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The Effect of Product Demand Decline on Investments in Innovations: Evidence from the U.S. Defense Industry

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The end of the Cold War led to a substantial decline in defense product demand. This study investigates the effects of product demand decline on defense firms' investments in R&D for innovations. Our evidence indicates significant lower levels of R&D intensity for the low demand period (1993 to 1998) than for the high demand period (1984 to 1989). We also find significant declines in the defense firms' return on assets over the period, which is mainly attributable to a significant decrease in the firms' efficiency of using assets to produce sales. The defense firms, despite decline in defense product sales, generally maintained their total sales by partially shifting their capacity to commercial markets, which might be at the sacrifice of profitability, operating efficiency, and R&D investments for innovations.

INTRODUCTION

In the organizational decline literature, researchers debate on whether the decline in product demand will inhibit or stimulate the innovations of an organization (e.g., the review by Mone, McKinley, and Barker, 1998). One stream of studies contends that organizational decline including product demand decline would inhibit innovations. Resource scarcity due to product demand decline restricts information processing of an organization and imposes an urgency to conserve resources, which leads to organizational rigidity and undermines its capacity to innovate (Staw, Sandelands, and Dutton, 1981; Cameron, Whetten, and Kim, 1987; D'Aunno and Sutton, 1992; Ocasio, 1995; Barker and Mone, 1998). In contrast, the other stream of studies suggests that product demand decline could serve as a stimulus for innovations. They contend that poorer performance caused by product demand decline pressures an organization to be more risk-seeking in its investment decisions, and motivates it to search for innovative solutions for improving its performance (Miles and Cameron, 1982; Cameron, 1983; Lant, Milliken, and Batra, 1992; Haveman, 1993; Hundley, Jacobson, and Park, 1996; Wiseman and Bromiley, 1996).

The end of the Cold War in 1989 led to a substantial decline in US defense procurement spending. US Defense procurement from the defense industry had declined from more than 120 billion for 1984 to around 45 billion for 1998, both in constant 1999 US dollars (the Department of Defense, Green Book 1999). The defense industry during 1980s-1990s provides a natural context to investigate the effects of

product demand decline. Thus, the purpose of this study is to empirically examine the effects of declining product demand during 1980s-1990s on R&D investments of US defense-contracting firms. The evidence provided by this study helps to test which of the competing views could better explain the US defense industry's response to the declining demand subsequent to the end of the Cold War.

The declining demand for defense products substantially deteriorated the operating environment of US defense firms (Lundquist, 1992). There have been extensive discussions on defense firms' strategy alternatives for rapidly declining demand in defense markets (Lundquist, 1992; Minnich, 1993; Dial and Murphy, 1995; Gholz and Sapolsky, 2000). The strategies adopted by major defense contractors include "acquisitions to achieve critical mass; diversification into nondefense areas, or converting defense operations to commercial products and services; globalization, i.e., finding international markets for defense operations; downsizing and consolidation; and exit" (Dial and Murphy, 1995, page 293). However, there is little evidence on the defense industry's strategic responses to the decline in defense products demand, and the effect on their investments in innovations. Our study intends to close this gap in the literature.

We believe the paper has importance to R&D researchers, as it finds that a substantial decline in product demand could significantly undermine firms' motivation and capacity for R&D investments for innovations. Keeping a R&D lead in developing advanced defense products is a critical strategy for the U.S. national security (Rogerson, 1989). This study could provide evidence helpful to assess the trends in defense R&D investments for innovations. Many technological innovations initially developed for military purposes have been later adapted for commercial purposes. Software and the internet are two classical examples (Campbell-Kelly, 2003). These technological innovations developed by the defense industry have since become critical to competitive advantages of the US economy. Thus, the effect of product demand decline on R&D investments for innovations of defense contractors could have implications beyond the area of national security. With the Great Recession since 2008 and subsequent deleveraging of U. S. customers, our study could also be relevant to the current issues in general with R&D investments in the U.S.

The organization of the remaining of this study is as follows. Section 2 develops the major hypotheses. Section 3 describes the sample firms and data characteristics. Section 4 presents the empirical evidence. Section 5 concludes with a summary and implications of the findings.

