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"Competing Explanations of U.S. Defense Industry Consolidation in the 1990s and Their Policy Implications"

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Abstract

Was the consolidation of defense industry in the 1990s driven by U.S. Department of Defense (DOD) directives, or was it driven instead by the same forces that drove consolidation in many other sectors of the U.S. economy in the 1990s? To better understand the roles of DOD policy and economy-wide forces in shaping the U.S. defense industry, we test for structural breaks in defense industry and spending data and compare our findings to those relating to other sectors and the general economy. We identify structural breaks in the defense-related data in the early 1980s and throughout the 1990s, roughly consistent with changes in the U.S. economy, including broader merger trends. Overall, our results are more consistent with the view that economy-wide factors drove defense industry consolidation, largely independent of the DOD policy changes that occurred early in the 1990s.

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1. Introduction

In this paper we test for structural breaks in U.S. defense industry and spending data over the last five decades. The defense industry data, which include various measures of market concentration, capture trends in consolidation; the spending data, defined broadly to include measures of contract awards, budget authority, and expenditures and investment, capture trends in market size. We identify structural breaks in those data and compare them to structural breaks found in data relating to the rest of the economy to address a lingering debate among defense analysts, policy practitioners, and executives as to the forces behind the consolidation of the defense industry in the 1990s. Was the consolidation the result of an explicit directive of the U.S. Department of Defense (DOD) or was it driven by the same forces that led to consolidation in many sectors of the U.S. economy in the 1990s? In an era in which concerns about the future of the defense industry are again prominent, the answer bears directly on whether and how the DOD might choose to engage as a policymaking and procuring agency. If broader economic forces drive industry behavior, the DOD may face limitations in promoting competition, spurring innovation, or otherwise shaping the defense industry. We interpret structural breaks in the data as indicative of changes in defense spending, the defense industry at large, and the broader economy, which, in the context of two stylized narratives, provides a statistical approach to explaining defense-industry consolidation.

The first stylized narrative, representing what we refer to as the "DOD-policy-centric" view, describes the DOD as the primary engineer of defense industry consolidation in the 1990s. The defense budget had been declining steadily since the mid-1980s and the DOD was seeking to reduce excess capacity and check rising costs. In response, at a 1993 dinner now referred to as the "Last Supper," the DOD asserted its support for industry-wide consolidation (see Augustine (1997, 2006) for an eyewitness account). The DOD backed its assertion by agreeing to reimburse firms for some merger-related costs and, later, through antitrust oversight (for discussions see Gholz and Sapolsky (1999-2000), Markusen and Costigan (1999) and Markusen (1997)). Without explicitly denying the relevance of economy-wide factors, this narrative claims DOD policy as the dominant factor in the consolidation process. For example, the former chairman of the Lockheed Martin Corporation, Norman R. Augustine, characterizes the

Last Supper as perhaps "the most critical moment in the defense industry's consolidation" (Augustine (1997)). His comments suggest that the defense industry was hesitant to consolidate, even when faced with a declining budget, without encouragement from its largest purchaser, the DOD.[1]

In contrast, a stylized "economy-centric" view places economy-wide phenomenon at the center of a story in which the same forces that drove the large number of mergers in the rest of U.S. economy also drove the consolidation of the defense industry in the 1990s. Such forces included developments in capital markets, innovation in technology, and deregulation (see Holmstrom and Kaplan (2001) and Andrade, Mitchell and Stafford (2001) for details on merger activity in the U.S. economy). While the economy-centric view does not dismiss the impact of the decline in the defense budget, or the response of the DOD to that decline, it suggests that other forces provide a more telling explanation of defense-industry consolidation. Hensel (2007), for example, offers evidence that defense industry mergers in the 1990s are more correlated with economy-wide mergers than with DOD spending (see also Flamm (1998) and Oden (1998) for relevant discussions of evidence that is supportive of an economy-wide perspective).

We use the methods of Bai and Perron (1998, 2003) to estimate structural breaks in data that measure defense industry consolidation, defense spending, and economy-wide trends. First, we test for structural breaks in six different indicators of consolidation. These data include the concentration ratios of the top-4 and top-100 recipients of prime contract awards from DOD; that is, the collective market shares of the top-4 and top-100 DOD contractors, respectively, ranked by the dollar value of their awards. For a complementary perspective, we also construct and test two new time series, the aggregate number of subsidiaries of the top-4 and top-100 firms. Lastly, for robustness with respect to the two concentration ratios, we construct and test Herfindahl-Hirschman index (HHI) values for the top-4 and top-100 firms.

[1] This being a stylized narrative, it would be incorrect to attribute it, in its purest form, to any one person or group of people; rather, it represents an amalgam of statements focused on the role of the DOD in directing consolidation. For example, taking a softer tone a decade later, Augustine (2006) describes the consolidation as "inevitable" by virtue of the declining defense budget and credits the Last Supper with hastening the inevitable. He does not, however, consider broader economy-wide forces as contributing to that inevitability. Other statements tending toward a DOD-centric perspective can be found in Deutch (2001) and, to a lesser extent, General Accounting Office (1998), both of which also speak to the decline in the defense budget, but emphasize the DOD's leadership.

Next, as indicative of defense spending, we test for breaks in the real dollar value of DOD contract awards, DOD budget authority, real federal defense consumption expenditures, and real federal defense gross investment. The last two series, both sub-components of U.S. Gross Domestic Product (GDP) as reported in the National Income and Product Accounts (NIPA), provide alternative perspectives on defense spending. Lastly, as indicative of broader economic phenomenon, we test for breaks in the number and dollar value of all mergers and acquisitions in the U.S. economy and for breaks in total U.S. budget authority.

If DOD policy was the dominant driver of change in the industry, we would expect to see breaks in the consolidation data consistent with the policy changes that emerged in 1993. From a DOD-policy-centric perspective, the consolidation of the industry might then be seen as a direct response to DOD's policy actions and an indirect response to the budgetary decline. Alternatively, if economy-wide forces drove the change, we would expect to find consolidation-related breaks consistent with breaks found in other sectors of the U.S. economy or consistent with breaks found in merger activity in the U.S. economy overall.[2] Lastly, regardless of the strength of either narrative on consolidation, we might expect to find a break in the spending data in the mid-1980s, marking a steady decline in the defense budget that began in or around 1985.

Overall, we find consistent evidence of breaks primarily in the mid-1990s and, to a lesser extent, in the early to mid-1980s. In particular, structural breaks in the concentration ratio of the top-4 firms, in the number of subsidiaries for the top-4 firms, and in the HHI measures in the mid-1990s are matched by a structural break in the number of mergers in the U.S. economy found in 1995. Though one could argue the timing is consistent with the DOD-policy-centric view, the preponderance of breaks found in the mid-1990s and their estimated confidence intervals suggest, in our interpretation, a closer link to broader economic activity (we discuss the details of the break results in Section 3). Moreover, we find some evidence of structural breaks in the same series at various dates in the 1980s suggesting the consolidation of the defense industry in the 1990s may have had its antecedents in 1980s.

[2] Various studies have found evidence of structural change in the U.S. economy during the 1980s and in the 1990s (see Ahmed *et al.* (2004) and Davis and Kahn (2008) for examples and Section 2 for discussion).

The break analysis in this paper provides novel statistical evidence on the timing of change in the defense industry relative to changes in the defense budget over time and with respect to the broader economy.[3] On balance, the break dates we estimate suggest a correspondence between changes in the defense industry, defense spending, and the broader economy, especially as embodied in mergers and acquisitions data. While certainly not ruling out the relevance of specific DOD policy in shaping the defense industry, the break date analysis in this paper supports the general view that the consolidation of the defense industry would have occurred with or without the DOD's explicit approval. Our break analysis serves as a complement to Hensel (2007), Greenfield and Brady (2008), Pages (1998), Oden (1998) and others who have explored the role of DOD policy and economy-wide factors through quantitative means. Moreover, the approach, identifying break dates to better understand the effects of government policy on industrial structure, may be fruitfully employed to consider other government policies meant to influence other sectors of the economy.

The next section of this paper describes the perspectives on defense-industry consolidation in greater detail. Section 3 describes the data, explains the structural break analysis, and presents and interprets the results. Section 4 concludes.

