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The Changing Shape of the Defense Industry and Implications for Defense Acquisitions and Policy

Victoria A. Greenfield

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Work in Progress

Victoria A. Greenfield, Ph.D.

Crowe Chair Professor, U.S. Naval Academy

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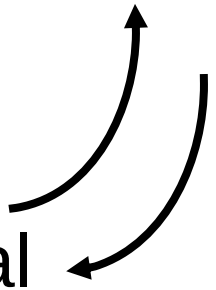
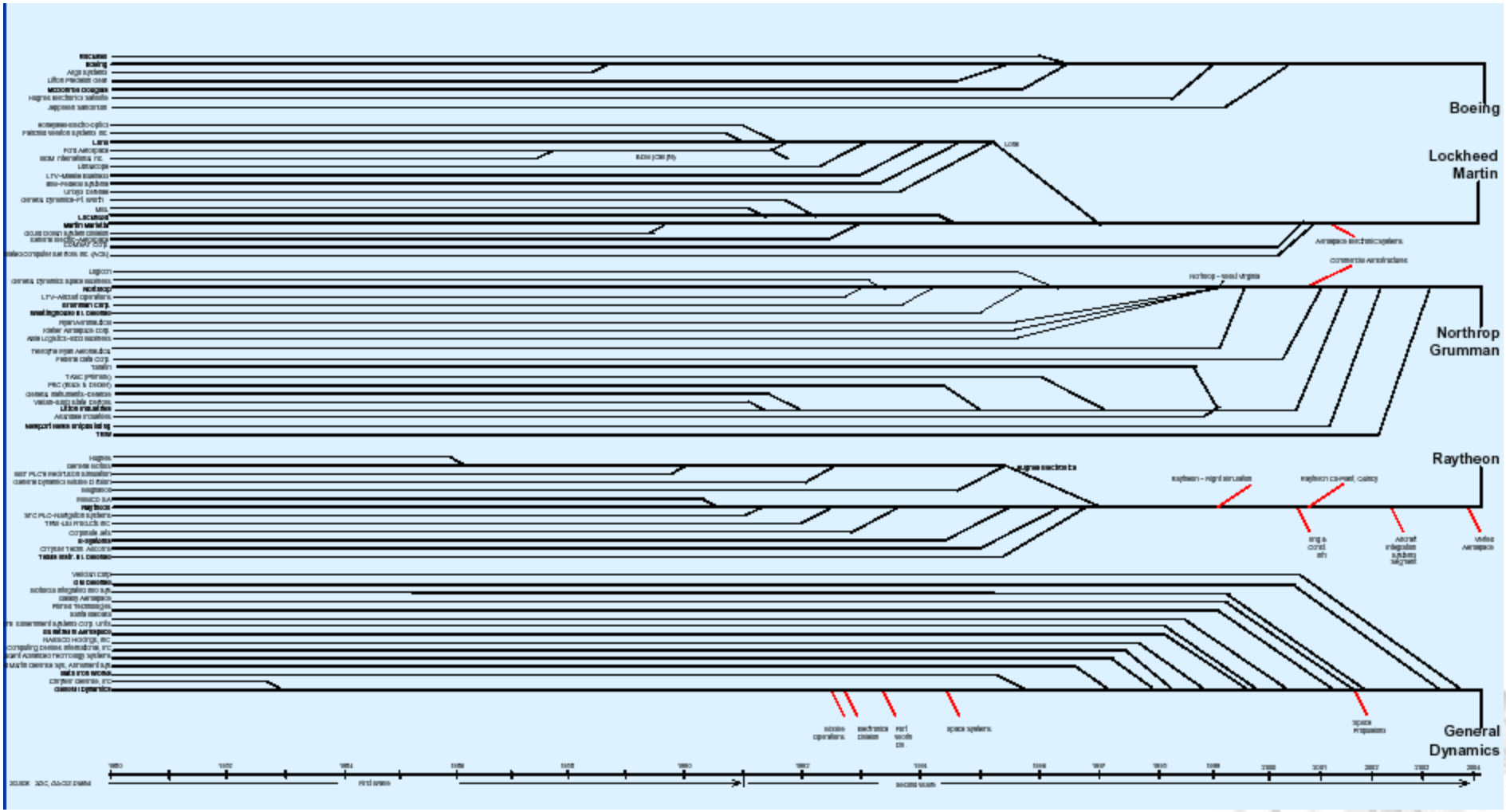
Wave of Consolidation Hits Defense Industry in 1990s

- Cold War ends… less defense spending
- Top-tier and other defense firms merge
  - Lockheed and Martin Marietta
  - Boeing and McDonnell Douglas
- DOD provides institutional and some financial support for mergers
  - Antitrust policy process
  - Cost reimbursements



"Last Supper" (1993)

The “Eye Chart” Provides One Perspective



Source: Chao (2005), citing others

Research Goals

- Establish statistical facts
  - How has consolidation reshaped the defense industry?
  - How might it continue to reshape the industry?
  - What forces have promoted it?
- Consider implications for defense acquisitions using standard economic models and tools
  - Concentration and competition
  - Concentration, productivity, and innovation

Approach

- Define defense industry in terms of DOD “market” and suppliers of goods and services
- Draw data from DD350, DOD top 100 company reports, budget documents, DOL, DOC/BEA, FactSet Mergerstat, and AIA to establish facts and assess implications, using
  - Descriptive statistics
  - Time series and correlation analyses