HYPOTHESES

One body of organizational decline research suggests that product demand declines would inhibit innovations of an organization. Staw, Sandelands, and Dutton (1981) develop a theoretical model on the effect of external "threat" on organizational behavior. They define threat as "an adverse condition in the environmental, such as resources scarcity, competition, or reduction in the size of the market" (page 515). Their model, called by them "threat-rigidity effects", suggests that threat could affect organizational behavior in three ways. First, it restricts an organization's capacity for processing information, and results in a lower number of innovative alternatives to be considered. Second, threat increases an organization's concern with improving control and coordination of organizational activities, which generally leads to centralization of authority and more formalized procedures. Third, resource scarcity due to the environmental adversity imposes an urgency to conserve resources through cost cutting and results in a "dominance of efficiency concerns". All these lead to more rigidity in organizational behavior, which consequently inhibits organizational innovations. The theoretical model of "threat-rigidity effects" have been supported by empirical evidence from studies such as Sutton and D'Aunno (1989), D'Aunno and Sutton (1992), Ocasio (1995), and Barker and Mone (1998). Based on this stream of research, we expect that defense product demand decline subsequent to the end of the Cold War would decrease defense contractors' innovations. We call this "inhibiting view".

R&D intensity is commonly used as a proxy for R&D investments for innovations in prior research. Thus, the general method we use to test for a change in R&D investments involves a comparison of defense firms' R&D intensity for the high demand (1984-1989) and the low demand (1993-1998) period.

A decrease in R&D intensity, vis-à-vis nondefense firms in the same industry, reflects the decreased investment in R&D by defense firms. We provide the following hypothesis:

> *H1a: Industry-adjusted R&D intensity for defense firms during the low-demand period (1993-1998) was lower than that during the high-demand period (1984-1989).*

In contrast with the inhibiting view, some studies on organizational decline suggest that external threat could serve as a stimulator for organizational innovations. This stream of research, based on organizational learning or prospect theories, contends that organizational decline such as lower financial performance, makes organizations to be more risk-seeking for changes or adaptations (Singh, 1986; Bromiley, 1991; Haveman, 1993; Wiseman and Bromiley, 1996), and consequently stimulates managers to search out innovative solutions to problems of their organizations (Miles and Cameron, 1982; Lant, Milliken, and Batra, 1992). The organizational learning theory suggests that organizations are more tended to change and adapt "when their performance is below aspiration level, or perceived as failure" (Lant and Mezias, 1992). Firms are more likely to incur performance below aspiration when facing a substantial decline in product demand. According to the prospect theory, decision makers tend to be more risk- averse "in choices involving sure gains" whereas to be more "risk seeking in choices involving sure losses" (Kahneman and Tversky, 1979). Following this line of research, the severe decline in defense product demand could motivate defense firms to engage in riskier R&D projects as a way to gain competitive advantage in the more challenging defense or commercial product markets. Both the organizational learning and the prospect theories suggests that defense firm would be more motivated to engage in innovation activities for surviving the intensified competition resulted from the decline in defense product demand. Based on this *stimulating view*, we provide the following hypothesis:

> *H1b: Industry-adjusted R&D intensity for defense firms during the low-demand period (1993-1998) was higher than that during the high-demand period (1984-1989).*

SAMPLE AND DATA

Following McGowan and Vendrzyk (2002), our sample period is from 1984 to 1989 for the period of high demand for defense product, and from 1993 to1998 for the period of low demand for defense product. We consider 1990 to 1992 as the transition period from high to low demand since most defense contracts last for more than one year, and many defense contractors might begin to have substantial declines in defense sales a few years later than the declines in the awarded volume of contracts (Lundquist, 1992). The low demand sample period ends with 1998 because most firms stopped reporting segment sales to the government subsequent to 1998 due to the change in disclosure requirements on segment reporting by the SEC in January1999 (SEC Final Rule 33-7620).

Our initial sample is 56 firms (or their parent companies) included in the annual DOD report, *100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards of 1989*, with nonzero sales to the U. S. government included in Compustat segment files of 1989.[1] Please refer to the Appendix for the list of the sample firms. The majority of firms with defense sales also made sales to commercial markets. We examine R&D investments at the firm level, instead of segment level, because the data for R&D expenses are available only at the firm level for most sample firms. Another reason is that operations of government and commercial business are difficult to be clearly separated due to the existence of "externalities" (Bohi 1973) and "cost shifting" (Rogerson 1992; Lichtenberg 1992). We deal with this issue in our regression analysis by including defense dependence, the government sales as a percentage of total sales, as a control variable.

