Online Appendix

This document provides further discussion on the variability of government dependency between segments within a conglomerate, its impact on cross-subsidization, and the valuation consequences in the stock market. We also further discuss the choice between defense spending and non-defense spending, and present additional figures and tables referred to in the paper.

A.1 Government Dependency Diversity and Cross-Subsidization

In our Model (3), we evaluate a segment's OWN_GD without consideration for the other segments within the firm. Following Rajan, Servaes, and Zingales (2000), we define the diversity of a firm as the standard deviation of segment-sales weighted government dependency for the firm. With the diversity measure, we can distinguish between conglomerates that, for example, have two segments both with high OWN_GD compared to another conglomerate with two segments, one with high OWN_GD and one with low OWN_GD. To visualize the role of diversity in driving the investment sensitivity to government spending shocks, we split all segment-years in multi-segment firms into two groups: segment-years in low diveristy firms and those in high diversity firms, where high diversity and low diversity are defined relative to the sample median. We draw a graph similar to Figure 1 for each group and present them in Figure A1. Panel A of Figure A1 shows that among segments in low diversity firms, the investment differences between high government spending years and low government spending years generally increase as government dependency increases. Moving to segments in high diversity firms, we show that the upward trend there is moderate as illustrated by Panel B of Figure A1.

We further use a more parametric approach to quantify the visual differences in Figure A1. Specifically, we estimate Model (2) for high diversity firms and low diversity firms respectively, where high (low) diversity firms are firms with diversity higher (lower) than the sample median. Standard errors are clustered at the firm level.

The regression results are presented in Table A2.[1] In Columns 1 and 3 (2 and 4), segment investment is regressed on the interaction of government dependency and government spending for low (high) diversity firms. The coefficient on the interaction term is positive and statistically significant in low diversity firms, whereas it turns negative and statistically significant in high diversity firms. In the last two rows of Table A2, we test the statistical significance of differences in coefficients across regressions, and the results are also highly significant. These results indicate that the investment of segments in high diversity firms is less sensitive to government spending shocks than that in low diversity firms, consistent with what Figure A1 shows. Taking the estimates in Columns 1 and 2 for example, when GOVSPEND increases from 3.4% to 3.8% (an interquartile change), the impact of government dependency on investment in low diversity firms goes from -0.298 (-2.302+3.4×0.590 and t value -1.66) to -0.062 (-2.302+3.8×0.590 and t value -0.40), for a difference of 0.236 (0.4×0.590 and t value 3.88). For the same increase in government spending, the impact in high diversity firms goes from 0.053 (0.431-3.4×0.111 and t value 0.98) to 0.008 (0.431-3.8×0.111 and t value 0.17), for a difference of -0.044 (-0.111×0.4 and t value -1.92). The difference between the impact in high diversity firms and that in low diversity firms is -0.280 (-0.4×0.701 and t value -4.37). This sharp difference highlights the role of a firm's diversity in driving the investment behavior of segments within the firm. The evidence that segments in high diversity firms exhibit substantially lower investment sensitivity to government spending shocks suggests that more government dependent segments do not benefit as much from positive government spending shocks because the headquarter diverts some of the gains to other segments within the firm, which lends further support to the notion of cross-subsidization. Moreover, the fact that segments in low diversity firms behave similarly to stand-alone firms substantiates the ex ante uniformity of government

[1] We present results using triple interactions in Table A3, and the results are robust.

spending shocks between stand-alone firms and conglomerates.[2]

A.2 Government Dependency Diversity and Firm Valuation

In this section, we explore the valuation impact among different types of multi-segment firms. In particular, we are interested in one dimension along which multi-segment firms differ from each other: the variability of government dependency within a conglomerate (i.e., *diversity* from Section A.1). We have shown that high diversity multi-segment firms are more likely to engage in cross-subsidization when government spending increases in the above section. Therefore, if cross-subsidization indeed destroys firm value, high diversity firms are expected to experience a larger drop (or a smaller increase) in valuation for the same degree of government spending shocks. We test this hypothesis using the following regression model:

