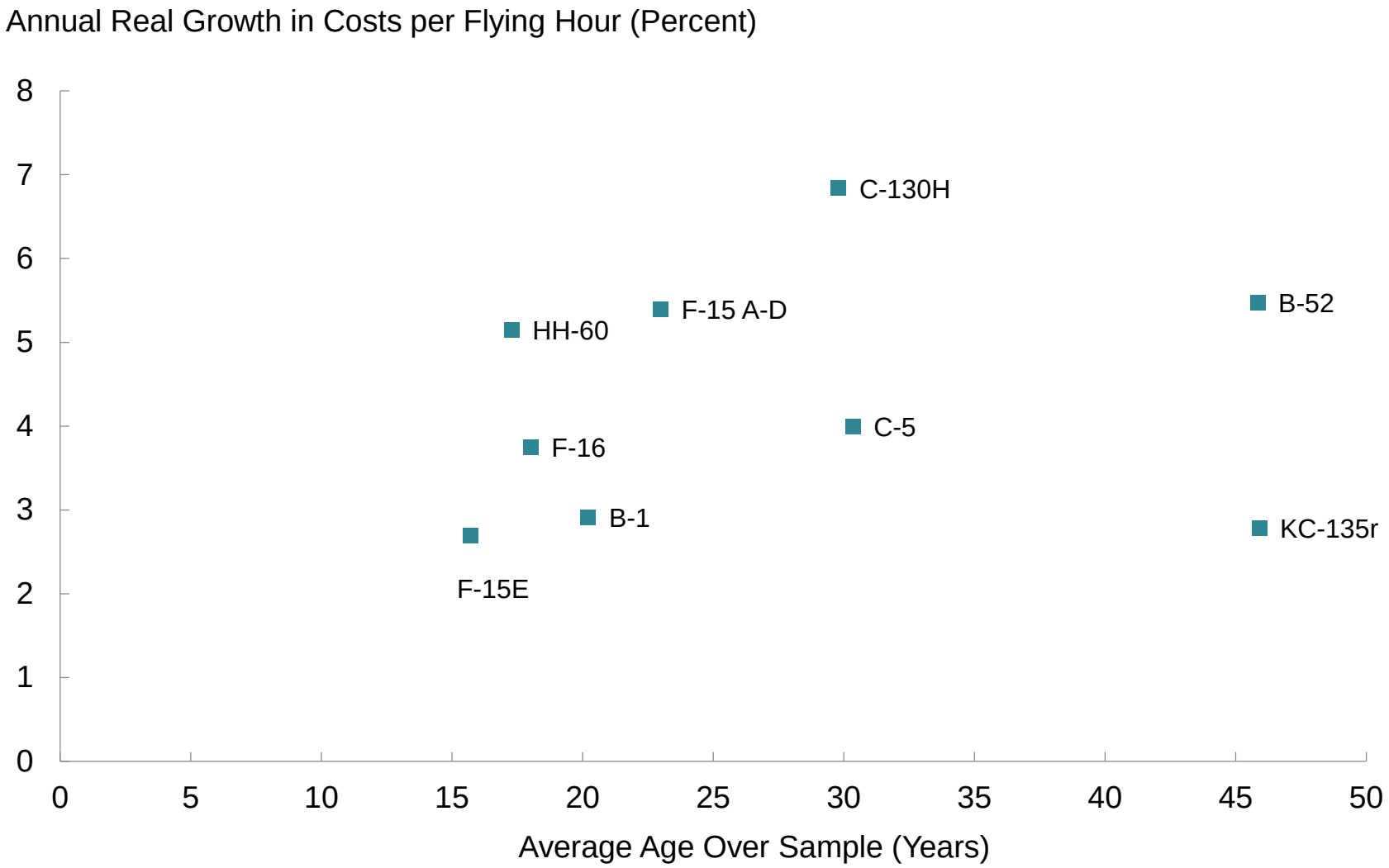
The model that did not account for the budget found results comparable to those from prior research.