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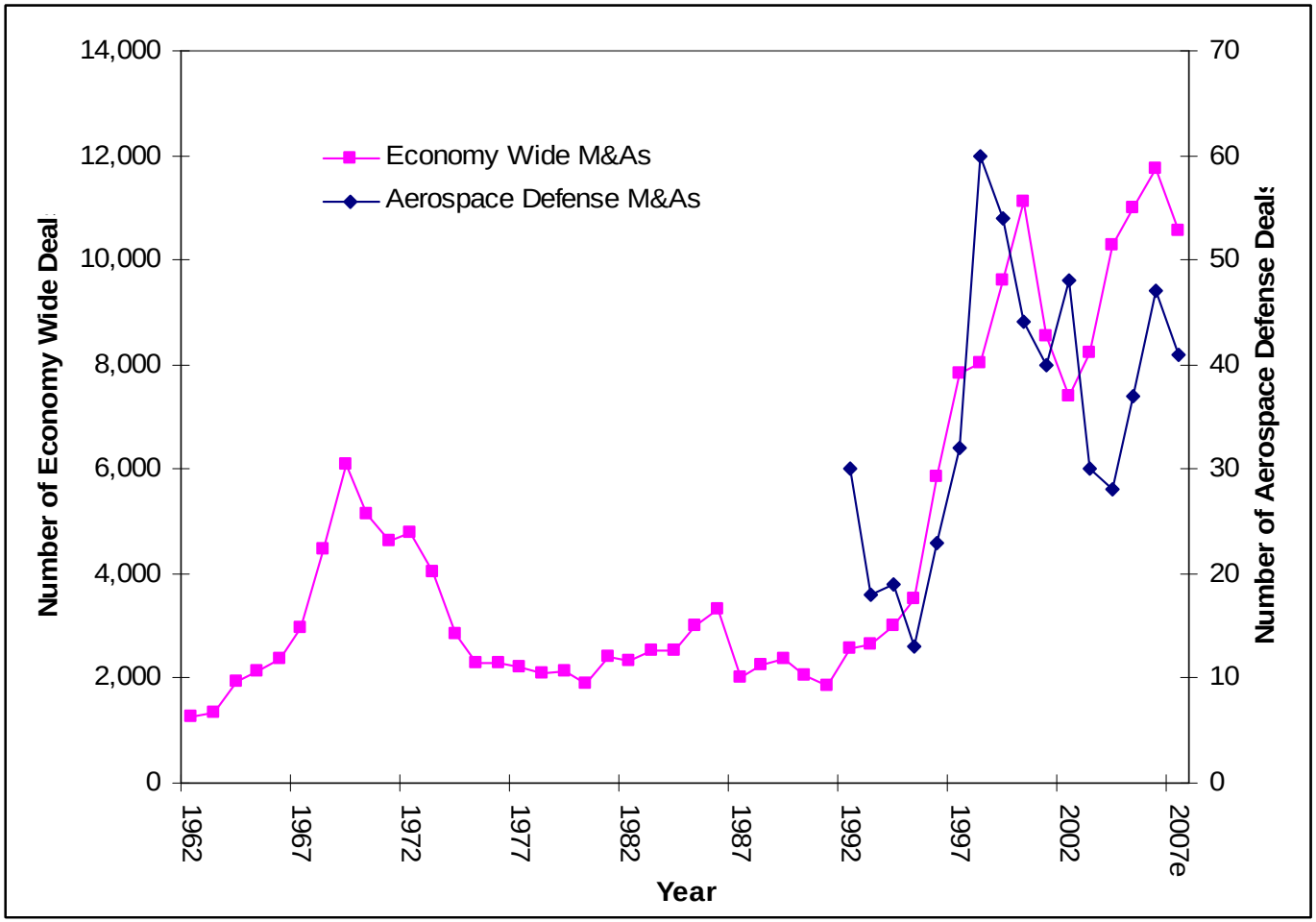
Data Sources and Use

- Mergerstat data show broad trends
- DD350 collects data on DOD contract actions
  - Can sort prime contracts and tally dollars by “Ultimate Parent Company” for 1984-2006 and supplement with “pre-digested” data from top-100 reports for 1958-1983
    - Rankings allow firm-level comparisons
    - 4-, 8-, 20-, 50-, and 100-firm industry CRs
      - indicate (proxy) consolidation
      - allow market-level and cross-industry comparisons
  - Changes in reporting methods and criteria, especially thresholds, pose substantial challenges

M&As Economy Wide and in Aerospace Defense

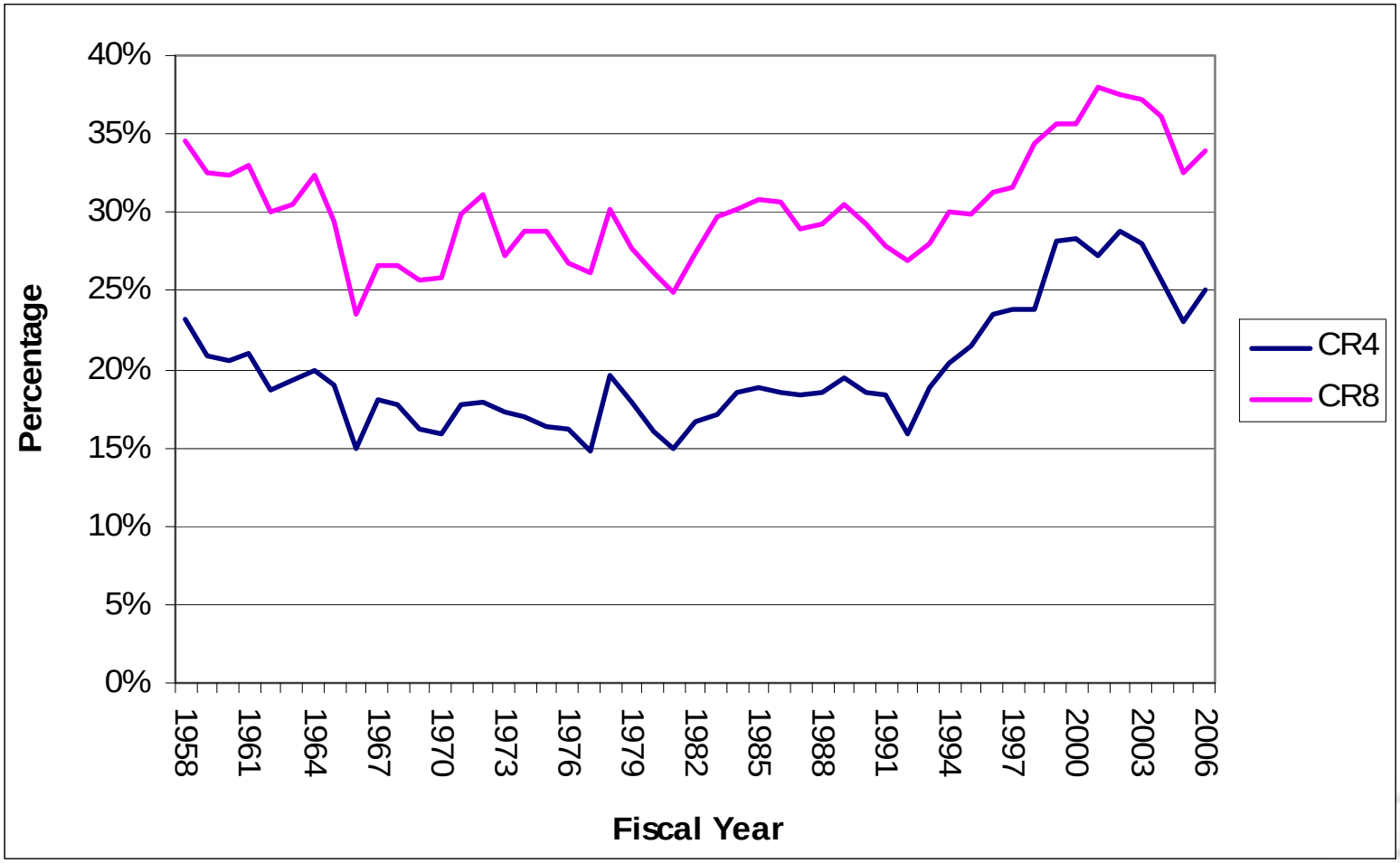


Source: Author based on data from FactSet Mergerstat, LLC, 2007 and 2008.