$$
\begin{aligned}
(A1) \qquad & \mathrm{DEPENDENT}_{\mathrm{i,t}} \\
& = \alpha_i + \delta_t + \beta_1 \mathrm{FIRM\_GD}_{\mathrm{i}} \times \mathrm{GOVSPEND}_{\mathrm{t-1}} \times \mathrm{HIGH\_DIVERSITY}_{\mathrm{i,t}} \\
& + \beta_2 \mathrm{FIRM\_GD}_{\mathrm{i}} \times \mathrm{HIGH\_DIVERSITY}_{\mathrm{i,t}} + \beta_3 \mathrm{GOVSPEND}_{\mathrm{t-1}} \times \mathrm{HIGH\_DIVERSITY}_{\mathrm{i,t}} \\
& + \beta_4 \mathrm{FIRM\_GD}_{\mathrm{i}} \times \mathrm{GOVSPEND}_{\mathrm{t-1}} + \beta_5 \mathrm{HIGH\_DIVERSITY}_{\mathrm{i,t}} + \varepsilon_{i,t},
\end{aligned}
$$

where i indexes firms and t indexes years. The dependent variable is either the natural logarithm of firm i's Q ratio in year t or the excess value of firm i in year t. $\mathrm{HIGH\_DIVERSITY}_{i,t}$ is a dummy variable indicating whether the diversity of firm i in year t is above the sample median, and other variables are defined in the same way as those in Model (5).

[2] While the evidence presented in the paper supports an explanation of cross-subsidization, it could also be driven in part by the possibility that segments in stand-alone firms and those in multi-segment firms are fundamentally different. For instance, in the context of investment opportunities, Whited (2001) notes that segment Q may be a better proxy for stand-alone firms than they are for conglomerate divisions. Our measure of government dependency is based on the type of products produced by an industry that are consumed by the government, thus less subject to the above issue. Nevertheless, we alleviate this concern by examining the heterogeneity among multi-segment firms with these tests. Theories on both sides in the literature stress the role of diversity in driving resource transfer within the firm. For instance, the efficient internal capital market models argue that headquarters have the option to reallocate resources from divisions with lower investment opportunities to divisions with higher investment opportunities. An increase in the diversity increases the value of this option and therefore should increase the amount of resource transfer within the firm. By contrast, the cross-subsidization models argue that large investment inefficiencies are most likely to occur when there is a pronounced differential in divisions' investment opportunities.

Standard errors are clustered at the firm level.

The results of Model (A1) are reported in Table A4. In Columns 1 and 4, we show that on average high diversity firms have higher Q and excess value. In Columns 2 and 5, we regress measures of firm value on the interaction of firms' government dependency and the level of government spending. The coefficient on the interaction term therefore captures the valuation impact of government spending shocks. β_4 in Column 2 is positive and statistically significant, indicating that firms with higher government dependency enjoy a larger increase in valuation when government spending increases. The economic magnitude is nontrivial. For a one-standard-deviation increase in government spending, the value of firms that sell 10% more of their products to the government increases by 12% more. In contrast, β_4 is negative and statistically insignificant in Column 5, suggesting that the excess value of firms does not increase for the same degree of government spending shock. This complements the results in Column 4 of Table 7 because the excess value for stand-alone firms is zero on average by construction. The contrast between Column 2 and Column 5 reveals that when government spending increases, the beneficial role of government dependency diminishes once multi-segment firms are benchmarked against a portfolio of comparable stand-alone firms in the same industries. In Columns 3 and 6, we further interact FIRM_GD and GOVSPEND with the high diversity indicator of a firm. The coefficient on the triple interaction term, β_1, therefore captures the valuation differences between high diversity firms and low diversity firms in the presence of government spending shocks. Across both specifications, β_1 is negative and statistically significant, providing support for our hypothesis that high diversity firms experience a smaller increase in valuation when government spending shocks intensify. The economic comparison of the valuation impact in high diversity versus low diversity firms is striking. Based on the estimates in Column 3, for a one-standard-deviation increase in government spending, the value of low diversity firms that sell 10% more of their products to the government increases by 20.3%

more (4.055×0.5×10%). However, for the same increase in government spending, the value of similar high diversity firms only increases by 2.1% (4.055×0.5×10%-3.632×0.5×10%) more. Using excess value as the dependent variable in Column 6 reveals a similar pattern. The valuation impact of government spending shocks on low diversity firms is similar to that on a portfolio of stand-alone firms, as manifested by the insignificance of β_4 in Column 6. These results demonstrate that the valuation inferiority of multi-segment firms to stand-alone firms brought about by government spending shocks mainly comes from high diversity firms.