2. Defense-Industry Consolidation, DOD Policy, and the Economy

By 1993 the DOD was facing a budget that had been shrinking since the mid-1980s. Figure 1 displays total defense "budget authority," from 1947 to 2006; the series captures the decade long decline in one measure of the defense budget.[4] Concerned about excess capacity among its suppliers and rising costs, the DOD lent its support to the

[3] A few studies have sought to identify structural breaks in defense-related data, though none has sought to use them to help explain the consolidation of the defense industry. Amara (2006) tests for structural breaks in the defense expenditures of all NATO allies, focusing on the common behavior (and changes to that behavior) across the allies in the pattern of defense spending over time. In other applications, Abu-Qarn and Abu-Bader (2007) test for structural breaks in the defense expenditures of countries involved in the Israeli-Arab conflict since 1960, while Dunne and Perlo-Freeman (2003) consider structural breaks in defense spending for a panel of developing countries.

[4] Budget authority is the authority to incur legally binding obligations that will result in immediate or future federal outlays. Most defense budget authority is provided by the Congress in the form of enacted appropriations. Less technically, one might describe budget authority as the amount of funding that the Congress makes available to the DOD to spend—it is a measure of potential, but not actual spending. The sources of these and all other data are discussed in the next section.

consolidation of the U.S. defense industry.[5] At a dinner event now referred to as the "Last Supper," then-Deputy Defense Secretary William Perry painted a grim fiscal picture and voiced the agency's support for consolidation to the nation's top defense executives. As a practical matter, the DOD's backing included not only explicit encouragement, but also financial incentives and, later, a more pro-active role in the federal antitrust oversight process. Among its most controversial decisions, the DOD articulated a change in reimbursement policy, under which it would reimburse its suppliers for some restructuring costs in accordance with established criteria.[6] The policy, lacking popular appeal, came to be known as "payoffs for layoffs" (see Augustine (1997, 2006), Gholz and Sapolsky (1999-2000), Markusen and Costigan (1999), and General Accounting Office (1995) for discussions of these events).

The decline of the defense budget, as displayed in Figure 1, the DOD's policy decision in 1993, and a subsequent wave of mergers and acquisitions in the defense sector are suggestive of a DOD policy effect in shaping the industry. Figure 2 displays the wave of merger activity that occurred, showing the number of mergers in the defense sector against the total number for all sectors—other than defense—in the United States in the 1990s.[7] It appears that defense merger activity increased rapidly starting in 1995, if not sooner, offering credence to the timing of events explicit in the DOD-policy-centric view.[8] Indeed, Chu and Waxman (1998) suggest the change in DOD policy was the dominant driver behind many of the mergers and acquisitions (see also Korb (1996) for discussion). In particular, Chu and Waxman (1998) cite the aerospace industry as *prima*

[5] Through successive rounds of military base realignments and closures, the DOD was also seeking to consolidate its own operations. The year 1993 was, of course, also the first year of the Clinton Administration, and approximately two years after the end of the first Gulf War.

[6] John Deutch, another then-high-ranking DOD official, articulated the change in a DOD memorandum dated July 1993. See General Accounting Office (1995) for details on the change in policy.

[7] Figure 2 is based on a similar figure from Greenfield and Brady (2008). In the version in this paper, the total merger and acquisition series excludes the defense component. Note that, unfortunately, the Mergerstat data for defense-sector mergers and acquisitions does not extend back to the 1980s.

[8] The number of mergers surged in 1995, but several important mergers occurred in previous years, such as the Northrop-Grumman merger of 1994. Oden (1998) provides discussion on this general period, documenting 16 mergers or acquisitions involving notable defense suppliers that occurred between 1994 and 1997.

facie evidence of the importance of DOD policy driving the emergence of Lockheed Martin and Boeing as that industry's two main U.S. suppliers.[9]

In contrast, a "proponent" of the economy-centric view might suggest that the wave of mergers among defense firms was simply part of and driven by the same forces that drove the larger wave of mergers in the U.S. economy in the 1990s, observing the close correspondence between the two data series in Figure 2, and perhaps even the 1980s. In the 1980s, for example, Flamm (1998) notes the defense industry had its share of merger activity over a period of time, prior to 1985, during which the defense budget was actually expanding. Over that same period, mergers and acquisitions in the U.S. economy were occurring at a historically high rate (see Holmstrom and Kaplan (2001) for details).

If not the change in DOD policy, what then might explain the consolidation of the defense industry? Holmstrom and Kaplan (2001) cite developments in capital markets (with an emphasis on maximizing shareholder value), innovation in technology, and deregulation throughout both the 1980s and 1990s as key factors driving the merger activity of the 1990s (see also Andrade, Mitchell and Stafford (2001) for a study emphasizing deregulation, in particular, in explaining the merger activity).[10,11] A close analysis of the defense mergers of the 1990s provides another reason to look beyond the policy-centric narrative. Oden (1998) provides evidence that, perhaps contrary to common perception, most of the mergers and acquisitions in the defense industry in the 1990s were motivated by "market extension" in that one firm acquires another to diversify its product line. This is in contrast to a horizontal merger in which one firm acquires another firm with identical or very similar product lines to reduce excess

[9] The Lockheed Corporation and the Martin Marietta Corporation merged to form "Lockheed Martin" in 1995; The Boeing Company and the McDonnell Douglass Corporation merged in 1997.

[10] Structural changes in the U.S. economy after the mid-1980s and in to the 1990s have been the subject of much discussion, most of which center on understanding a noticeable change in the performance of the U.S. economy after 1984. The post-1984 experience is characterized by (and explained by) a number of factors including innovations in both inventory management in manufacturing and in the financial sector in general. See Ahmed *et al.* (2004) for an overview and Davis and Kahn (2008), Dynan *et al.* (2006), and McCarthy and Zakrajsek (2007) for examples.

[11] Emblematic of the forces highlighted by Holmstrom and Kaplan (2001), and providing a parallel example from another sector for perspective, is the consolidation of commercial banking in the U.S. that occurred over the decade. The number of commercial banks in the U.S. peaked in 1984 at approximately 14,500, and that number fell to just over 8,500 by the end of 1999 (see Wheelock and Wilson (2004) and Berger *et al.* (1999) for discussions of those developments).

capacity and lower costs—in other words, to deal with the DOD's articulated concerns (see Oden (1998) for a detailed discussion).

Indeed, as displayed in Figure 2, the data on defense and economy-wide merger activity in the 1990s exhibit similar patterns. To better understand the connection in the data, Hensel (2007) compares the mergers and acquisition in the defense sector to those in the rest of the U.S. economy on the basis of both the total number and aggregate dollar value during the 1990s. She calculates correlations between the two series of approximately 0.65 and 0.94 for the total number and aggregate dollar value of mergers and acquisitions, respectively. She interprets the correlation evidence as supporting the notion that the merger activity was driven mostly by factors related to broader economy. Flamm (1998), too, concludes that data on defense equipment investment as well as data on defense-related manufacturing do not support the general notion that the mergers and acquisitions that occurred in the 1990s were a "natural" outcome of the change in defense policy that occurred in the beginning of that decade. His analysis, like those of the broader economy, points to technological change as a driving force.

Ultimately, however, we would be remiss in presenting only the two stylized perspectives without considering the range of perspectives between them. In a study attempting to sort through the relative importance of broader economic forces, DOD spending, and DOD policy decisions, Greenfield and Brady (2008) implement a regression analysis on annual data spanning 1958-2006. They find that both economy-wide mergers and acquisitions and defense spending help to explain defense industry consolidation, but the 1993 changes in DOD policy do not.

Overall, the explanation for defense-sector consolidation likely lies somewhere between the stylized narratives, with economy-wide forces, the defense budget, and the DOD's actions playing a part, but it is as yet unclear how to order the importance of the various forces at work.[12] Oden (1998), for example, stresses a range of market forces, but also recognizes the DOD's support for consolidation played a role in advancing the

[12] Even if the mergers and acquisitions of the 1990s were "market extending" (as discussed in Oden (1998)) they might still have been responsive to a declining defense market, in-so-much-as firms were seeking new opportunities in new product markets through their diversification. Also, in a market in which the DOD is often the primary purchaser of particular goods or services, it can be difficult to separate spending from policy; arguably, spending is a manifestation of policy. Discussions of these points, particularly the role of defense spending, can be found in various defense-related and legal publications including Schwartz (1996), Goodman (1998), Defense Science Board (1994, 1997), and Kramer (1999).

mergers of the mid-1990s. Pages (1998), too, notes that the DOD's support for mergers and acquisitions, in particular, the encouragement and reimbursements, helped reinforce market trends. And while Greenfield and Brady's (2008) results downplay the significance of specific DOD policy actions, the simultaneity of changes in the broader economy and the defense budget makes it difficult to tell a simple story.[13]

In light of the two stylized explanations and the uncertainties surrounding the evolution of the defense-sector consolidation, in the next section we attempt to identify possible break points in various defense-related data. Structural break points may help clarify the relevance of DOD policy in comparison to general market forces in spurring change in the defense sector.