CRs Suggest Differences Across and Within Defense Industry Levels

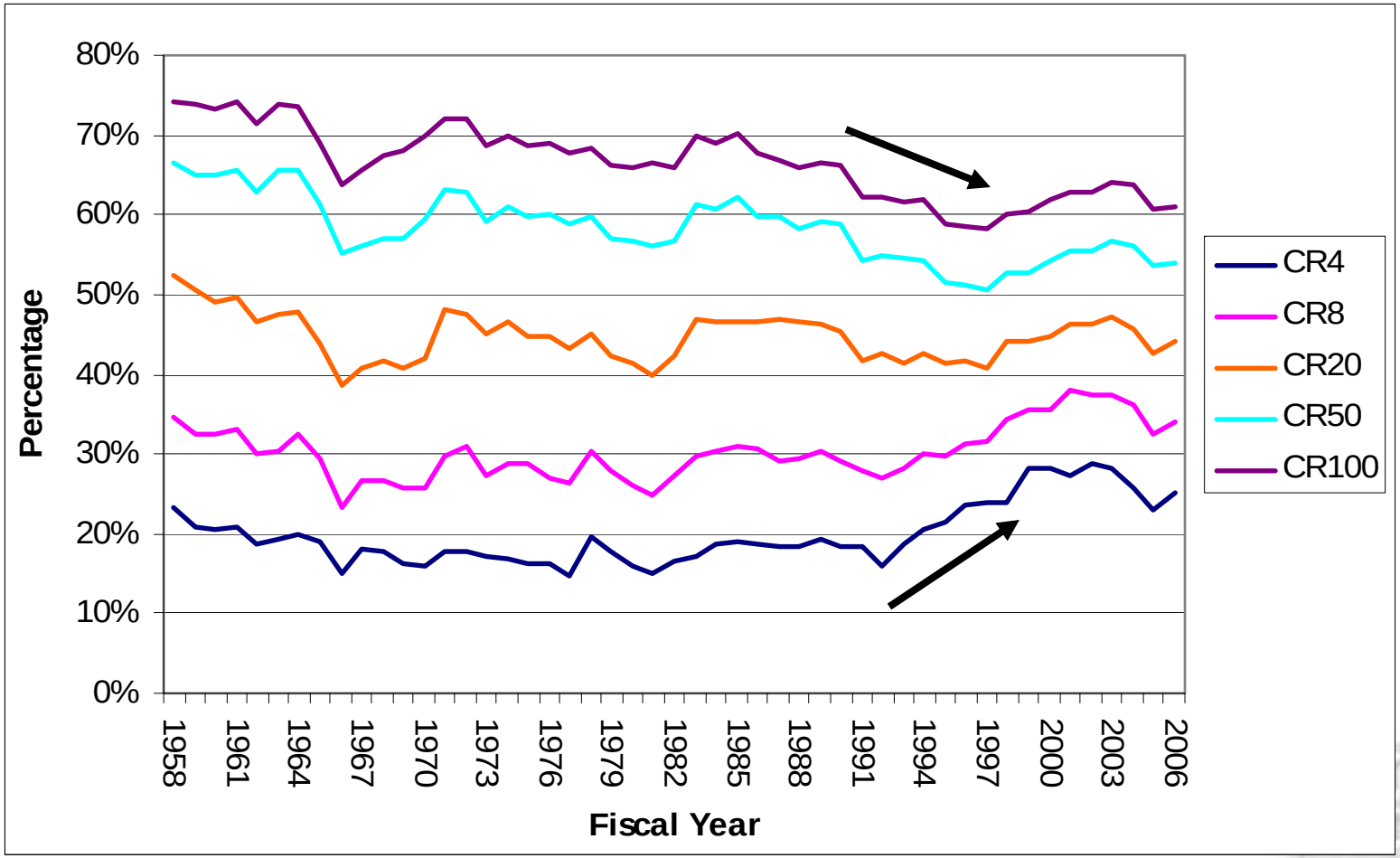
- 4- and 8-firm CRs move together
- 50- and 100-firm CRs also move together
- 4/8- and 50/100-firm CRs do not move together uniformly (e.g., 1990s v. 2000s)
- 20-firm CR acts as “pivot”

4- and 8-Firm CRs Move Together



Source: Author based on data from DOD DD350 and top 100 reports (1958-2006).