A.3 Defense Spending and Non-defense Spending

We use different definitions of government spending to conduct our analyses. The starting point of our analysis in the paper is that industries that are more reliant on government increase their investment when government spending increases. We first use different versions of government dependency and government spending to examine this starting point. In Table A5, we construct two other versions of government dependency and government spending: In Columns 1 and 2, we use defense spending; in Columns 3 and 4, we use total spending. As evident in Table A5, industries that are more reliant on defense spending do not increase their investment when defense spending increases. This is our motivation for not using defense spending in the paper.

Of course, it is somewhat puzzling why defense firms are not more sensitive to defense spending. We conjecture that two factors may contribute to this. First, most of the time-series variation in defense spending may come from expenditures related to weapons manufacturing. Using the top 100 defense contractors from 1980 to 1995, Goyal, Lehn, and Racic (2002) show that the sales of weapon manufacturers to the government increased significantly during the Reagan defense buildup of the early 1980s and declined substantially with the end of the cold war. However, during the same time period, the sales of top defense contractors that are not

weapon manufactures to the government barely changed. This contrast is clearly displayed in their Figure 3. However, we cannot separate an industry's dependency on weapon spending from its dependency on defense spending in general using the BEA input-output tables.

To better illustrate the issue, we first select nine most prominent weapon manufacturers from the top 100 defense contractors from 2006 to 2016 (a firm needs to appear at least in five years from 2006 and 2016 to be selected).[3] We then select nine defense contractors that are clearly not related to weapons manufacturing. Lastly, we randomly select nine firms from S&P 500 as the control group. These firms are listed in Table A6. We then examine how our defense spending measure (defined as defense outlays in the previous year scaled by GDP in the previous year) affects the investment of each group of firms. We present the results in Table A7. In Column 1, we only include weapon firms and S&P 500 firms. The coefficient on the interaction term is positive and significant, indicating that relative to S&P 500 firms during the same time period, weapon manufacturers significantly increase their investment when defense spending increases. However, the same pattern is not observed in the sample consisting of non-weapon firms and S&P 500 firms, as evidenced by the insignificant coefficient on the interaction term in Column 2. These results are largely consistent with Goyal, Lehn, and Racic (2002). For example, in their Table 1, they show that weapon manufacturers reduce their investment in the presence of defense spending reduction from late 1980s to early 1990s, while non-weapon manufacturers barely change their investment during the same period. In Column 3, we include both weapon manufacturers and non-weapon manufacturers in the same regression, and the results suggest that when defense spending increases, weapon manufacturers invest significantly more than non-weapon manufacturers.

Second, the weapon manufacturing industry is usually dominated by a few very large

[3] The top 100 contractors are only available on fpds.gov from 2006 onward.

firms. Therefore, although each weapon manufacturer (prominent examples in Column 1 of Table A6) takes a large portion of defense contracts, they are treated equally as those non-weapon manufacturers that only supply a small portion of defense contracts in the regression. In other words, the majority of our firm-years may not change their investment significantly when defense spending increases (because they are not weapon manufacturers). Hence, defense spending is not useful for studying the main hypotheses of the paper.

References

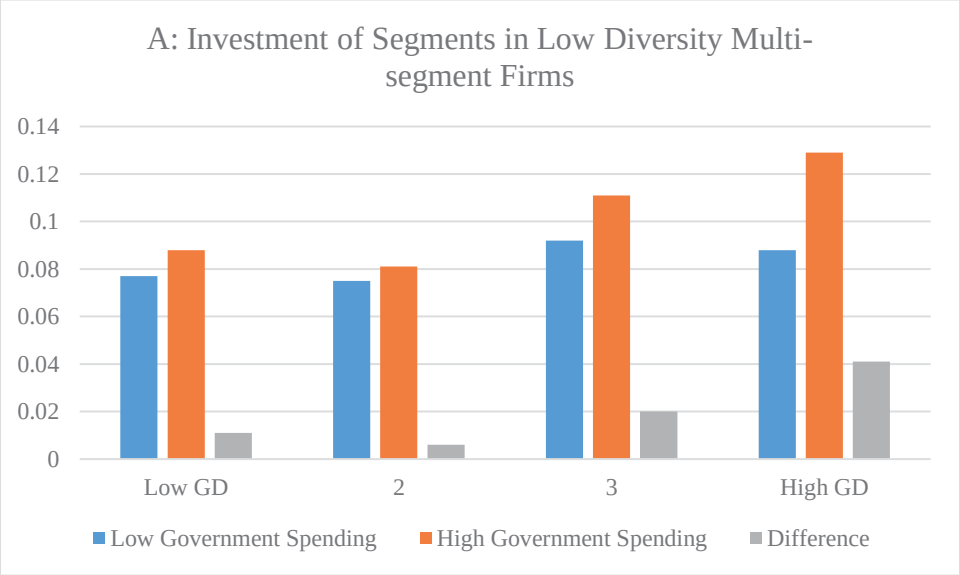
Goyal, Vidhan K., Kenneth Lehn, and Stanko Racic. "Growth opportunities and corporate debt policy: the case of the US defense industry." *Journal of financial economics* 64, no. 1 (2002): 35-59.