3. Structural Breaks in the Defense Industry

We apply the Bai and Perron (1998, 2003) methodology to identify structural breaks in our data and to better assess the narratives surrounding the consolidation of the defense industry. In this section, we explain the data, their sources, and the break test methodology; then, we discuss our results.

3.1 The Data

We work with an array of data intended to represent defense industry consolidation, defense spending, and economy-wide conditions, including mergers and acquisitions. Table 1 provides a list of data and data sources discussed in this section.

3.1.1 Data on Defense Industry Consolidation

We focus our assessment of defense industry consolidation on the concentration ratios of the top-4 and top-100 recipients of DOD prime contract awards, ranked by the net dollar value of their annual awards. Figure 3 displays the concentration ratio data, capturing general trends in the defense industry. The share of contracts awarded to the top-100 firms declines gradually until the mid-to-late 1990s while the top-4 ratio shows a noticeable increase beginning approximately in 1992.

[13] Weidenbuam (2003) provides compelling discussion on the influence of the DOD in driving the relative success or failure of firms that manufacture military equipment, in particular. He also notes that such firms, too, cannot help but be shaped by non-defense economic trends.

We follow Greenfield and Brady (2008) who define the ratios as the top-4 and top-100 firms' shares of the net dollar value of all DOD contract awards in a given year. They compute the ratios from two sources, a publicly available DOD database and an annual DOD publication.[14] A federal form, the "DD350," which is completed for each DOD contract action over a certain dollar threshold, provides the underlying data for each source. By merging the data from the two sources, they construct a consistent, annual time series spanning 1958 through 2006. The DD350 database has known limitations both in terms of coverage and reliability, but it is the best available means of identifying DOD's suppliers and calculating their market shares.[15]

We also use the DD350-derived data, likewise spanning 1958-2006, to create two new series that provide alternative measures of consolidation, the aggregate number of subsidiaries of the top-4 and top-100 firms.[16] In addition, as an alternative measure of concentration, we construct the HHI values for the top-4 and top-100 firms, respectively. The U.S. federal government routinely uses the HHI in making determinations in antitrust cases. For the top-4 firms, for example, one simply squares the individual market share of each, and then sums the squared shares together to derive the index value.

3.1.2 Data on Defense Spending

We consider three different measures of defense spending, broadly defined to include data on industry-specific spending, in the form of contract awards; total potential spending, in the form of budget authority; and expenditures and investment from the National Income and Product Accounts (NIPA).

For the real dollar values of the contract awards to the top-4 firms, the top-100 firms, and all firms, also derived from the DD350 database, we test for a break in the growth rate of each series from 1959-2006 (calculated as the first difference in the log of each

[14] See DOD, "100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards," for fiscal years 1996-2006, at http://siadapp.dmdc.osd.mil/procurement/historical_reports/statistics/procstat.html and available in hard copy through the Defense Technical Information Center for 1958-1997.
[15] See Greenfield and Brady (2008) for a more thorough discussion of the concentration ratios and data.
[16] Our data series includes only the subsidiaries that received DOD prime contract awards.

series). Each series is deflated using the implicit price deflator available from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA).[17]

For a second measure of defense spending, we test the real growth rate of DOD budget authority, where the growth rate is the log difference (multiplied by 100 and deflated with the implicit price deflator with a base year of 2000). Tests indicate this series is stationary (while the level of the series is not). The underlying data for 1947 through 2005 are found in the DOD FY2007, "Green Book," Table 6.8. The data for 2006 are from the FY2008 "Green Book."

For a third measure of defense spending, we test for breaks in the means of the log difference of BEA data from the NIPA on real federal defense consumption expenditures and real federal defense gross investment. We estimate the breaks in each series with quarterly data from 1947 through the second quarter of 2007, in seasonally adjusted 2000 dollars.

3.1.3 Data on Economy-Wide Measures

Finally, we consider two types of economy-wide indicators: mergers and acquisitions involving U.S. firms and total U.S. budget authority. In the case of mergers and acquisitions, we evaluate the number and total logged value of all mergers and acquisitions involving U.S. firms since 1962 and 1968, respectively (where the natural log represents the real value, deflated with the implicit price deflator with base year 2000). The data are from FactSet Mergerstat, LLC, a firm that specializes in tracking the value and number of mergers and acquisitions.[18] For total U.S. budget authority, we evaluate annual data from 1947 through 2006.[19]

3.2 Break Tests

We use the statistical techniques of Bai and Perron (1998, 2003) which allow us to estimate multiple break dates without prior knowledge of when those breaks occur. Bai

[17] Augmented Dickey-Fuller tests were performed on each series considered in this paper. Growth rates are used where ADF test indicated the data in levels were non-stationary.
[18] See Hensel (2007) and Greenfield and Brady (2008) for additional details on this data source.
[19] These data are available from the Policy Agendas Project, a joint project of the University of Texas, the University of Washington, and Pennsylvania State University. Stationarity tests suggest these series are best modeled with a time trend.

and Perron (1998, 2003) provide a least-squares based algorithm for estimating the unknown breaks, a series of significance tests for conducting inference, and suggestions for how to interpret the various tests (see also Andrews (1993) and Andrews, Lee and Ploberger (1996) for work underpinning their methods). In the interest of brevity, we provide insight to the intuition behind their approach and then refer the reader to Bai and Perron (1998, 2003) for more details.

Consider estimating the simple linear function,

$$y_t = z_t'\delta_t + u_t$$

for $t = T_{j-1}+1,...,T_j$, $j = 1,...,m+1$, and z_t is a $q \times 1$ vector of covariates.[20] This function shows a complete structural change model where all the coefficients are subject to breaks (see Bai and Perron (2003) for the more general partial change model). One then estimates both the coefficients δ_j and the break dates over *m*-partitions where $(T_1,...,T_m)$ denotes the break dates defining the partitions. The estimates are obtained by minimizing the sum of squared residuals,

$$\sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} (y_t - z_t'\delta_t)^2$$

The estimates of the breaks are such that, $(\hat{T}_1,...,\hat{T}_m) = \arg\min_{T_1,...,T_m} S_T(T_1,...,T_m)$, with minimization taken over all partitions, and where S_T is the sum of the squared residuals. The break dates are found such that the optimization identifies a break date at any point in the sample, then searches over the remaining partitions until another break date is found and so on. Bai and Perron (1998, 2003) provide a more detailed explanation of the method for optimizing over each partition, essentially a grid search. Given the grid search has located one or more breaks, one then applies Bai and Perron's (1998, 2003) statistical tests to identify which breaks are statistically significant.

Bai and Perron (1998, 2003) recommend choosing the break dates by testing the null hypothesis of m = 0 breaks versus the alternative of m = k breaks. This is done by evaluating the *supF(m|0)* and *supF(m+1|m)* tests.[21] Based on the application of these

[20] We use Bai and Perron's (1998, 2003) notation. The brief summary here is based on Brady (2008).
[21] Bai and Perron (1998, 2003) also provide "Double Maximum Tests." In this paper, these statistics do not provide any additional information not already given by the *supF* tests, so we do not report them. See Bai and Perron (2003), pages 15-16, for a case in which they are useful in practice.

tests, one can then choose the number of breaks, and hence, the final model. The *supF(m|0)* generalizes the *supF* test detailed in Andrews (1993) to test for multiple break points. The *supF* test is motivated by the fact that in a hypothesis test of structural change, the break point, T_j, appears as a parameter under the alternative hypothesis but not the null. Therefore, the usual Wald, LaGrange Multiplier (LM), or Likelihood Ratio (LR) statistics fail to have standard asymptotic properties (see Andrews (1993) and Andrews, Lee and Ploberger (1996) for discussion on this point). The *supF(m|0)* is constructed for a maximum number of specified m and compared to critical values provided by Bai and Perron (1998).

The *supF(m+1|m)* provides a variant of the *supF* test for the presence of m+1 breaks given that m breaks are present. This provides a sequential method for choosing the number of breaks when the first test has confirmed the existence of at least one break. We choose the number of breaks first by checking the *supF(m|0)* results to confirm that there is at least one break. If so, then we find the m where the *supF(m+1|m)* value is no longer significant based on the critical values. For example, if *supF*(2|1) is significant, this suggests that there are two breaks, given one break has been found. If the next test, *supF*(3|2), is insignificant, then one can conclude that there are, in fact, only two breaks, given the two breaks confirmed by the previous test.

Tables 2 through 13 display the results of the *supF(m|0)* and *supF(m+1|m)* tests and the estimated break dates. In our application of the tests, we set the maximum number of possible breaks to four.[22] Table 14 summarizes the findings from Tables 2 through 13. In addition, Figure 4 reproduces the break date estimates displayed in Table 14 along with the estimated confidence intervals for each date.