B-1 Costs per Flying Hour Generally Increased as the System Aged



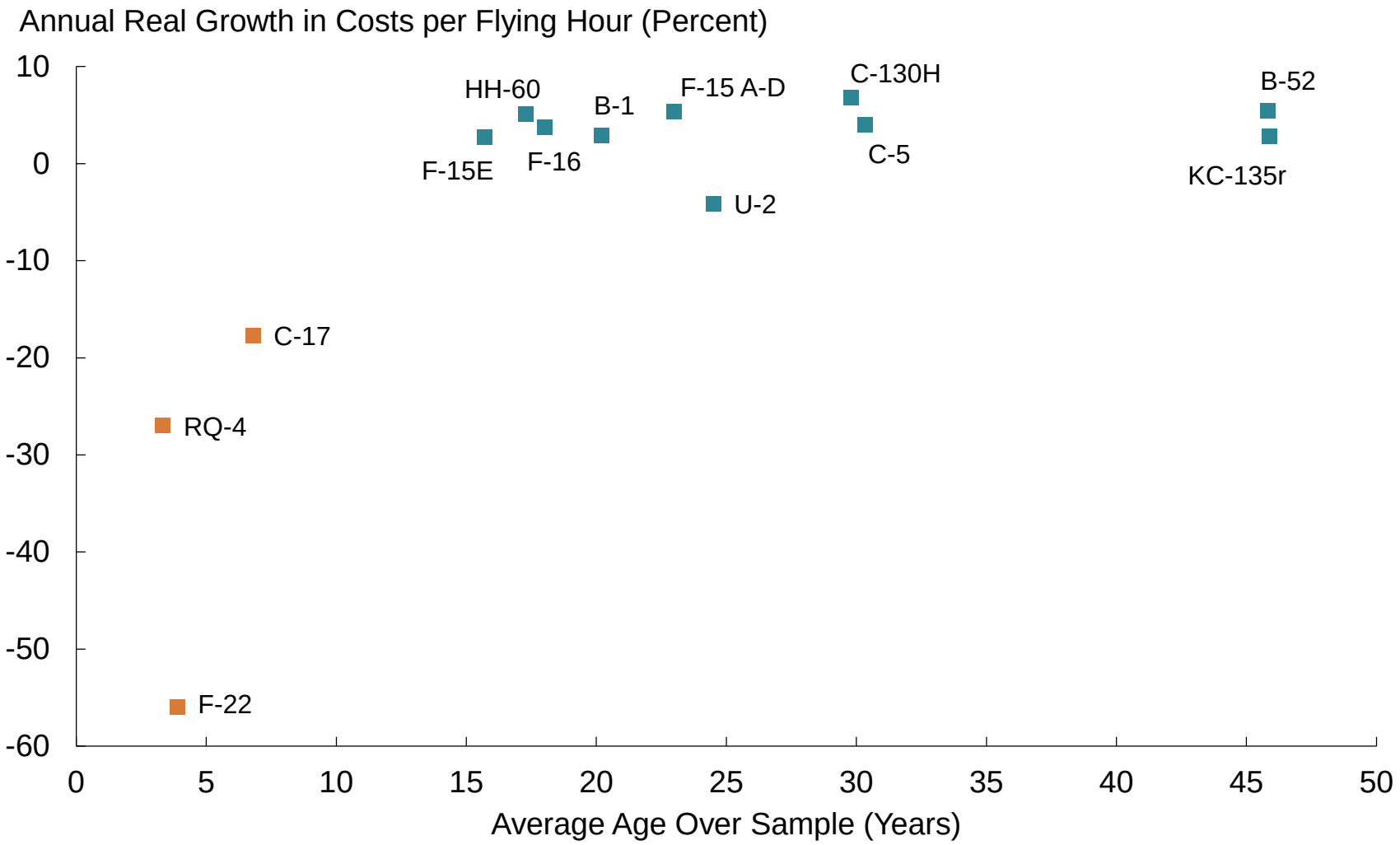
Estimates that did not account for the Air Force’s budget show an additional year of age is associated with costs per flying hour mostly in the range of 3 to 6 percent.