We report sample breakdowns by industry in Table 1, Panel A. Most of the sample defense firms (86% of the 56 firms) concentrate in manufacturing industries with four-digit SIC codes from 2000 to 3999. We report sample breakdowns by year in Table 1, Panel B. Facing with declining product demand,

some defense firms could be delisted due to mergers & acquisitions or even bankruptcies. Thus, the number of the sample firms decreased from 56 in 1989 to 42 in 1998.

TABLE 1
***PANEL A:* INDUSTRY BREAKDOWN FOR SAMPLE FIRMS OF 1989**

Industry	First two digits of SIC codes	Number	Percentage
Building construction contractors	15	1	1.8%
Chemicals & allied products	28	3	5.4%
Primary metals	33	1	1.8%
Fabricated metal products	34	2	3.6%
Industrial and commercial machinery and computer equipment	35	7	12.5%
Electronic and other electrical equipment	36	5	8.9%
Transportation equipment	37	23	41.1%
Measuring, analyzing and controlling instruments	38	7	12.5%
Communication services	48	1	1.8%
Wholesale durable goods	50	1	1.8%
Business services	73	2	3.6%
Services-engineering, accounting, research, and management	87	3	5.4%
Total		**56**	**100%**

***PANEL B:* YEAR BREAKDOWN FOR SAMPLE FIRMS**

	High-Demand Period						Low-Demand Period						
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**Total**
Firms	52	54	54	55	55	56	52	50	48	46	44	42	608

The substantial decline in demand for defense products posted a challenging operating environment for US defense industry. As Lundquist (1992) pointed out, "The cuts will be deeper and longer than any in our history, deeper and longer than anyone in Washington or industry wants to admit. The cuts will force industry to retrench because they will reduce revenue by a greater margin than defense contractors can make up through globalization, diversification, or commercialization." To have an overview of the effects of declining product demand subsequent to 1989 on operating environment of defense industry, our empirical examination covers the defense firms' profitability, capital intensity, financial flexibility, and operating efficiency variables, in addition to R&D investment variables. Firms in different industries exhibit different operating and financial characteristics. Thus, we examine these variables both without adjustment and being adjusted by their respective industry medians. For each of those variables, the industry-adjusted measure for each sample year is the difference between a firm and the median of Compustat firms that have the same first two digits of SIC codes with the firm. The definitions for the financial, efficiency and innovations variables used in our empirical examination are included in Table 2.

TABLE 2
VARIABLE DEFINITIONS

Variable	Definition
Profitability Variables:	
NI/AT:	return on assets, measured as net income divided by total assets at the end of fiscal year.
NI/SALE:	return on sale, measured as net income divided by net sales.
Financial Flexibility Variables:	
DT/AT:	debt leverage, measured as total liability divided by total assets.
CHE/AT:	financial resources, measured as cash and short-term investments divided by total assets.
Capital Intensity Variables:	
PPENT/AT:	capital intensity, measured as net book value of property, plant, and equipment divided by total assets at the end of fiscal year.
CAPX/SALE:	capital intensity, measured as capital expenditures (CAPX) divided by net sales.
Operating Efficiency Variables:	
SALE/AT:	efficiency of assets to produce sales, measured as net sales divided by total assets at the end of fiscal year.
SALE/PPENT:	efficiency of plant assets to produce sales, measured as net sales divided by net property, plant & equipment assets at the end of fiscal year.
SALE/EMP:	efficiency of employees to produce sales, measured as net sales divided by number of employees at the end of fiscal year.
NI/EMP:	efficiency of employees to produce profits, measured as net income divided by number of employees at the end of fiscal year.
Innovations Investments Variables:	
RD/AT:	research and development intensity, measured as research and development expenses scaled by total assets.
RD/SALE:	research and development intensity, measured as research and development expenses scaled by net sales.
RD/S&GA:	research and development intensity, measured as research and development expenses scaled by selling and general administrative expenses.
Other Variables:	
GovSal:	sales made by a firm to the domestic government
SALE:	control variable for the size effect, measured by net sales in millions of 1998 constant dollar .
Post:	a dummy variable. It equals 1 if a firm year is during 1993 to 1998 (i.e., post the defense product demand decline), and equals 0 if a firm year is during 1984 to 1989 (i.e., pre the demand decline).
Control:	a dummy variable, which equals 1 if a firm is one of the non-defense firms in the control group; otherwise, if a firm is one of the sample defense firms, it equals 0.
Defense: Dependence:	the degree to which a defense firm depends on government contracts for its sales, measured as sales to domestic government divided by net sales