3.3 The Results of the Break Tests

We apply a common template in reporting the results of the structural break tests. Panel A of each table, *e.g.*, Table 2 in the case of the top-4 concentration ratio, presents the results of an AR(0) specification and Panel B of the same table presents the results of an

[22] Bai and Perron (1998) suggest as a rule of thumb that five is an appropriate number for most post-WWII samples. This means that the test allows for the possibility that there have been up to five events or points at which a break has occurred over the last 60 years; in this application, setting the maximum to 4 or 5 yielded the same results for our approximately 50-year sample.

AR(1) specification.[23] In addition, we also re-specify and test each of the AR(0) and AR(1) models with a trend term; however, we do not report the trend results unless they diverge from those without the trend or provide other insight.[24] Unless noted otherwise, we report all significance tests at the 5-percent level. Lastly, we reserve contextual interpretation of estimated break dates until section 3.4.

3.3.1 Breaks in the Top-4 Concentration Ratio

Table 2 displays the results for the top-4 concentration ratio. The value of the *supF(m|0)* test for the AR(0) process, displayed in Panel A, is statistically significant for all *m* (up to *m*= 4). The sequential *supF(m+1|m)* is statistically significant up to *m* = 3; that is, given the existence of at least two breaks, the *supF*(3|2) = 15.54. The next test, *supF*(4|3) = 0.347 is below the critical value. This reveals three breaks for this series. The estimated break dates are 1964, 1983, and 1995; the 95 percent confidence intervals for each date are 1961 to 1966, 1977 to 1989, and 1993 to 1996, respectively.[25]

For the AR(1) process, displayed in Panel B, we find one break in 1992. The *supF(m|0)* test is statistically significant at the five percent level for all *m*, but the sequential *supF(m+1|m)* is not statistically significant when *m* = 2. The confidence interval for 1992 is 1989 to 1995. Across the specifications, the evidence strongly suggests a break sometime in early to mid-1990s.

3.3.2 Breaks in the Top-100 Concentration Ratio

Table 3 displays the results for the top-100 concentration ratio. The value of the *supF(m|0)* test for the AR(0) model, displayed in Panel A, is statistically significant for all *m*. The sequential *supF(m+1|m)* is statistically significant up to *m* = 2. This process reveals two breaks in this series. The estimated break dates are 1964 and 1990; the 95 percent confidence intervals for each date are 1961 to 1965 and 1988 to 1992,

[23] We follow Timmerman (2001) in using these two simple model specifications, where the simplicity is motivated by a lack of a clear structural model underlying the various data processes. Higher autoregressive orders do not make a substantial difference in the estimated break dates, so we do not report results for additional models.

[24] Greenfield and Brady (2008) model the concentration ratios with a deterministic time trend, implying the process is trend-stationary. Dickey-Fuller and Phillips-Perron tests of stationarity support this choice.

[25] Bai and Perron (1998, 2003) provide asymmetric confidence interval estimates.

respectively. If we include a time trend in the AR(0) model, we find an additional break in 1999, with 1995 and 2003 marking the confidence interval. In the AR(1) model, we find a break for the top-100 firms in 1990. However, the statistical support for this break is weaker than in the previous cases; the 1990 break is statistically significant only at the ten percent level, with a confidence interval spanning ten years.

3.3.3 Breaks in the Number of Subsidiaries of the Top-4 and Top-100 Firms

Tables 4 and 5 display the results for the aggregate number of subsidiaries for the top-4 and top-100 firms, respectively. For brevity, we refer the reader to the accompanying tables for a detailed reporting of the *SupF* statistics, but do not include them in the discussion in the remainder of Section 3.3. Also, we direct the reader to Figure 4 for information on the confidence intervals around each of the breaks.

For the number of subsidiaries of the top-4 firms, the AR(0) model without a trend provides evidence of breaks in 1968, 1984 and 1995 (Table 4, Panel A), but we find less statistical support for a break in this series when we model it as an AR(0) process with a trend or as an AR(1) process, with or without a trend. For the top-100 series, the evidence is also weak. We find evidence of a break in 1967 in the AR(0) model without a trend term (Table 5, Panel A) and breaks in 1980 and 1989 in the AR(0) model with a trend term. However, we find no evidence of breaks in either version of the AR(1) model, whether with or without a trend term.

3.3.4 Breaks in the HHI Values for the Top-4 and Top-100 Firms

Tables 6 and 7 display the results for the HHI values for the top-4 and top-100 firms. The break dates for the top-4 HHI value are nearly identical to those shown in Table 2 for the top-4 concentration ratio. Though if a trend term is included in the AR(0) model, the evidence is strongest for two breaks, one in 1995 and another in 1965; for the AR(1) model, the addition of a trend has no practical effect, 1992 is still statistically significant. For the top-100 HHI value, the results are somewhat similar to the top-4 HHI value, but somewhat different from the top-100 concentration ratio. For the AR(0) model without a trend term, two breaks are found in 1964 and 1995. The AR(0) model with a trend also yields a 1995 break date, but the 1964 date is no longer significant. The 1995 break point

is also found for the AR(1) model (both with and without a trend term). The 1995 break date differs from the 1990 date found for our measure of top-100 concentration, but, as shown in Figure 4, the confidence intervals around the two dates overlap.

3.3.5 Breaks in the Aggregate Real Dollar Value of Awards to the Top-4 Firms, the Top-100 Firms, and all DOD Contractors

For an initial consideration of defense spending, we test the real growth rate of the value of DOD contracts awarded to the top-4 and the top-100 firms. In addition, we test the real growth rate of the dollar value of all DOD prime contract awards.

We did not find any breaks in the top-4 series; however, Tables 8 and 9 display the results for the value of awards to the top-100 firms and to all DOD contractors, respectively. Table 8, Panel A shows that for the top-100 awards, at least one break is found in 1999. Note, too, the *supF*(2|1) test indicates the presence of a second break in 1985, but the sequential method does not substantiate that break. If a time trend is included in the AR(0) model, we find and confirm the 1985 break. For the AR(1) model without trend, no break is found for the top-100 awards; for the series including a trend, a 1985 break is found and confirmed again. Lastly, the results for the value of awards to all firms, displayed in Table 9, partially mimic the results for the value of awards to the top-100 firms. For the AR(0) models, the results are the same; however, we find no evidence of a break in either version of the AR(1) model.

3.3.6 Breaks in the Defense Budget Authority Data

For a second perspective on defense spending, we next look at DOD budget authority. The results displayed in Table 10 provide some, albeit weak corroboration of a relationship between defense spending and industry consolidation. The growth rate of the series modeled as an AR(0) process without a trend presents statistical evidence of breaks in 1984 and 1996. However, these dates, found using Bai and Perron's (1998) global optimization procedure, are not confirmed by the sequential procedure. On the other hand, for the AR(0) model with trend, a break is found for 1998 and confirmed by the sequential procedure.

For a third and final perspective on defense spending, we also look at two NIPA defense categories, defense consumption and investment. Panel A of Table 11 displays the results for the test of the growth rate of real national defense consumption expenditures for the AR(0) and AR(1) model. For the AR(1) model, the *supF* tests and sequential procedure indicate that three breaks exist, in late 1955, in early 1986, and in the second half of 1997 (though we do not find statistically significant breaks for the AR(0) version of the model). For defense gross investment, shown in Panel B of Table 11, we find breaks earlier in the sample period, in 1956 and 1972.

3.3.7 Breaks in Economy-Wide Indicators

As a primary indicator of economy-wide activity, we test for breaks in the series for economy-wide mergers and acquisitions. As displayed in Table 12, we find evidence of a break in the number of mergers and acquisitions in 1995 in both the AR(0) and AR(1) models; we also find evidence of a break in 1969 in the AR(1) model. With a trend term included, we find additional breaks in 1967 and 1973 in the AR(0) model, and again in 1969 and 1995 in the AR(1) model. Tests on the total (logged) real dollar value of the mergers and acquisitions, displayed in Table 3, reveal significant breaks in 1980 and 1987 in the AR(0) model without a trend term and in 1987 alone in the AR(0) model with a trend term. Lastly, tests on a different broad, economy-wide indicator, total U.S. budget authority, fail to identify any statistically significant breaks; hence, we do not report the results of those tests.