A Number of Air Force Systems Experienced Sizable But Highly Varying Increases in Costs per Flying Hour



Some aircraft are still in the immature phase and experienced declining costs.

Some Younger Air Force Fleets (F-22, RQ-4, C-17) Experienced Declining Costs per Flying Hour as They Aged

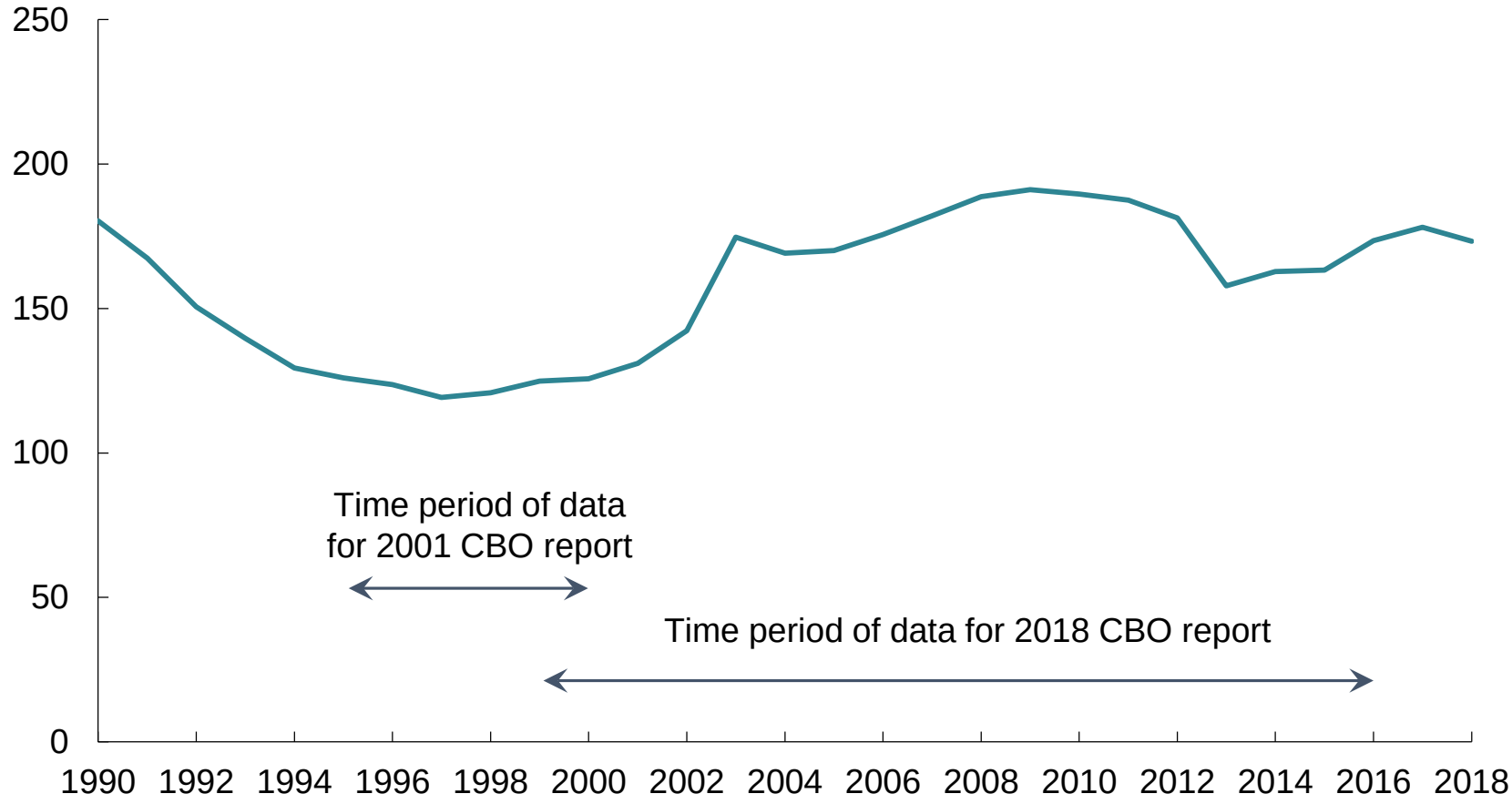


The Air Force’s budget increased significantly between 2000 and 2016.