4/8- and 50/100-Firm CRs Do Not Move Together Uniformly

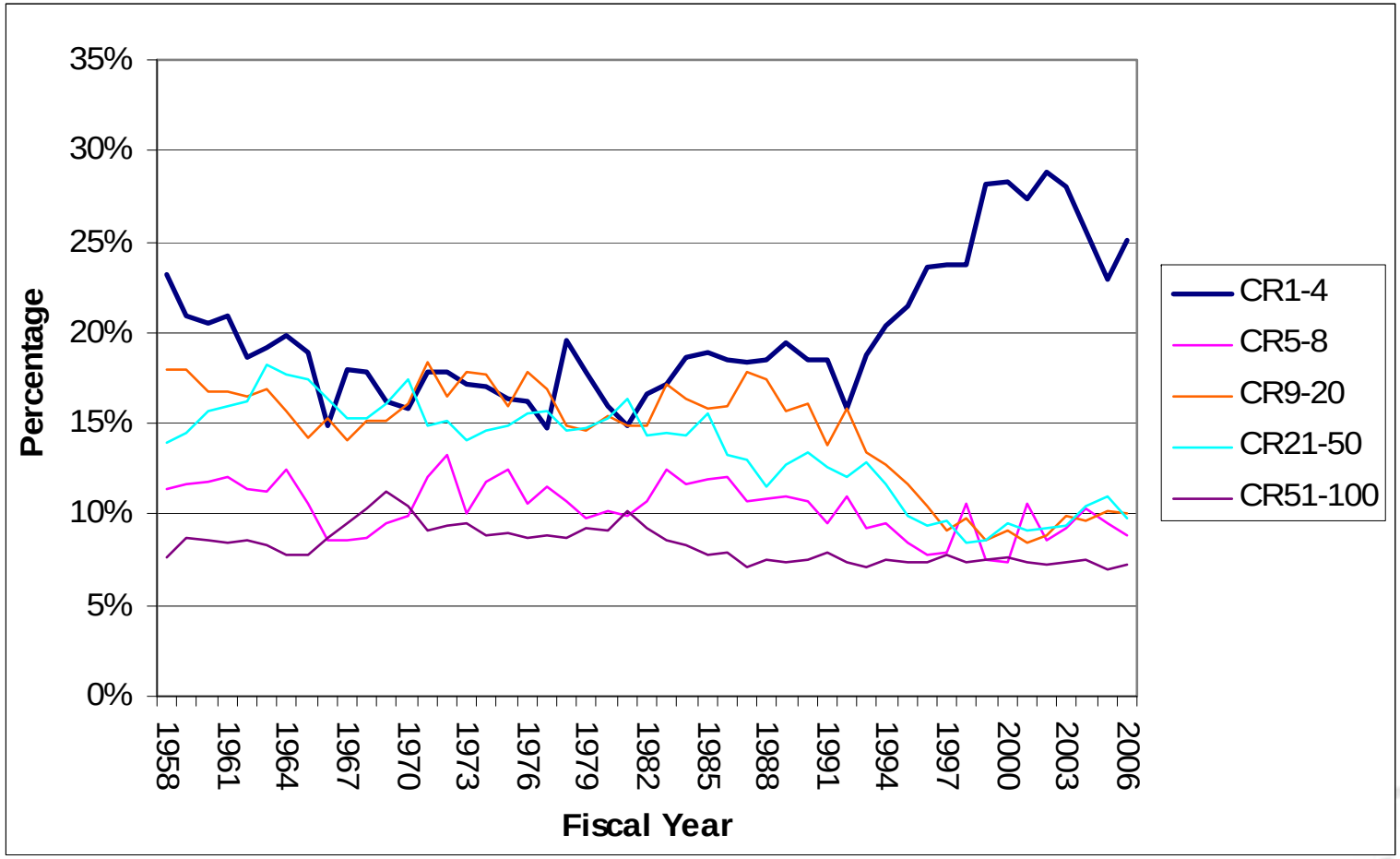


Source: Author based on data from DOD DD350 and top 100 reports (1958-2006).

Alternative Data Presentations Shed Light on Market-Level Differences

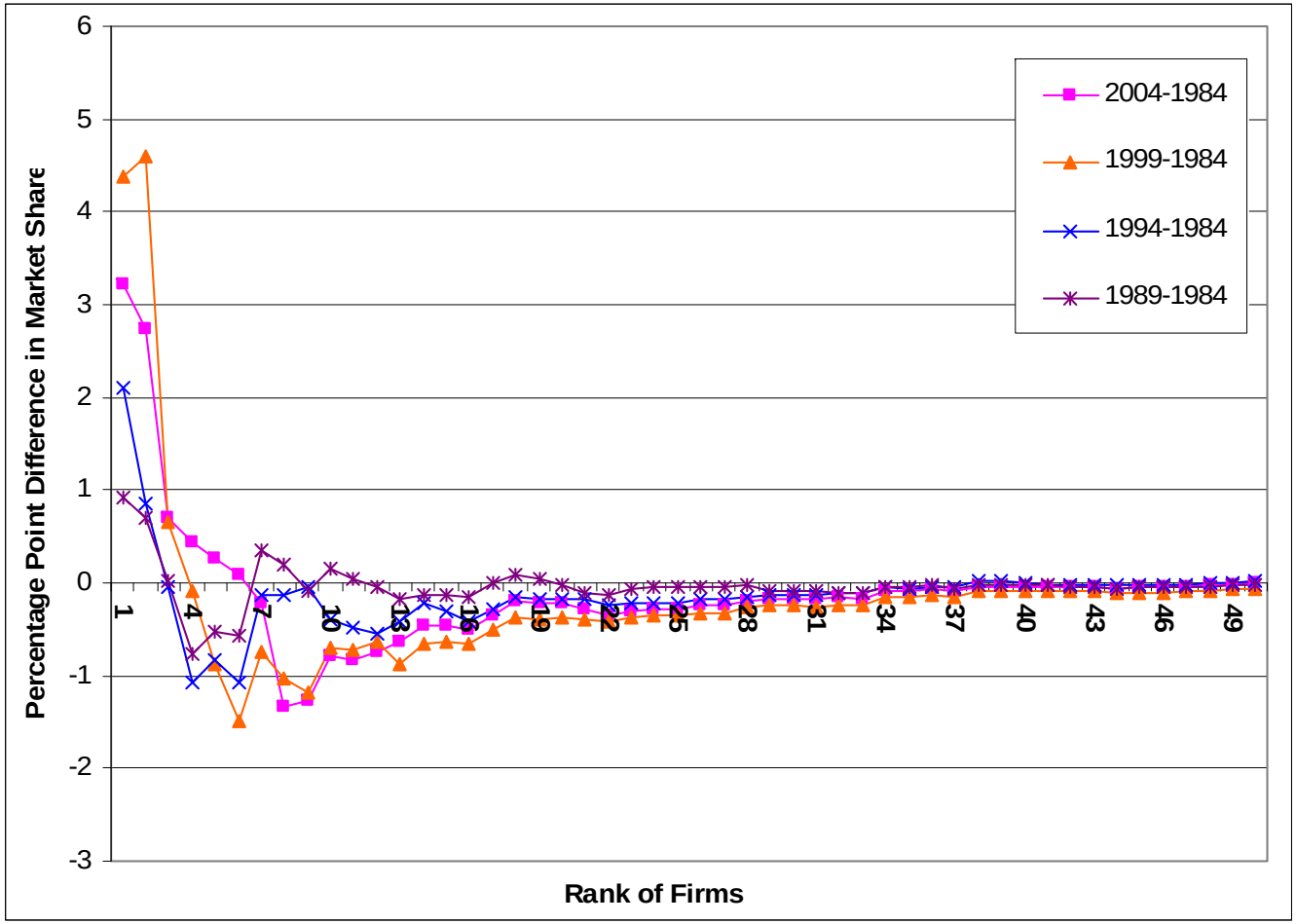
- Market-level breakouts, i.e., 1-4, 5-8, 9-20, 21-50, and 51-100-firms, set top 4 apart.
- Comparisons of equally-ranked firms over time show transition at top-most levels and consequences for other levels
  - Firms 1-4 gain market share
  - Firms 5-8 and 9-20 lose market share
  - Firms 21-50 converge to “business as usual”

CR Rises for Very Top-Most Firms



Source: Author based on data from DOD DD350 and top 100 reports (1958-2006).