3.4 Interpretation of the Break Dates

We focus the discussion of the results on the 1980s and the 1990s, with most confidence attached to the break dates in the 1990s.[26]

From the DOD-policy-centric view, the "signifying" year in the 1990s is 1993, the year of the Last Supper. From this perspective, the 1995 break date and the 3-5 year confidence intervals found for the data representing consolidation—in particular, the top-4 concentration ratio, the top-4 HHI, and the number of subsidiaries for the top-4—may

[26] As Figure 4 reveals, the 1990s break dates are estimated more precisely than most of the dates found in the 1980s—we say more on this point below.

all be indicative of a policy effect. The elapse of time between the policy events and the heaviest period of merger activity may be explained by lags in implementation on the part of both the DOD and the firms themselves.[27] Even if responding directly to DOD policy, the firms might require months if not years to negotiate among themselves, navigate the federal antitrust process, and finalize transactions.

However, against a broader backdrop, the *post hoc ergo propter hoc* reasoning applied to the consolidation that occurred in the 1990s and the DOD policy change appears less certain. The most direct economy-centric supportive evidence is the break in the series for total mergers and acquisitions which occurs in 1995 with a 95 percent confidence interval spanning 1993 to 1996. The estimated date for the economy-wide mergers corresponds to the break date estimates in 1995 for the consolidation data, with confidence intervals ranging, for the most part, from 1992 to 1997.

The coincident and relatively well-defined break dates in the consolidation data and the economy-wide merger data, both occurring in 1995 and both with narrow confidence intervals, are consistent with evidence cited earlier favoring the economy-centric explanation of defense industry consolidation. For example, they are consistent with Hensel's (2007) descriptive statistical evidence that the mergers in the defense sector are highly correlated to those in the broader economy.

The economy-centric explanation also seems more reasonable given breaks found in the top-4 concentration ratio in 1983, the top-4 HHI value in 1983, and number of subsidiaries for the top-4 in 1984. Though the confidence intervals for the 1980s break dates are wider and offer less precise measurement of the breaks dates, we think the 1980s break dates are useful for at least two reasons. First, the 1983 to 1984 dates are evocative of broader structural change that occurred in the U.S. economy at that time. A multitude of studies have identified structural break points in many other macroeconomic time series in the mid-1980s (see McConnell and Perez-Quiros (1999), and Stock and Watson (2002)).[28,29] Second, though confidence intervals are wide, the *SupF* tests and

[27] Indeed, Gholz and Sapolsky (1999-2000) discuss the political resistance the DOD faced with its pro-consolidation stance—resistance which the authors argue slowed the effectiveness of the policy.
[28] Various authors, including Kim and Nelson (1999) Campbell (2005), Cecchetti *et al*. (2004), Ahmed *et al.* (2004), Brady (2008), and Ramey and Vine (2005) provide numerous examples and explanations of structural change in various sectors of the U.S. economy.

the sequential procedure from the Bai and Perron (1998) provide strong statistical evidence that a break occurred at *some* point over that decade, which suggests the industry was evolving before the DOD decided to support consolidation.[30]

That the structure of the defense industry was undergoing change during the 1980s along with the rest of the U.S. economy is consistent with points noted by Flamm (1998). First, merger activity occurred during this period while the defense budget was still increasing, which is consistent with a wave of merger activity in the U.S. economy during the 1980s. And second, the mid-1980s is a well-recognized point at which the defense budget began to decline. Consistent with the latter fact are the breaks found in the defense budget authority data found tentatively in 1984 (or 1985 if a trend is included in the model), and in 1986 for the NIPA series on defense consumption expenditures (though the latter's confidence interval is wide).[31] The structural breaks in the defense budget data are relevant to both stylized explanations of defense-industry consolidation, but each explanation might offer a different interpretation of the breaks. The economy-centric view might expect concurrent breaks if the breaks in defense spending were tied to larger economy-wide phenomenon. From the DOD-policy-centric perspective, the lag between the breaks in the fiscal data in the 1980s and the apparent surge in defense industry consolidation, might indicate the industry waited for a policy cue from the DOD, even if that cue came years after the decline in the budget began.

Given the inherent complexities of the defense industry and the forces that stand to affect it, one would not expect to side completely with either of the stylized narratives. For example, the 1990 break date found for the top-100 ratio, with a confidence interval of 1988 to 1992, suggests the industry was evolving either in line with the economy-wide

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[29] In replication of those studies, in an earlier draft we applied the Bai and Perron (1998, 2003) method to the growth rates of real U.S. GDP, real private fixed investment, and total government spending from 1947 through 2007. The results generally accord with the findings of the literature: structural breaks are evident at least from 1982 to 1985.

[30] To look at the 1980s further and to substantiate the Bai and Perron (1998) tests, we applied simple Chow break tests to the 1980s dates for the top-4 concentration ratio for the sub-sample 1958 to 1994 (once the 1995 break date is found, the Bai and Perron (1998) method then checks the sub-samples for additional breaks). The Chow results (not reported) agree with the Bai and Perron (1998) results in two respects—a break occurred in the data at some point in the 1980s, but depending on the particular specification, the break occurred as early as 1980 or as late at 1989.

[31] Chow tests on the budget authority data match the results from Bai and Perron's (1998) *SupF* results reported in Table 10—for the simple AR(0) model, a break occurs in 1984, but no breaks are confirmed for the other specifications. For the NIPA series, the Chow test confirms a break at some point in the 1980s.

structural forces apparent in the early 1980s, or simply as the defense budget began to shrink, or both. However, if the breaks in the industry data that are identified in the 1980s are considered in context with both the broader changes in the U.S. economy during that decade and the decline in the defense budget, the coincident and more precise break estimates found in the 1990s for the economy-wide merger data and the defense industry data seem more suggestive of the economy-centric explanation of events. On balance, the DOD's support for consolidation seems less consequential than a DOD-policy-centric view would otherwise hold.

4. Conclusion

Overall, the common structural breaks found for the defense-related and economy-wide data offer more direct support for the economy-centric explanation of the consolidation of the defense industry in the 1990s than for the DOD-policy-centric explanation. Of course, common timing of the break dates does not imply causation nor does it rule out the possibility of a DOD-policy-centric explanation, such as the lagged explanation proposed previously. However, a comparison of breaks across defense industry, defense spending, and economy-wide data in the 1980s and 1990s provides a statistical basis for assessing the roles of DOD policy decisions and broader economic forces in consolidation. The break date analysis in this paper supports the argument that the consolidation of the defense industry would have occurred with or without the DOD's explicit approval.

In the least, as the defense budget declined steadily from 1985 to 1998, the break dates found here for the consolidation of the defense industry offer statistically identifiable points consistent with changes in the broader economy. Ultimately, our findings suggest that the DOD cannot effectively promote competition, spur innovation, or otherwise alter the shape of the defense industry through policy actions taken in isolation. Instead, the DOD would benefit from close consideration of economy-wide forces when it crafts its policies in this and future decades. The DOD may be the world's largest purchaser of many defense-related goods and services, but broader economic forces may yet challenge its authority.

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Table 1 Summary of Data Series and Sources

Data Series	Coverage	Source
Defense Industry Data	-	-
Top-4 and top-100 concentration ratios	1958-2006	DD350-derived
Top-4 and top-100 number of subsidiaries	1958-2006	DD350-derived
Top-4 and Top-100 Herfindahl-Hirschman indices	1958-2006	DD350-derived
Value of Awards to Top-4 and Top-100 ($2000)	1958-2006	DD350-derived
Value of Awards to All firms ($2000)	1958-2006	DD350-derived
Defense Spending Data	-	-
Defense Budget Authority, real $2000	1958-2006	DOD Green Book
National defense consumption expenditures ($2000)	1947-2007	BEA, NIPA
National defense gross investment ($2000)	1947-2007	BEA, NIPA
Economy-Wide Data	-	-
Total U.S. Budget Authority ($2000)	1958-2006	Policy Agendas Project
Number of all U.S. mergers and acquisitions	1962-2007	Factset Mergerstat, LLP
Value of all U.S. mergers and acquisitions ($2000)	1968-2007	Factset Mergerstat, LLP

Notes: Real $2000 values derived from BEA GDP deflator

Table 2 Structural Break Tests on the Concentration Ratio of the Top 4 Firms

A. Concentration Ratio modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	134.22	8.58	22.17	8.58	1964
2	78.93	7.22	15.54	7.22	1983
3	62.85	5.96	0.347	5.96	1995
4	46.92	4.99	-	4.99	-

B. Concentration Ratio modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	22.78	11.47	8.59	11.47	1992
2	16.75	9.75	-	12.95	-
3	14.64	8.36	-	-	-
4	12.89	7.19	-	-	-

Notes: *SupF* statistics estimated using Bai and Perron (1998, 2003) methods, with Gauss code made available by Bai and Perron. Critical values from Table 1, Bai and Perron (1998). In choosing the number of breaks, column 2 establishes the existence of at least one break and column 4 provides a sequential test to test for more breaks given at least one exists--please see the text for more details. Column 6 displays the break dates as chosen by the sequential procedure. The results are generally the same if a trend term is included in each model unless otherwise noted (see the text for complete details on the results displayed here and in the subsequent tables). See Figure 4 for confidence intervals for each date.