RESEARCH METHOD AND EMPIRICAL RESULTS

Evidence for Defense Firms' Financial and Operational Characteristics

To provide evidence on changes in the operating environment of defense industry, we first compared profitability, total sale, defense sales, and employment of defense firms for high-demand period (1984-1989) and for low-demand period (1993 to 1998). We use non-parametric tests, median tests, for the

comparisons instead of mean tests because the financial and operational variables usually are not normally distributed. The results are reported in Table 3, Panel A. We found that median defense firms earned a significantly lower return on assets for both unadjusted (χ^2=5.24, p<0.05) and industry-adjusted returns (χ^2=20.74, p<0.01) during the low-demand period, but had no significant change in return on sales over the period. For median defense firms, the defense sales for the low-demand period (1993-1998) are less in amounts (in 1998 constant dollars, χ^2=30.58, p<0.01) and consist of a lower percentage of their total sales (χ^2=16.53, p<0.01) than for the high-demand period (1984 to 1989). Although the median amount of total sales (in 1998 constant dollars) declined from $4,936 million to $4,352 million, the change is not statistically significant for the median tests (χ^2=1.30, p>0.10). The results suggest that the defense firms partially compensate their loss of sales from defense products by making more sales to their commercial markets or foreign markets. The median number of employees for the sample defense firms declined significantly from 37,966 to 28,500 (χ^2=2.94, p<0.10). Additionally, the substantial decline in defense product demand seemed to have significantly undermined defense firms' financial flexibility. The median defense firm exhibited significantly higher debt leverage, measured as total liabilities divided by total assets, for both unadjusted (χ^2=5.20, p<0.05) and industry-adjusted measures (χ^2=4.49, p<0.05). As for financial resources measured by cash and short-term investments scaled by total assets, the industry-adjusted measure exhibited a significant decrease in median (χ^2=5.19, p<0.05) although no significant change in unadjusted measure. Our findings indicate that the product demand declines after 1989 had a substantial negative effect on the sample defense firms' profitability and operations.

With the decline in products demand, one strategy predicted by theories that could be adopted by defense firms is to substantially lower its investment level, called "milking or harvesting the investment" (Perry, 1986). We examined the defense firms' capital intensity using two measures, net property, plant, and equipment divided by total assets (PPENT/AT) and capital expenditures divided by net sales (CAPX/SALE). The results are also reported in Table 3, Panel A. The median defense firm experienced a significant decline in both the unadjusted and the industry-adjusted capital intensity measures. The results indicate that consistent with the theories, the defense firms indeed cut capital investments as a response to the declining defense product demand.

Prior studies suggest that firm managers have strong incentives to maintain the size of their firms, and could delay downsizing and restructuring to the declined product demands at the cost of operating efficiency (Dial and Murphy, 1995; Sanders, 2001). To investigate the defense firms' operating efficiency, we compared medians of total asset sale efficiency (net sale/total assets), plant asset sale efficiency (net sales/net property, plant, & equipment), employee sale efficiency (net sales /number of employees), and employee profit efficiency (income before extraordinary items /number of employees) for the high- and low-demand period. The results are reported in Table 3, Panel B. The median defense firm experienced a significant decline in efficiency of assets to produce sales for both the unadjusted (χ^2=15.24, p<0.01) and the industry-adjusted measure (χ^2=13.99, p<0.01) from the high- to low-demand period. According to the DuPont Model, a firm's return on assets can be represented by its return on sale multiplied by its efficiency of using assets to produce sales (NI/AT =NI/Sale × Sale/AT). Thus, the change of NI/AT can result from changes in NI/Sale and/or changes in Sale/AT. Our evidence suggests that the significant decline in defense firms' median return on assets, as reported in Table 3, Panel A, can be mainly attributable to deterioration in their efficiency of using assets to produce sales since there is no significant change in defense firms' median return on sales. For a firm's efficiency of using plant assets to produce sales, we found no significant change in the median. For efficiency of employee to produce sales, the median defense firms improved from $139.37 thousand to $166.43 thousand for unadjusted measure (χ^2=32.72, p<0.01) over the period. For industry-adjusted efficiency of employee to produce sales, however, the defense firms experienced no significant change in the median (χ^2=0.81, n. s.). The results are similar for efficiency of employee to produce income. The results indicate that although defense firms improved their employee efficiency to produce sales and income over the period, the improvement was not better than what were achieved by their peer firms operating in the respective industries. Our evidence suggests that the defense firms in general cut their capital investments and workforce to adapt to the substantially lower demand for their defense products. But some of them might have not shrunk