Accounting for that budget reduced the association between cost and aircraft age by up to half in the 2000s.

The Air Force's Total Budget Increased Markedly in Real Terms Between 2000 and 2010

Total Air Force Budget, by Fiscal Year (Billions of 2016 dollars)

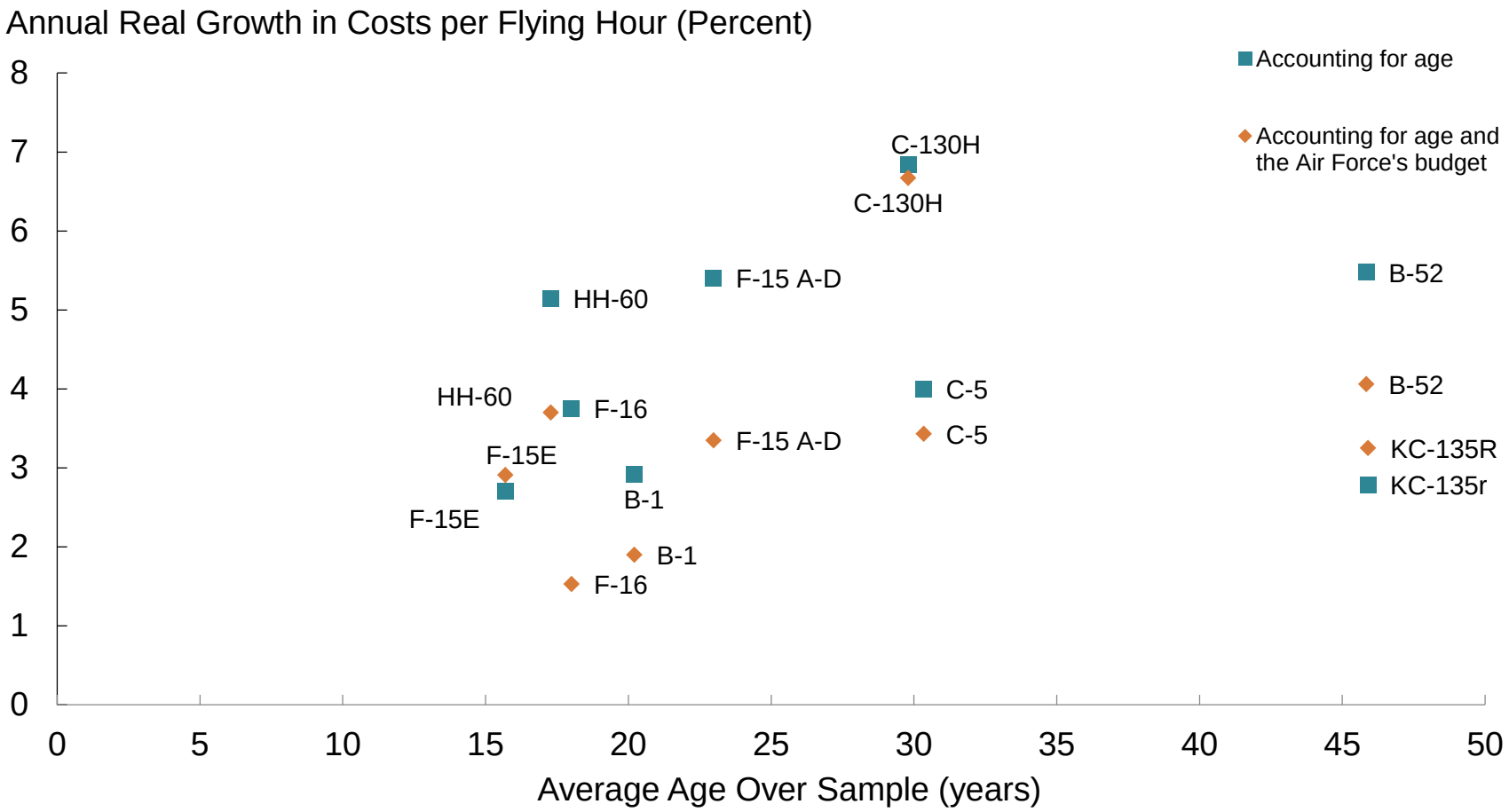


The model that accounted for the size of the Air Force's budget found growth rates that were more consistent with those of models based on 1990s' data.