Table 3 Structural Break Tests on the Concentration Ratio of the Top 100 Firms

A. Concentration Ratio modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	135.34	8.58	147.53	8.58	1964
2	327.03	7.22	7.74	7.22	1990
3	280.82	5.96	3.41	5.96	-
4	208.88	4.99	-	4.99	-

B. Concentration Ratio modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	10.13*	11.47	5.36	11.47	1990
2	8.68	9.75	-	12.95	-
3	7.27	8.36	-	14.03	-
4	7.22	7.19	-	-	-

Notes: *See* notes to Table 2. * indicates statistical significance the ten percent level.

Table 4 Structural Break Tests on the Number of Subsidiaries of the Top 4 Firms

A. Subsidiaries modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	95.99	8.58	76.49	8.58	1968
2	199.52	7.22	54.08	7.22	1984
3	146.68	5.96	0.77	5.96	1995
4	117.56	4.99	-	4.99	-

B. Subsidiaries modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	8.35	11.47	15.5	11.47	-
2	11.8	9.75	19.45	12.95	-
3	14.82	8.36	1.63	14.03	-
4	13.31	7.19	-	-	-

Notes: *See* notes to Table 2.

Table 5 Structural Break Tests on the Number of Subsidiaries of the Top 100 Firms

A. Subsidiaries modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	132.44	8.58	7.66	8.58	1967*
2	70.54	7.22	12.33	7.22	-
3	95.87	5.96	15.15	5.96	-
4	59.93	4.99	-	4.99	-

B. Subsidiaries modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	5.97	11.47	11.31	11.47	-
2	12.82	9.75	3.29	12.95	-
3	18.21	8.36	-	14.03	-
4	13.38	7.19	-	-	-

Notes: *See* notes to Table 2. *There are some cases when the sequential method of choosing breaks leads to inconsistent results; specifically, it is difficult to reject the supF(1|0) test, but not for a higher value of m, as see in panel B. In this case, Bai and Perron (2003, p15-16) provide a way to interpret this test, which involves referring to their "UD Max" or the "WDmax" test.

Table 6 Structural Break Tests on the HHI Value for the Top 4 Firms

A. HHI-Top Four modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	124.96	8.58	10.72	8.58	1965
2	65.39	7.22	13.51	7.22	1983
3	57.93	5.96	0.19	5.96	1995
4	41.55	4.99	-	4.99	-

B. HHI-Top4 modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	27.92	11.47	11.72	11.47	1992
2	24.59	9.75	10.91	12.95	-
3	21.23	8.36	-	-	-
4	20.58	7.19	-	-	-

Notes: *See* notes to Table 2. See the text for an explanation of the HHI values.

Table 7 Structural Break Tests on the HHI Value for the Top 100 Firms

A. HHI-Top 100 modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	76.3	8.58	20.44	8.58	1964
2	53.1	7.22	9.61	7.22	1995
3	38.06	5.96	0.69	5.96	-
4	28.59	4.99	-	4.99	-

B. HHI-Top 100 modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	17.41	11.47	6.23	11.47	1995
2	12.63	9.75	-	12.95	-
3	9.23	8.36	-	14.03	-
4	9.11	7.19	-	-	-

Notes: *See* notes to previous table.

Table 8 Structural Break Tests on the Top 100 Firms: Real Growth Rate of total Award Value ($)

A. Top 100 growth rate modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	16.93	8.58	9.08	8.58	1999
2	28.83	7.22	6.9	7.22	1985*
3	23.82	5.96	-	5.96	-
4	18.24	4.99	-	4.99	-

B. Top 100 growth rate modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	3.66	11.47	7.62	11.47	1985*
2	20.39	9.75	-	12.95	-
3	15.93	8.36	-	14.03	-
4	12.11	7.19	-	-	-

Notes: *See* notes to Table 2. The *Sup* (2|1) test suggest an additional break is found in 1985 (though the sequential procedure does not substantiate that date). *If a trend is included for both models (panels A and B), the 1985 break date is identified. We did not find breaks for the top four firm-award value. Growth rates for each series are calculated using constant 2000 dollars.

Table 9 Structural Break Tests on All Firms: Real Growth Rate of total Award Value ($)

A. All firm growth rate modeled as AR(0): 1958 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	14.91	8.58	7.03	8.58	1999
2	19.97	7.22	-	7.22	1985*
3	17.81	5.96	-	5.96	-
4	14.47	4.99	-	4.99	-

B. All firm growth rate modeled as AR(1): 1959 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	2.48	11.47	4.02	11.47	-
2	3.09	9.75	-	12.95	-
3	9.03	8.36	-	14.03	-
4	8.57	7.19	-	-	-

Notes: *See* notes to Table 2 and Table 8. *If a trend is included for both models, a 1985 break date is identified and confirmed by the sequential method for model A.

Table 10 Structural Break Tests on Real Defense Budget Authority ($)

A. Budget Authority ($) Growth Rate modeled as AR(0): 1958 - 2007

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	5.62	8.58	12.44	8.58	1984*
2	12.47	7.22	4.2	7.22	1996*
3	13.58	5.96	-	5.96	-
4	12.98	4.99		4.99	

B. Budget Authority ($) Growth Rate modeled as AR(1): 1958 - 2007

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	4.38	8.58	4.5	8.58	-
2	4.38	7.22	-	7.22	-
3	6.42	5.96	-	5.96	-
4	7.35	4.99		4.99	-

Notes: *See* notes to Table 2. For the model results shown in panel A, the UDMax of 13.58 and the WDmax statistic of 22.31 are significant at the 5 percent level. *The break dates are indentified by Bai and Perron's (1998) global optimization, but are not confirmed by the sequential procedure. If a trend term is included in the AR(0) model, the sequential procedure finds a statistically signficant break in 1998.

Table 11 Structural Break Tests on the Mean Growth Rate of Defense Spending 1947 to 2007

A. Real Federal National Defense Consumption Expenditures modeled as AR(0)

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	2.05	11.47	4.39	11.47	-
2	5.35	9.75	-	12.95	-
3	6.01	8.36	-	14.03	-
4	9.80	7.19	-		-
5	7.83	5.85	-		-

Real Federal National Defense Consumption Expenditures modeled as AR(1)

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	30.17	11.47	19.84	11.47	4th Quarter 1955
2	24.65	9.75	16.78	12.95	1st Quarter 1986
3	22.46	8.36	9.37	-	3rd Quarter 1997
4	19.82	7.19	-	-	-
5	17.18	5.85	-	-	-

B. Real Federal National Defense Gross Investment modeled as AR(0)

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	4.46	11.47	4.63	11.47	-
2	4.26	9.75	-	12.95	-
3	4.32	8.36	-	-	-
4	5.19	7.19	-	-	-
5	3.9	5.85	-	-	-

Real Federal National Defense Gross Investment modeled as AR(1)

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	18.69	11.47	12.28	11.47	1st Quarter 1956
2	16.37	9.75	5.42	12.95	2nd Quarter 1972
3	12.37	8.36	-	-	-
4	11.46	7.19	-	-	-
5	7.87	5.85	-	-	-

Notes: *See* notes for Table 2. Growth rates for each series are calculated using constant 2000 dollars.

Table 12 Structural Break Tests on the Number of U.S. Mergers and Acquisitions

A. M&As modeled as AR(0): 1962 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	211.06	8.58	7.31	8.58	1995*
2	118.75	7.22	107.63	7.22	-
3	132.83	5.96	-	5.96	-
4	115.81	4.99	-	4.99	-

B. M&As modeled as AR(1): 1963 - 2006

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	25.52	11.47	20.32	11.47	1969
2	22.1	9.75	5.85	12.95	1995
3	18.01	8.36	8.55	14.03	-
4	15.61	7.19	-	-	-

Notes: *See* notes to Table 2. *See notes for Table 5. Also, with a trend term in the model, the sequential procedure finds additional breaks in 1967 and 1973. For the AR(1) model in Panel B, the results are identical if a trend term is included.