TABLE 3
RESULTS FOR MEDIAN TESTS

Panel A:

Variables	High-demand (median)	Low-demand (median)	Median Tests ($\chi 2$)
Profitability			
Return on Sale (NI/SALE)	n=326	n=282	
Unadjusted	0.0417	0.0433	0.24
Industry-Adjusted	0.0127	0.0109	0.60
Return on Assets (NI/AT)	n=326	n=282	
Unadjusted	0.0578	0.0477	5.24**
Industry-Adjusted	0.0229	0.0057	20.74***
Total Asset, Sale, and Government Sale	n=326	n=282	
Total Assets (AT)[b]	4185.1	3916.9	0.03
Total Sale (SALE)[b]	4936.2	4351.9	1.30
Government Sale (GovSal)[b]	1416.4	681.01	30.58***
Government Sale/Total sale (GovSal/SALE)	0.3740	0.2090	16.53***
Employment	n=322	n=281	
Number of employees (EMP)	37966	28500	2.94*
Financial flexibility			
Debt leverage (DT/AT)	n=326	N=280	
Unadjusted	0.1780	0.2076	5.20**
Industry-Adjusted	-0.0388	-0.0095	4.49**
Financial resources (CHE/AT)	n=326	n=282	
Unadjusted	0.0492	0.0474	0.11
Industry-Adjusted	-0.0200	-0.0322	5.19**
Capital Intensity			
PPENT/AT	n=326	n=282	
Unadjusted	0.2873	0.2425	9.55***
Industry-Adjusted	0.0591	0.0413	5.19**
CAPX/SALE	n=322	n=278	
Unadjusted	0.0488	0.0390	18.12***
Industry-Adjusted	0.0073	0.0004	8.96***

Panel B:

Variable	High-demand (median)	Low-demand (median)	Median Tests ($\chi 2$)
Operating Efficiency			
Asset Efficiency (SALE/AT)	n=326	n=282	
Unadjusted	1.3407	1.1847	15.24***
Industry-Adjusted	0.0709	-0.0739	13.99***
Plant Asset Efficiency (PPENT/AT)	n=326	n=282	
Unadjusted	4.4246	4.6394	0.66
Industry-Adjusted	-0.5136	-0.6939	1.30
Employee Sale Efficiency (SALE/EMP)[a]	n=322	n=281	
Unadjusted	139.37	166.43	32.72***
Industry-Adjusted	9.2938	12.398	0.81
Employee Profit Efficiency (NI/EMP)[a]	n=322	n=281	
Unadjusted	5.6051	6.7573	6.41**
Industry-Adjusted	1.7122	1.6583	0.01
R&D Intensity			
R&D/AT	n=288	n=255	
Unadjusted	0.0421	0.0301	9.60***
Industry-Adjusted	0.0051	-0.0038	10.21***
R&D/SALE	n=288	n=255	
Unadjusted	0.0323	0.0254	5.81**
Industry-Adjusted	0.0067	-0.0036	11.26***
R&D/S&GA	n=275	n=235	
Unadjusted	0.2040	0.1829	4.93**
Industry-Adjusted	0.0582	0.0389	4.17**

*, **, *** represent significance level 10%, 5%, and 1%, respectively.

a. Employee sale and profit efficiency variables are in thousands of 1998 constant dollar.

b. Amounts of total sale and government sale are in millions of 1998 constant dollar.

sufficiently. Given the evidence of no significant change in median net sales and total assets from the high demand to the low demand period in spite of a significant decline in defense sales (refer to Table 3, Panel A), the results suggest that many manufacturing defense firms responded to defense product demand declines by partially shifting or diversifying their resources to commercial business. Being successful with the commercial markets requires defense firms to utilize new skills such as marketing and sales. And relative to commercial firms, defense firms tend to have high cost structures and low operating efficiencies due to longtime serving the government. Therefore, defense firms, in the process of

commercialization or diversification, could be forced to enter unfamiliar territories, and suffer lower efficiency and profitability (Lundquist, 1992; Anand and Singh, 1997).