The model that accounted for the Air Force's budget found that the association between aging and cost growth was mostly in the 2 to 4 percent range.

Other factors (such as mission capable rates and number of hours flown) had smaller associations or were insignificant.

Including the Air Force's Total Budget as an Independent Variable Generally Reduced the Association With Age



Additional Information on CBO's Approach

How CBO Explored Factors That Could Explain the High Recent Growth

1. Measure simple association:

   $Ln(Cost/FH) = a + b1*age$

2. Use an enhanced regression that accounts for the budget:

   $Ln(Cost/FH) = a + b1*age + b2*budget$

3. Examine several aircraft types:
   - B-1B, B-52, C-130, C-17, C-5, F-15 A-D, F-15E, F-16, F-22A, HH-60G, KC-135, RQ-4, U-2
   - Use annual AFTOC data from 1999 to 2016
   - Most data are from the midpoint of an aircraft's life

Cost=annual operating cost; age=average age in years; budget=Air Force Total Obligation Authority.

Regression Results for Simple Model, Dependent Variable Is Ln(Cost/FH)

	Estimated Coefficient (Standard Error)	
Aircraft	Intercept	Age
B-1	10.55**	0.0291**
	(.103)	(.005)
B-52	8.47**	0.0548**
	(.329)	(.007)
C-130H	8.44**	0.0685**
	(.099)	(.005)
C-17	18.83**	-0.1771**
	(.082)	(.011)
C-5	9.88**	0.0400**
	(.206)	(.007)
F-15 A-D	8.94**	0.0542**
	(.143)	(.006)
F-15E	9.93**	0.0271**
	(.126)	(.008)
F-16	9.11**	0.0375**
	(.176)	(.010)
F-22	15.05**	-0.5610**
	(.791)	(.176)
HH-60	9.22**	0.0515**
	(.155)	(.009)
KC-135T	8.36**	0.0278**
	(.248)	(.005)
RQ-4	12.28**	-0.2730**
	(.681)	(.188)
U-2	8.36**	-0.0412**
	(.248)	(.007)

** indicates that the P value is less than .01.

Regression Results for Model With Budget, Dependent Variable Is Ln(Cost/FH)

	Estimated Coefficient (Standard Error)		
Aircraft	Intercept	Age	AF Budget (Billions 2016$)
B-1	10.13**	0.0190**	0.0039**
	(.131)	(.004)	0.0010
B-52	8.25**	0.0406**	0.0055**
	(.258)	(.007)	(.0015)
C-130H	8.37**	0.0667**	0.0065**
	(.177)	(.006)	(.0014)
C-17	8.79**	-0.0986**	-0.0064
	(1.094)	(.015)	(.002)
C-5	8.83**	0.0343**	0.0076**
	(.400)	(.006)	(.003)
F-15 A-D	8.53**	0.0335**	0.0059**
	(.144)	(.006)	(.001)
F-15E	10.01**	0.0291**	0.0031*
	(.144)	(.010)	(.002)
F-16	8.21**	0.0153**	0.0084**
	(.225)	(.009)	(.002)
F-22	29.83**	-0.7444**	-0.0830
	(5.850)	(.162)	(.006)
HH-60	8.58**	0.0370**	0.0056*
	(.271)	(.009)	(2.716)
KC-135T	8.43**	0.0325**	-0.0018
	(.249)	(.006)	(.001)
RQ-4	3.35	-0.3491	0.0518
	(7.142)	(.395)	(.037)
U-2	11.98**	-0.0341**	-0.0029
	(.240)	(.008)	(.002)

* indicates that the P value is less than .10; ** indicates that the P value is less than .01.