Table 13 Structural Break Tests on the Real Value of U.S. Mergers and Acquisitions

A. M&A($) modeled as AR(0): 1969 - 2007

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	119.56	8.22	51.9	8.22	1980
2	133.42	6.53	0.09	6.53	1987
3	102.76	5.08	-	5.08	-

B. M&A($) modeled as AR(1): 1969 - 2007

Number of Breaks *m*	*SupF(m|0)*	5% Critical Value	*SupF(m+1|m)*	5% Critical Value	Estimated Break Dates from Sequential Method
1	26.47	10.9	9.02	10.9	1977
2	18.31	8.98	3.88	8.98	-
3	19.68	7.13	-	7.13	-

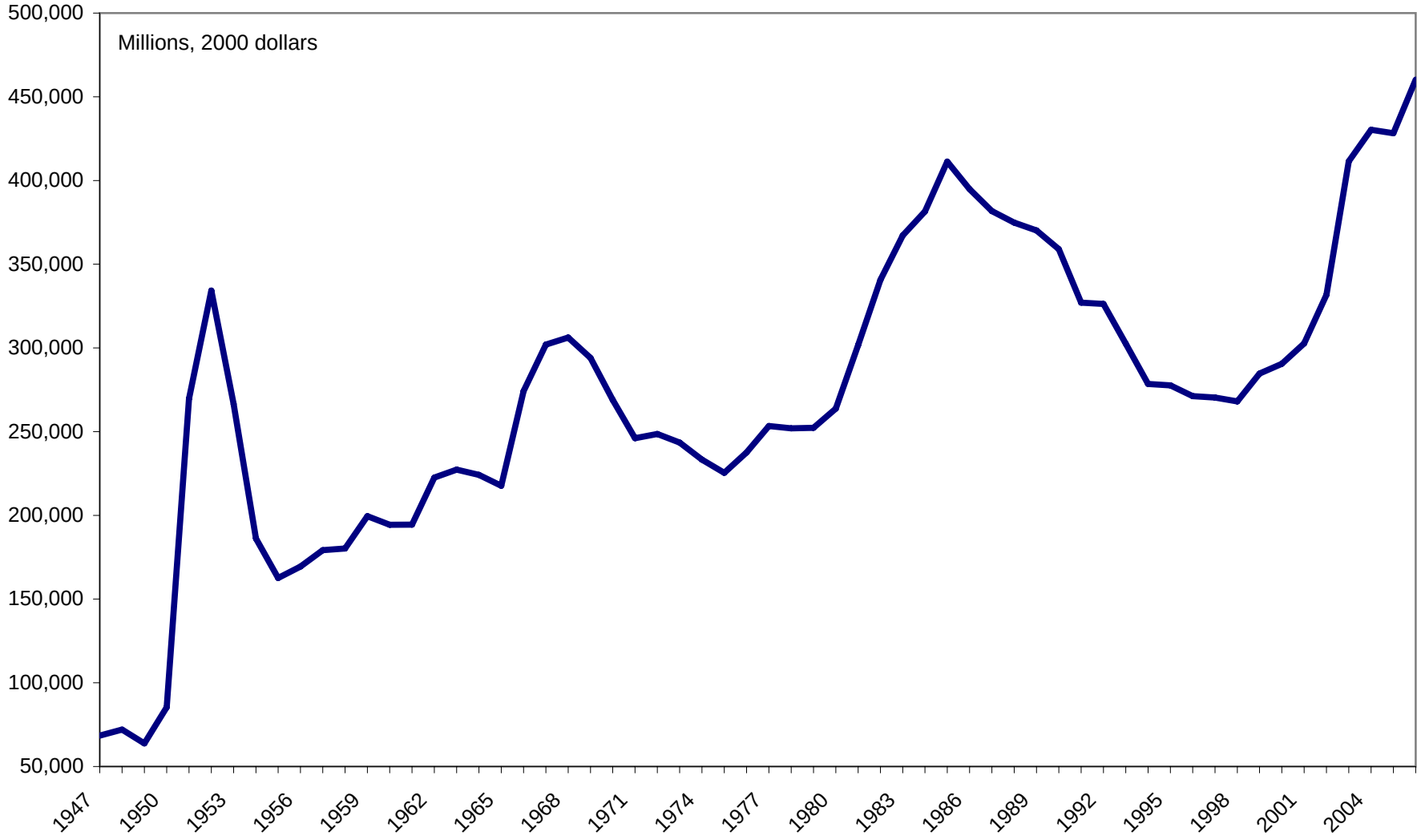
Notes: *See* notes to Table 2. For the AR(0) model with a trend term, only the 1987 break date is found. For the AR(1) model with trend term, no break is found. The maximum number of breaks possible is set to 3.

Table 14 Summary of Break Dates identified in the 1980s and 1990s

Data	1980s	1990s
Concentration Ratio Top Four	1983	1992, 1995
Concentration Ratio Top 100	-	1990
Number of Subsidiaries Top Four	1984	1995
Number of Subsidiaries Top 100	-	-
Herfindahl-Hirschman Index Top Four	1983	1992, 1995
Herfindahl-Hirschman Index Top 100	-	1995
Value of Awards to Top Four ($)	-	-
Value of Awards to Top 100 ($)	1985	1999
Value of Awards to All Firms ($)	1985	1999
Defense Budget Authority ($)	1984	1996, 1998
Federal National Defense Consumption Expenditures ($)	1986	1997
Federal National Defense Gross Investment ($)	-	-
Total U.S. Budget Authority ($)	-	-
All U.S. Mergers and Acquisitions	-	1995
All U.S. Mergers and Acquisitions ($)	1980, 1987	-

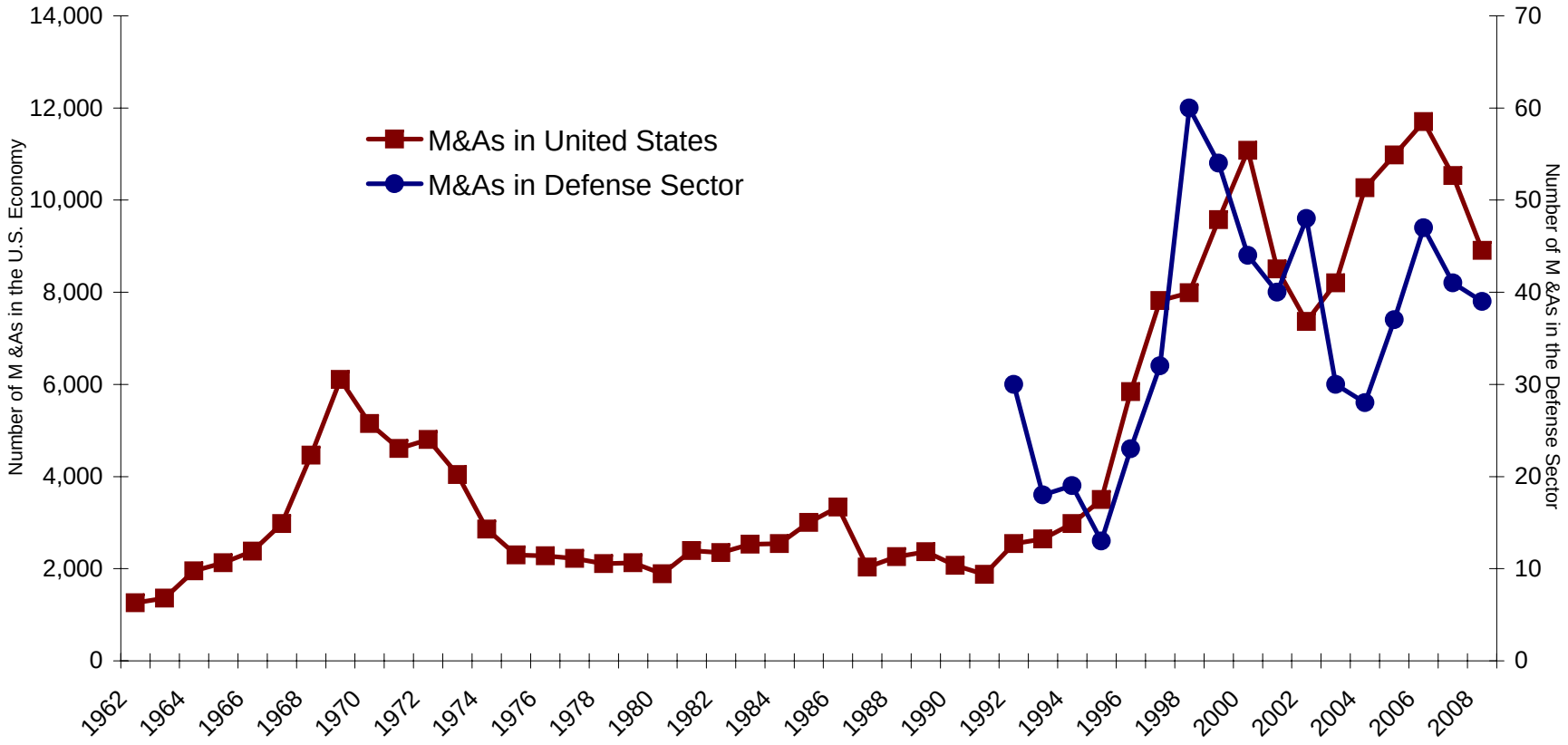
Notes: This table summarizes information found in Tables 2 through 13. The dates shown are found using the methods of Bai and Perron (1998, 2003). See the notes to the individual tables and the text for further discussion on the models estimated and full details of the results. Also, definitions and explanations for each data series are found in the text. Note that ($) indicates 2000 constant dollars. Lastly, dates were identified in earlier periods for many of the series, but we do not report those results here (because we focus on the post-1980 period). Please see the text for the comparison of the dates shown here with break dates found for other sectors of the U.S economy in the 1980s and 1990s.