Rajan, Raghuram, Henri Servaes, and Luigi Zingales. "The cost of diversity: the diversification discount and inefficient investment." *The Journal of Finance* 55.1 (2000): 35-80.

Whited, Toni M. "Is it inefficient investment that causes the diversification discount?." *The journal of Finance* 56.5 (2001): 1667-1691.

Figure A1: Investment of Segments in Low Diversity versus High Diversity Multi-segment Firms

The y axis represents segment investment rates, where investment is defined in Table 1. The x axis represents the level of government dependency (GD) broken down into quartiles, where GD is defined in Table 1. Low Government Spending denotes years in which GOVSPEND in the previous year is lower than the 75th percentile; High Government Spending denotes years in which GOVSPEND in the previous year is higher than the 75th percentile. GOVSPEND is defined in Table 1.



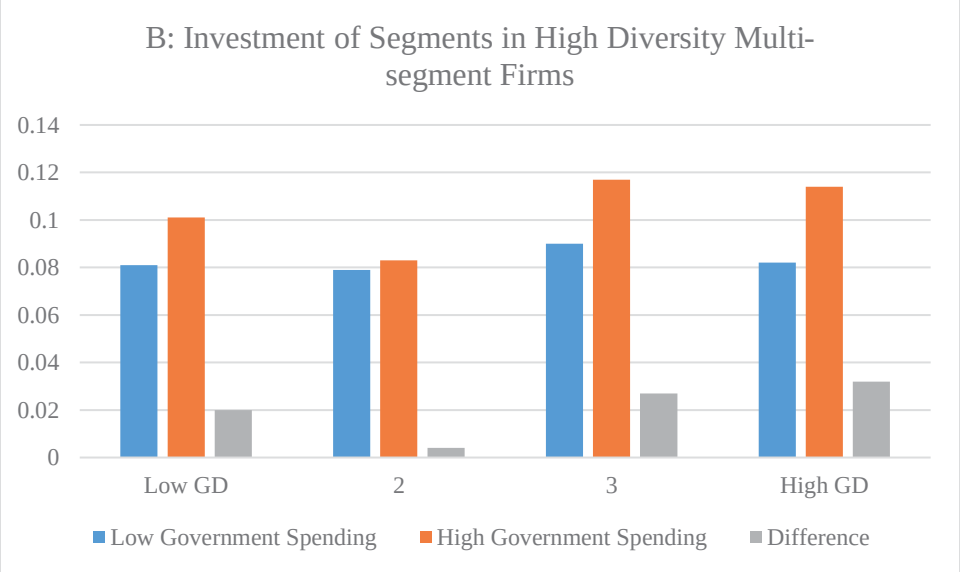


Table A1: Government Dependency of Selected Industries

This table lists a sample of industries with their government dependency. The data and the industry classifications are from the 2007 Benchmark Input-Output Accounts table.