Evidence for Testing the Hypotheses

Results from Median Tests

Following prior studies (e.g., Hitt et al. 1996; Lev and Sougiannis 1996), we use R&D intensity as a proxy for R&D investments for innovations, which is generally measured as reported R&D expenses divided by net sales of a firm.[2] Large fluctuations of a firm's net sales could result in substantial variations in the measure of R&D divided by total sale, which does not necessarily represent significant changes in R&D activities. To mitigate potential bias from this, we also examined two additional variables for a firm's R&D intensity: reported R&D expenses divided by total assets and R&D expenses divided by selling and administrative expenses. A firm's total assets are generally more stable than its net sales. Selling and administrative expenses of a firm are usually more stable than its net sales due to the short-term "stickiness" of these expenses. The results of median tests are reported in Table 3, Panel B. From the high-demand to the low-demand period, the median of R&D over net sales (R&D/SALE) significantly decreased from 0.0323 to 0.0254 for the unadjusted measure ((χ^2=5.81, p<0.05), and from 0.0067 to -0.0036 for the industry-adjusted measure ((χ^2=11.26, p<0.01). The median of R&D expenses scaled by total assets (R&D/AT) also declined over the period, and the decline was significant for both the unadjusted (χ^2=9.60, p<0.01) and the industry-adjusted measure ((χ^2=10.21, p<0.01). The median of R&D scaled by selling and administrative expenses also declined over the period. The decline is significant for both the unadjusted (χ^2=4.93, p<0.05) and the industry-adjusted measure (χ^2=4.17, p<0.05). In summary, the above results indicate a significant decline in R&D intensity for the defense firms from the high demand (1984-1989) to the low demand period (1993-1998). These results are consistent with our H1a, "*the inhibiting view*" that the decline in defense product demand over the period in general undermined the defense firms' ability to innovate through investments in research and development.

Results from Multivariate Regression Analyses

The preliminary evidence from the median tests suggests that decline in defense product demand significantly undermined defense firms' R&D investments. In the following section, we employ multivariate regression analysis to examine the effects of defense product demand decline on the defense firms. In the regression analysis, we included a control group of Compustat firms that had the same first two digits of SIC industry codes with our sample defense firms but reported no sales to the government in 1989. The control group is used to control for the change in R&D intensity due to confounding factors common to the respective industries in which the sample defense firms operate. The following regression model is employed:

$$\text{Dependent Variable} = \beta_0 + \beta_1 \text{Post} + \beta_2 \text{Post*Control} + \beta_3 \text{Control} + \beta_4 \text{ Defense Dependence} + \beta_5 \text{Industry} + \beta_6 \text{Sale} + \varepsilon \quad (1)$$

where ε is a random error term.

Dependent variables are the three variables for R&D intensity (R&D/AT, R&D/Sale and R&D/S&GA). *Post* is a dummy variable equal to 1 if the observation is in the low-demand period (1993 to 1998); it equals 0 for the high demand period (1984 to 1989). Control is a dummy variable which equals 0 if the observation is one of our sample defense firms; otherwise, it equals 1. R&D intensity for a firm's defense business could be systematically different from that for its commercial business (Lichtenberg, 1987). Thus, Defense dependence, which is measured as a firm's sales to the government scaled by its total net sale, is included to control the degree to which a firm depends on defense business for its total sales. Industry variable, measured based on a firm's first two digits of SIC code, is used to control the effect of industry characteristics on R&D intensity. Sale variable (in constant 1998 dollars) is included to control size effects. The definitions of the variables are included in Table 2. The coefficient of

the *Post* variable indicates the difference in R&D intensity from the high demand (1984-1989) to the low demand period (1993-1998) for the sample defense firms. The coefficient of the *Control* variable indicates the difference between the sample defense firms and non-defense firms in the control group for the high demand period. The coefficient of the interaction term *Post*×*Control* indicates the difference between the sample defense firms and non-defense control firms in the change of R&D intensity from high demand to low demand.