Comparisons of Equally Ranked Firms Show Transitions



Source: Author based on data from DOD DD350 (1984-2006).

Observations consistent with hollowing out of “5-to-20” market
(Good, bad, indifferent?)

Trends abating in recent years

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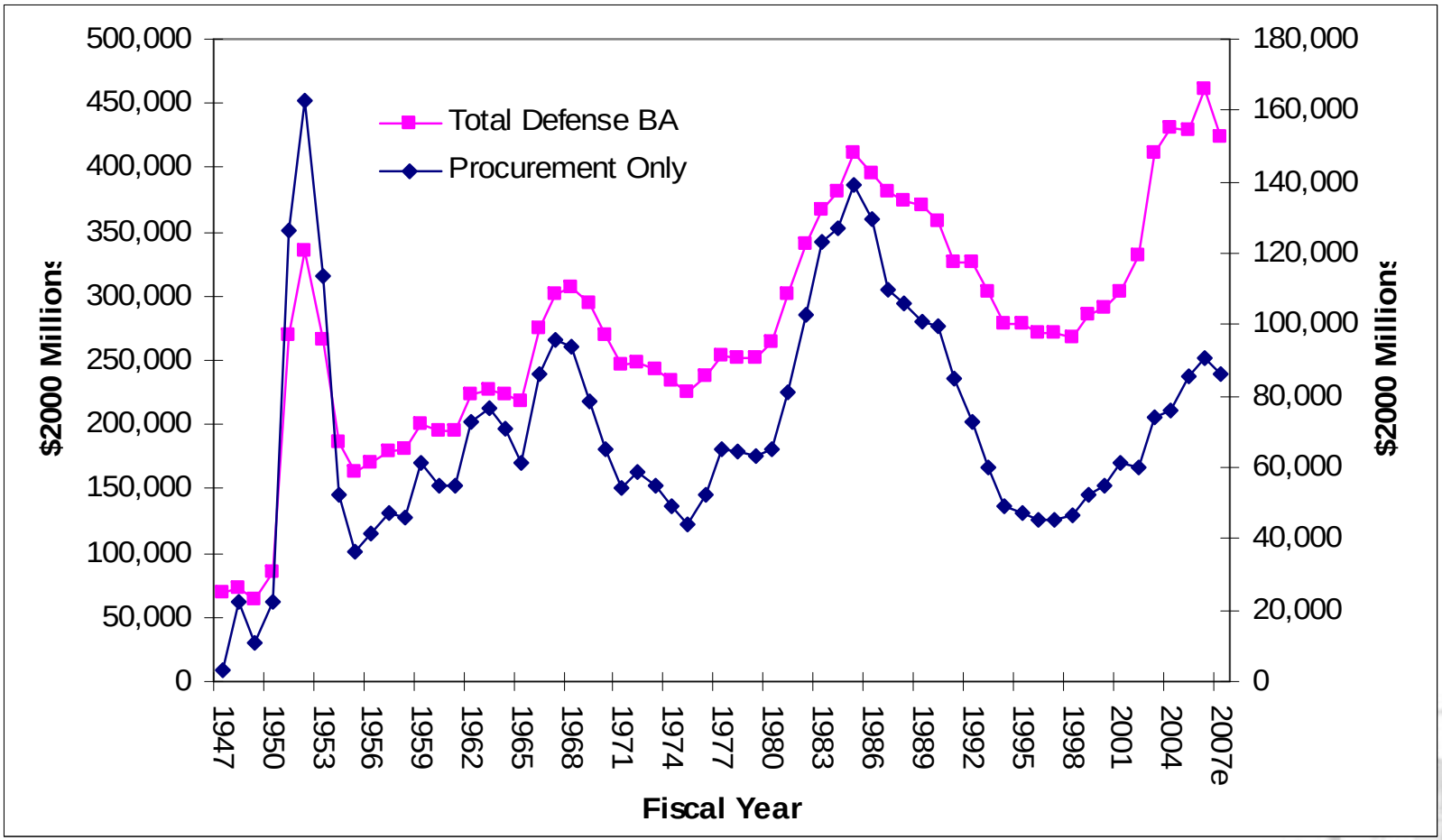
What Drives Consolidation?

- Changes in DOD Spending
  - Declining expenditures in 1990s
    - End of cold war
    - Mounting federal deficits
  - Increasing expenditures in 2000s (Iraq)
- DOD policy decisions and interventions
- Conditions in larger economy

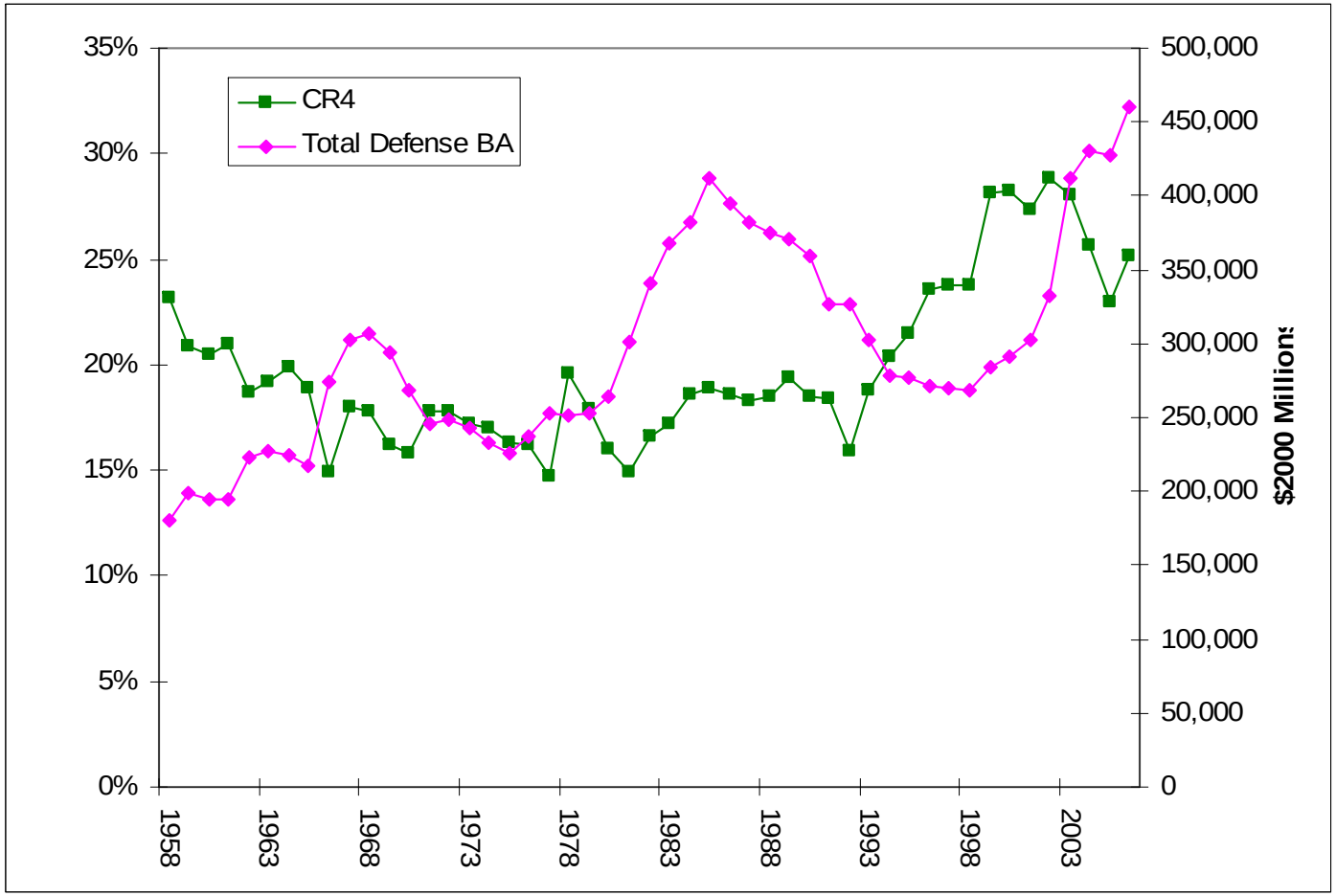
Given prominence of DOD as purchaser, market forces and policy actions not clearly separable