Figure 1: Defense U.S. Budget Authority



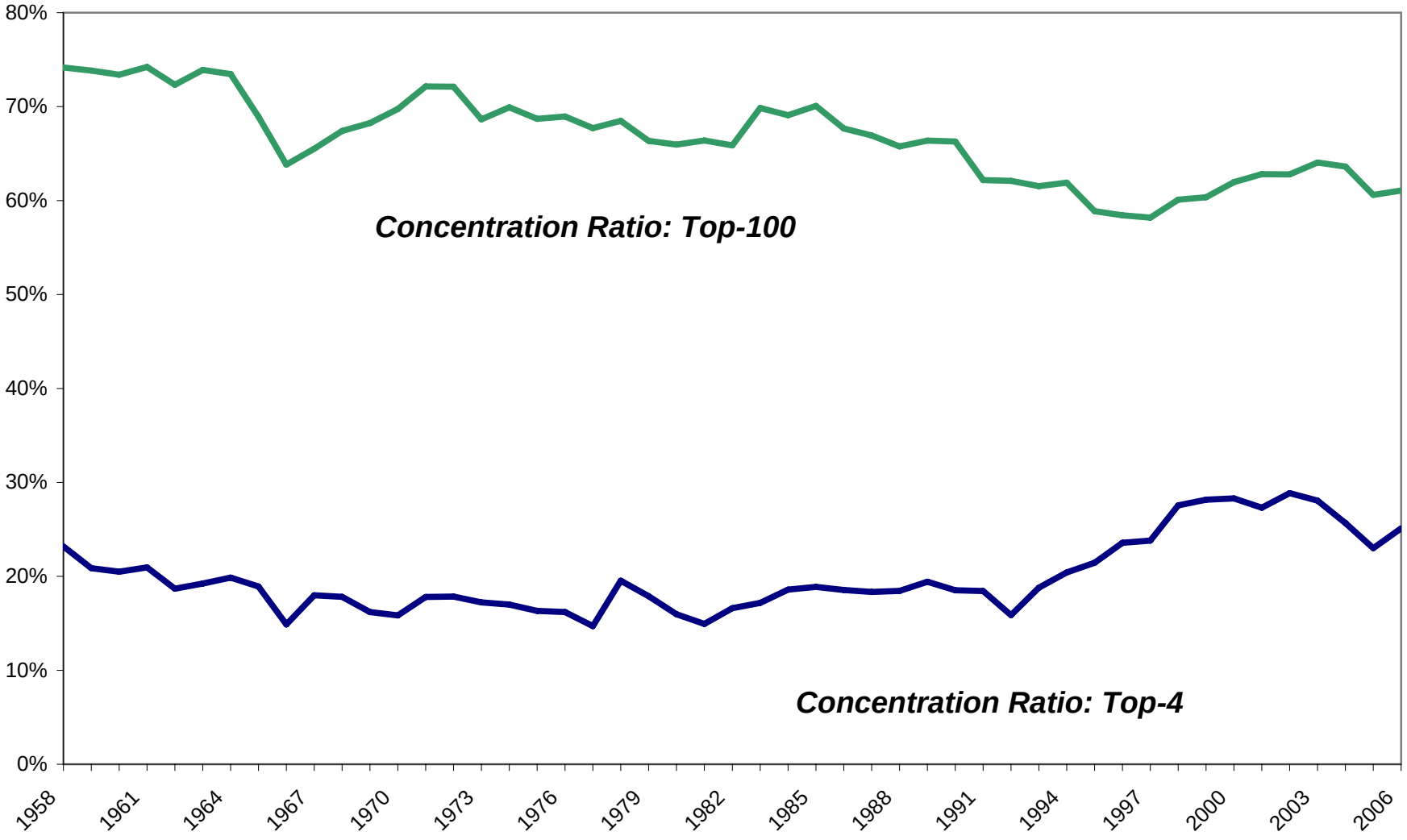
Source: DOD "Green Book" (see text for more details).

Figure 2 Mergers and Acquisitions in the U.S. Economy and in the Defense Sector



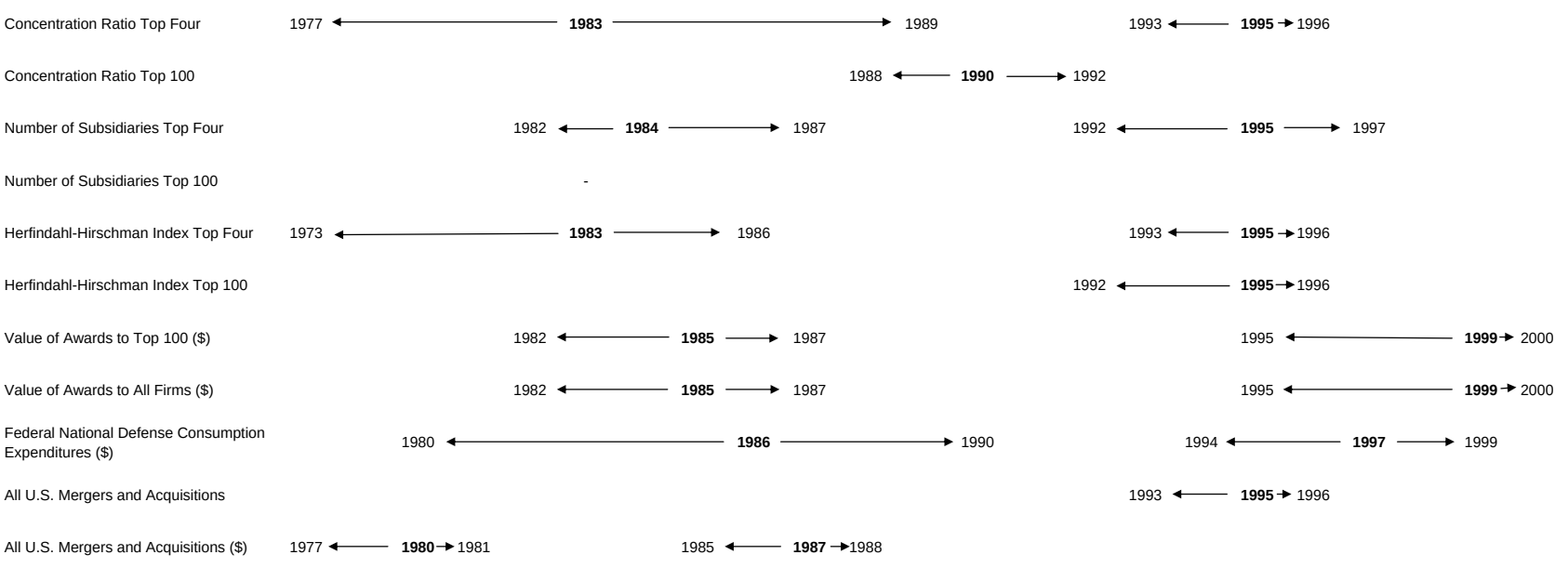
Notes: Reproduced from Greenfield and Brady (2008). Data are from FactSet Mergerstat, LLC. For "M&As in Defense Sector" we use Mergerstat's category of "seller industry" that includes Aerospace, Aircraft and Defense firms. This category is defined by the SIC classification codes 3761-3769, 3721-3728, and 3795 (see text for additional details, and Hensel (2007)). From 1992 on, "M&As in United States" excludes the defense sector.

Figure 3: Concentration Ratios for the Top-4 and Top-100 Firms receiving DOD Prime Contract Awards



Source: DOD publiciation “100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards" for 1958 through 2006.

Figure 4 Summary of Break Dates with Confidence Intervals Identified in the 1980s and 1990s



Notes: The dates in bold are the same break dates reported in Table 14. Confidence intervals are shown only for breaks confirmed statistically significant by the sequential procedure. The asymmetric confidence intervals are calculated using Bai and Perron's (1998, 2003) methods. See Bai and Perron (2003) for details.