Our sample defense firms tend to be relatively large in sizes. The minimum values of total assets and net sales are 97 million and 260 million, respectively (both in 1998 constant dollars). The non-defense firms with the same first two digits of SIC codes in the control group include many firms of small sizes. To improve the comparability of the sample defense firms and the control group, we exclude the observations with total assets and net sales smaller than 97 million and 260 million (in 1998 constant dollars), respectively. Different from median test, regression analysis is subject to the influence of extreme values. Thus, we trimmed the largest 3% of the three R&D intensity variables to address the undue effect of extreme values in the dependent variables.

TABLE 4
REGRESSION ESTIMATIONS RESULTS FOR TESTING THE HYPOTHESES [a]

	R&D Intensity		
Dependent Variables	R&D/AT	R&D/SALE	R&D/S&GA
Independent Variables	Coeff.	Coeff.	Coefficients
	(t-stat.)	(t-stat.)	(t-stat.)
Constant	0.0465***	0.0392***	0.2048***
	(12.33)	(10.49)	(16.92)
Post	-0.0119***	-0.0073**	-0.0197*
	(-3.56)	(-2.18)	(-1.78)
Post × Control	0.0173***	0.0135***	0.0419***
	(4.90)	(3.84)	(3.60)
Control	-0.0133***	-0.0090***	-0.0422***
	(-3.94)	(-2.69)	(-3.89)
Defense Dependence	-0.0116**	-0.0228***	0.0522***
	(-2.12)	(-4.21)	(2.85)
SALE[b]	0.0002***	0.0002***	0.0019***
	(3.07)	(4.86)	(10.99)
Industry	Yes	Yes	Yes
Adjusted R^2	0.010	0.017	0.049
F-Statistics	9.54***	15.70***	42.04***
N	5060	5060	4768

*, **, *** represent significance level 10%, 5%, and 1%, respectively.
a. We exclude the observations in the largest 3% of the respectively R&D intensity variables to address the potential undue influence of extreme values.
b. in billions of 1998 constant dollars

Table 4 reports the results for the regression tests. For the R&D intensity variables (R&D/AT, R&D/SALE and R&D/S&GA), the coefficients for the *Post* variable are significantly negative (t= –3.56, –2.18, and –1.78; significant at 1%, 5%, and 10% level, respectively). The results indicate that the sample defense firms experienced a significant decline in R&D intensity from the high demand (1984-1989) to the low demand period (1993 to 1998). The coefficients for the *Control* variable are significantly negative for all the three dependent variables at 1% level. The results suggest on average the sample defense firms have higher R&D intensity than the non-defense firms. The coefficients for Post×Control are significantly positive (t=4.90, 3.84, and 3.60, respectively; all significant at 1% level), which indicates that change in R&D intensity is significantly more negative for sample defense firms than that for the non-defense firms in the control group. Further examination (not reported in the table) indicates that for the non-defense firms in the control group, the coefficients of the *Post* variable (coeff.=0.0054 for R&D/AT, 0.0062 for R&D/SALE, and 0.0222 for R&D/XSGA) are significantly positive (t=4.84, 5.60, 6.10, respectively; all significant at 1% level). The results suggest that the non-defense firms in the control group actually experienced significant increases in R&D intensity over the period of 1984 to 1998, which is consistent with the general trend of increasing knowledge-orientation for U.S. economy. In summary, the evidence above suggests that declined demand in defense products significantly undermined defense firms' investments in R&D for innovations, which is consistent with our H1a, the "inhibiting view" and inconsistent with the competing "stimulating view".

CONCLUSIONS AND IMPLICATIONS

This study investigated the effects of product demand declines subsequent to the end of the Cold War on defense firms' profitability, financial flexibility, capital intensity, operating efficiency, and R&D intensity. We found that from the high demand (1984-1989) to the low demand period (1993 to 1998), defense firms in general experienced a substantial decline in profitability as measured by return on assets, which could be attributable to their lower efficiency of using assets to produce sales for the low demand period. The challenging environment faced by the defense firms also put some stress on their financial flexibility. As a response to the declined defense product demand, the defense firms downsized their capital investments and workforce. However, we also found that defense firms, although they experienced significant declines in sales to defense markets, generally managed to maintain their size in terms of total assets and net sales by diversifying into commercial markets or shifting their sources to their existing commercial business. Consistent with Dial and Murphy (1995), our evidence suggests that a significant portion of defense firms might not have downsized and restructured sufficiently, which might be at the sacrifice of profitability and operating efficiency.