Defense-Spending Cycles



Source: Author based on data from the DOD Green Book (2007 and 2008).

Industry Concentration v. Spending



Source: Author based on data from the DOD Green Book (2007 and 2008), DOD DD350 (1984-2006) and top 100 reports (1958-1983)

Empirical Model Considers Multiple Factors

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5$$

Where:

Y = 4-firm concentration ratio (in decimal terms, e.g., 0.18, 0.25, etc.) (CR4F)

X_1 = Lagged 4-firm concentration ratio (one period lag) (CR4F-L) +

X_2 = Lagged real DOD BA (in $2000 billions) (BA-L) -

X_3 = DOD policy (0, 1 dummy) (POL) +

X_4 = Number of economy-wide M&As (MA) +

X_5 = Trend term (Linear, 1…N) (TR) +

Results Support Multiple Factors

	Intercept	CR4F-L	BA-L	POL	MA	TR
(1)	**B_0**	**B_1**	**N/A**	**N/A**	**N/A**	**N/A**
Coefficient	0.18	0.913				
(t-stat)	(1.297)	(13.110)				
Test results	R^2(adj.) = 0.795; F = 171.878; DW = 2.082					
(2)	**B_0**	**B_1**	**N/A**	**N/A**	**N/A**	**B_5**
Coefficient	0.034	0.753				0.001
(t-stat)	(2.337)	(8.452)				(2.626)
Test results	R^2(adj.) = 0.820; F = 101.169; DW = 2.060					
(3)	**B_0**	**B_1**	**B_2**	**N/A**	**N/A**	**B_5**
Coefficient	0.059	0.710	-7.976E-5			.001
(t-stat)	(2.693)	(7.685)	(-1.515)			(3.024)
Test results	R^2(adj.) = 0.825; F = 70.291; DW = 2.133					
(4)	**B_0**	**B_1**	**B_2**	**B_3**	**N/A**	**B_5**
Coefficient	0.051	0.736	-6.315E-5	.007		.001
(t-stat)	(2.099)	(7.336)	(-1.086)	(0.694)		(2.165)
Test results	R^2(adj.) = 0.823; F = 52.172; DW = 2.153					
(5)	**B_0**	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**
Coefficient	0.069	0.609	-6.653E-5	0.008	2.628E-6	0.001
(t-stat)	(2.709)	(5.144)	(-1.180)	(0.885)	(1.883)	(1.817)
Test results	R^2(adj.) = 0.834; F = 45.103; DW = 2.109					

	Intercept	CR4F-L	BA-L	POL	MA	TR
(6)	**B_0**	**B_1**	**B_2**	**N/A**	**B_4**	**B_5**
Coefficient	**0.077**	**0.582**	**-8.682E-5**		**2.516E-6**	**0.001**
(t-stat)	**(3.283)**	**(5.101)**	**(-1.690)**		**(1.815)**	**(2.737)**
Test results	**R^2(adj.) = 0.835; F = 56.490; DW = 2.081**					

DOD Influences but Does not Control Defense Industry

- Autoregressive “Black Box” explains most of the variation in 4-firm CR, but…
- Defense budgets and economy-wide conditions matter too, while…
- DOD policy actions—e.g., the “Last Supper”—are not statistically significant

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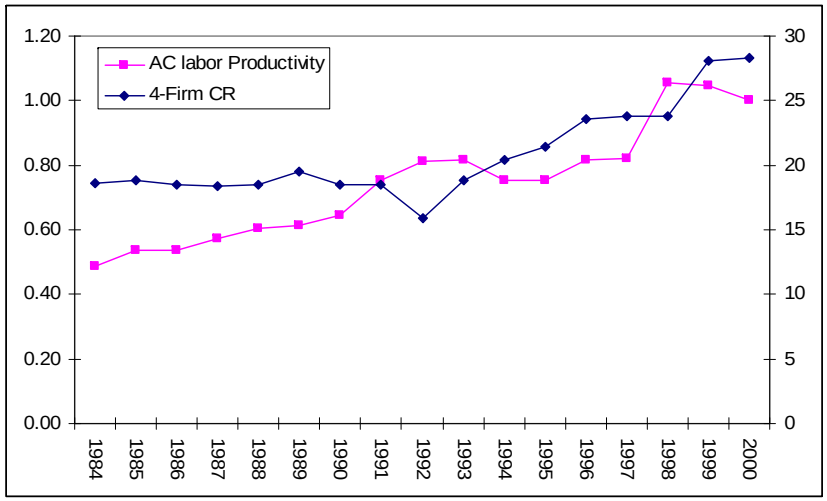
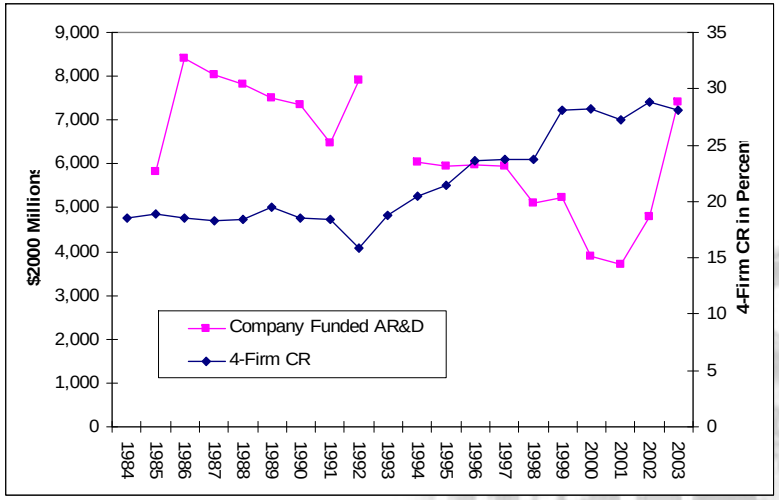
Concentration and Competition

- Preliminary assessment of “Extent of Competition” in DD350 for 1989-1994, 1999, and 2004 yields inconclusive results
  - Competition decreases among the very top-most firms, in aggregate, i.e. top 4
    - Competitive share drops from 61% to 48%
  - Competition has not increased—or decreased—uniformly at other market levels or even among top 4
  - Correlation between concentration and competition is +/- at different market levels

Concentration, Productivity, and Innovation

- Cursory look at data on labor productivity and R&D suggests areas of concern
  - Correlation between aircraft labor productivity and 4-firm CR is negative, after accounting for rise in manufacturing productivity
  - Correlation between company-funded applied R&D and 4-firm CR is also negative





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Conclusions

- In some sense, the “eye chart” is right
  - The top 4 firms, in aggregate, have become more concentrated and less competitive since the 1990s, albeit with a modest reversal post-2003
- But, the eye chart tells only part of the story
  - Differences across/within market levels, even within top 4
  - Market dynamism, including new, global entrants
  - Competition, productivity, and innovation?
- Moreover, DOD may have less control than it thinks
  - The Black Box suggests potential for additional consolidation in the not-too-distant future

Future Research

In progress for WEAI meetings

- Address structural breaks in time series
- Flesh out competition model, data, and results
- Pursue interest in relationship between competition, productivity, and innovation, especially innovation
  - Using R&D and patent data
  - Conducting cross-industry comparisons
  - Controlling for other economic forces
- Consider feasibility of analysis by product lines

Contact Information

- Victoria A. Greenfield
  Crowe Chair Professor
  Department of Economics
  U.S. Naval Academy
  589 McNair Road
  Annapolis, MD 21402
  Phone: 410 293 6896
  Cell: 571 239 8467
  vag@usna.edu

- Ryan R. Brady
  Assistant Professor
  Department of Economics
  U.S. Naval Academy
  589 McNair Road
  Annapolis, MD 21402
  rbrady@usna.edu

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Summary of Regression Results

- If BA decreases by one billion dollars in one year, CR4F increases by about 0.00009 in next year
  - Actual decrease in real BA in 2005 would have been associated with increase of about 0.0002 in CR4F in 2006*
- If economy-wide M&As increase by 1 in one year, CR4F increases by about 2.52E-06 in same year
  - Actual increase in economy-wide M&As in 2006, would have been associated with increase of about 0.002 in CR4F in 2006*
- Lagged industry concentration and economy-wide M&As are significantly correlated, but collinearity neither eliminates statistical significance nor confounds signage

*Actual increase in CR4F in 2006 was about 0.0213

Correlations Among Variables

Correlations

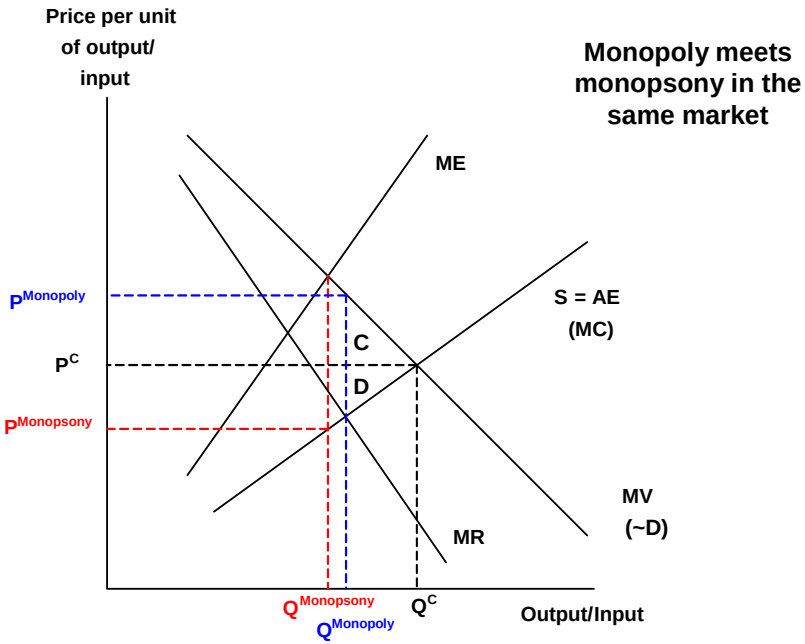
		CR4	CR4Lag	DODBA$2000 Lag_BEAGDP	AllMA#	Trend
CR4	Pearson Correlation	1	.891**	.158	.799**	.582**
	Sig. (2-tailed)		.000	.279	.000	.000
	N	49	48	49	45	49
CR4Lag	Pearson Correlation	.891**	1	.163	.794**	.561**
	Sig. (2-tailed)	.000		.267	.000	.000
	N	48	48	48	45	48
DODBA$2000Lag_ BEAGDP	Pearson Correlation	.158	.163	1	.324*	.693**
	Sig. (2-tailed)	.279	.267		.030	.000
	N	49	48	49	45	49
AllMA#	Pearson Correlation	.799**	.794**	.324*	1	.666**
	Sig. (2-tailed)	.000	.000	.030		.000
	N	45	45	45	45	45
Trend	Pearson Correlation	.582**	.561**	.693**	.666**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	49	48	49	45	49

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Consolidation and Competition

- The "simple market model"
  - Static bilateral monopoly
    - Prices higher*
    - Quantity indeterminant*
    - Net surplus indeterminant*
  - Bilateral monopoly with economies of scale
- Preliminary assessment of DD350 data on "Extent of Competition"…



*Compared with pure monopsony or quasi-monopsony

Preliminary Data Assessment

- DD350 reports on “Extent of Competition” for each award from 1989*-2006
  - A = “Competed”
  - C = “Follow on to Competed Action”
- Can tally sum of dollars awarded “A” or “C” for each ultimate parent company
  - Share of DOD contract dollars competitively awarded, direct or indirectly, provides measure of competition for firms and industry

*Data are available for 1988, but may be inconsistently coded.