We also found that defense firms in general experienced a significant decline in R&D intensity from the high demand (1984-1989) to the low demand period (1993-1998). This trend is in contrast with their respective industry non-defense peers which experienced a significant increase in R&D intensity over the period as the U.S. economy has become increasingly intellectual oriented. Our results suggest that the declines in defense product demand significantly undermined the defense firms' motivation and capacity to investing in R&D for technological innovations. The *inhibiting view* in the organization decline literature could better explain defense firms' responses to product demand decline than *the stimulating view*. As pointed out by Harbison, Moorman, Jones, and Kim (2000), the substantial lowered demand for defense products lead to a risky consequence for defense industry --- "the industry is eating its 'seed corn' in terms of reinvesting in innovations". Given the high importance of R&D innovations to the national security of the U.S. (Rogerson 1989), this might have produced undesired effects.

Defense industry is highly regulated with only one major buyer which is also the regulator: the Department of Defense. The contingency framework developed by Mone, McKinley, and Barker (1998) suggests that the effect of product demand decline on innovations depends on the institutions in which a company operates. Firms in regulated industries could face legal and political constraints that limit managers' capacity to seek innovative solutions. Regulations could also motivate firms in the regulated industries, especially defense industry, to compete in alternative ways such as active lobbying. This

potentially undermines defense firms' incentive to cope with the declining product demand through innovations and improving operating efficiency.

ENDNOTES

1. We treat all the sales to the government as defense sales since defense sales account for the majority portion of all the sales to the U.S. government for the firms in the list of index (Lichtenberg, 1992; McGowan and Vendrzyk, 2002).
2. The reported R&D expenses do not include R&D expenditures funded by a firm's customers including the Department of Defense.

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APPENDIX

SAMPLE DEFENSE FIRMS OF 1989

	Company Name	Primary SIC Code
1	ALLEGHENY TECHNOLOGIES INC	3724
2	ALLIANT TECHSYSTEMS INC	3480
3	ARVIN INDUSTRIES INC	3714
4	AVONDALE INDUSTRIES INC	3730
5	BOEING CO	3721
6	CBS CORP	3585
7	CERIDIAN CORP	3571
8	COMPUTER SCIENCES CORP	7373
9	CONTEL CORP	4813
10	CORDANT TECHNOLOGIES INC	3760
11	CRAY RESEARCH	3571
12	DIGITAL EQUIPMENT	3570
13	DIRECTV GROUP INC	3812
14	DYNCORP INC	8744
15	E-SYSTEMS INC	3812
16	EATON CORP	3714
17	FMC CORP	2800
18	GENCORP INC	3760
19	GENERAL DYNAMICS CORP	3721
20	GENERAL ELECTRIC CO	3600
21	GRUMMAN CORP	3721
22	HARRIS CORP	3663
23	HARSCO CORP	3440
24	HENLEY GROUP INC/DEL	3821

25	HERCULES INC	2821
26	HONEYWELL INC	3822
27	HONEYWELL INTERNATIONAL INC	3724
28	INTL BUSINESS MACHINES CORP	3570
29	KAMAN CORP -CL A	5080
30	LITTON INDUSTRIES INC	3812
31	LOCKHEED MARTIN CORP	3760
32	LOGICON INC	7371
33	LORAL CORP	3812
34	LTV AEROSPACE & DEFENSE CO	3728
35	LTV CORP	3312
36	MARTIN MARIETTA CORP	3760
37	MCDONNELL DOUGLAS CORP	3721
38	MORRISON KNUDSEN CORP OLD	1540
39	MOTOROLA INC	3663
40	NORTH AMERICAN PHILIPS CORP	3640
41	NORTHROP GRUMMAN CORP	3721
42	OLIN CORP	2800
43	OSHKOSH TRUCK CORP	3711
44	PERKINELMER INC	8711
45	RAYTHEON CO	3812
46	ROCKWELL AUTOMATION	3760
47	SCIENCE APPLCTNS INTL	8700
48	SEQUA CORP -CL A	3724
49	SUNDSTRAND CORP	3728
50	TENNECO AUTOMOTIVE INC	3523
51	TEXAS INSTRUMENTS INC	3674
52	TEXTRON INC	3720
53	TRACOR INC	3728
54	TRW INC	3760
55	UNISYS CORP	3570
56	UNITED TECHNOLOGIES CORP	3724