Is the Market Less—or More—Competitive?

- Competition has decreased among the very top-most firms, in aggregate, i.e., the top 4
  - Competitive share in 1989 = about 61%
  - Competitive share in 2004 = about 48%
- Competition has not decreased—or increased—uniformly at other market levels…
- Or even among the top 1-4
  - the first-ranked firm was more competitive in 2004 (55% “A” or “C”) than in 1989 (49% “A” or “C”)

How Does Competition Relate to Concentration?

- Correlations between competition and concentration do not tell a consistent story across or within market levels

Top 4	Top 8	Top 20	Top 50	Top 100
-0.5599	-0.3211	0.5675	0.8261	0.7834

Top 1-4*	Top 5-8	Top 9-20	Top 21-50	Top 51-100	101+
-0.5599	0.4420	-0.4021	0.0027	0.5513	0.0890

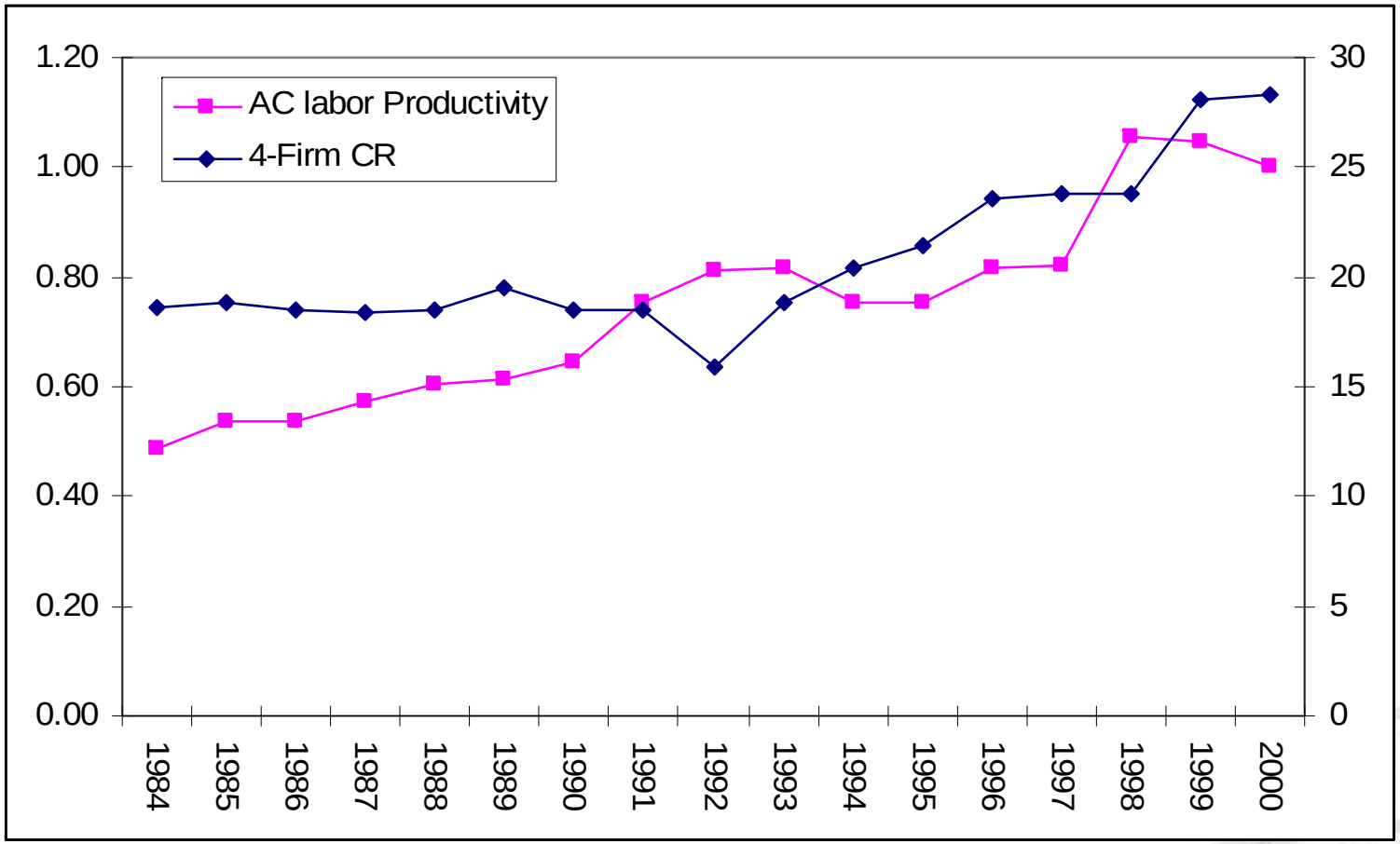
*The correlation is positive for the first-ranked firm.

Consolidation, Productivity, and Innovation

- If industry is more consolidated, hence less competitive, will it also become less productive and less innovative?
- Less competition may imply
  - Less incentive to raise productivity/innovate
  - More resources to raise productivity/innovate
    - And some incentive to preserve market position

Has industry, particularly at the top-most levels, become less productive or innovative?

Aircraft Labor Productivity and Defense Industry Concentration



Correlations and Partial Correlations

Correlations

		Aircraft Labor Productivity (2000=1)	U.S. Manufacturing Labor Productivity (2000=1)	CR4F
Aircraft Labor Productivity (2000=1)	Pearson Correlation	1	.947**	.753**
	Sig. (2-tailed)	.	.000	.000
	N	17	17	17
U.S. Manufacturing Labor Productivity (2000=1)	Pearson Correlation	.947**	1	.885**
	Sig. (2-tailed)	.000	.	.000
	N	17	17	17
CR4F	Pearson Correlation	.753**	.885**	1
	Sig. (2-tailed)	.000	.000	.
	N	17	17	17

**. Correlation is significant at the 0.01 level (2-tailed).

But… the partial correlation between aircraft labor productivity and the 4-firm concentration ratio, after controlling for the contemporaneous rise in manufacturing labor productivity, is actually -0.572 and moderately significant

Innovation and Industry Concentration