I-O Code	Industry	Government Dependency
33641A	Propulsion Units and Parts for Space Vehicles and Guided Missiles	0.412
335110	Electric Lamp Bulb and Part Manufacturing	0.224
322230	Stationery Product Manufacturing	0.139
541700	Scientific Research and Development Services	0.137
334220	Broadcast and Wireless Communications Equipment	0.127
541512	Computer Systems Design Services	0.096
335314	Relay and Industrial Control Manufacturing	0.089
334210	Telephone Apparatus Manufacturing	0.073
561200	Facilities Support Services	0.058
334300	Audio and Video Equipment Manufacturing	0.045
332410	Power Boiler and Heat Exchanger Manufacturing	0.031
5416A0	Environmental and Other Technical Consulting Services	0.021
327100	Clay Product and Refractory Manufacturing	0.015
325510	Petrochemical Manufacturing	0.010
311300	Sugar and Confectionery Product Manufacturing	0.000

Table A2: Firm Diversity and Segment Investment Sensitivity to Government Spending Shocks

This table reports the regression results of segment investment on the interaction of OWN_GD and GOVSPEND by separating the sample into low diversity firms and high diversity firms. The dependent variable is segment INVESTMENT. High (Low) Diversity includes firms whose diversity is above (below) the sample median, where diversity is defined as the standard deviation of segment sales-weighted government dependency for the firm. All other variables are defined in Table 1 of the paper. Standard errors are adjusted for clustering at the firm level, and the corresponding t statistics are reported in the parentheses below the coefficient estimates. * denotes significance at 10 percent, ** denotes significance at 5 percent, and *** denotes significance at 1 percent.

	Low Diversity	High Diversity	Low Diversity	High Diversity
	1	2	3	4
	INVESTMENT	INVESTMENT	INVESTMENT	INVESTMENT
OWN_GD × GOVSPEND (a)	0.590***	-0.111*	0.642***	-0.107*
	(3.88)	(-1.92)	(3.84)	(-1.77)
OWN_GD (b)	-2.302***	0.431*	-2.486***	0.411*
	(-3.63)	(1.91)	(-3.68)	(1.76)
SEGMENT_Q			0.003***	0.006***
			(4.96)	(8.63)
Segment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	59,540	60,018	59,256	59,798
R-squared	0.535	0.514	0.538	0.516
High (a) – Low (a)	-0.701***		-0.749***	
	(-4.37)		(-4.26)	
High (b) – Low (b)	2.733***		2.897***	
	(4.10)		(4.08)	

Table A3: Firm Diversity and Segment Investment Sensitivity to Government Spending Shocks

This table reports the regression results of segment investment on the triple interaction of OWN_GD, GOVSPEND, and the diversity indicator of the firm. The dependent variable is segment INVESTMENT. HIGH_DIVERSITY is a dummy variable indicating whether the diversity of the firm is above the sample median, where diversity is defined as the standard deviation of segment sales-weighted government dependency for the firm. All other variables are defined in Table 1 of the paper. Standard errors are adjusted for clustering at the firm level, and the corresponding t statistics are reported in the parentheses below the coefficient estimates. * denotes significance at 10 percent, ** denotes significance at 5 percent, and *** denotes significance at 1 percent.

	1	2
	INVESTMENT	INVESTMENT
OWN_GD × GOVSPEND × HIGH_DIVERSITY	-0.397***	-0.412***
	(-3.26)	(-3.13)
GOVSPEND × HIGH_DIVERSITY	0.003	0.003
	(0.99)	(0.97)
OWN_GD × GOVSPEND	0.341***	0.358***
	(2.96)	(2.86)
OWN_GD × HIGH_DIVERSITY	1.505***	1.551***
	(3.27)	(3.17)
OWN_GD	-1.279***	-1.343***
	(-2.90)	(-2.85)
HIGH_DIVERSITY	-0.011	-0.010
	(-1.06)	(-1.00)
SEGMENT_Q		0.005***
		(10.16)
Segment FE	Yes	Yes
Year FE	Yes	Yes
Observations	122,715	122,206
R-squared	0.494	0.496

Table A4: Cross-subsidization and the Value of Multi-segment Firms

This table reports the regression results of firm value on the triple interaction of FIRM_GD, GOVSPEND, and the diversity indicator of the firm. The dependent variable is the natural logarithm of firm Q in Columns 1 to 3, and excess value in Columns 4 to 6. HIGH_DIVERSITY is a dummy variable indicating whether the diversity of the firm is above the sample median, where diversity is defined as the standard deviation of segment sales-weighted government dependency for the firm. All other variables are defined in Table 1 of the paper. Standard errors are adjusted for clustering at the firm level, and the corresponding t statistics are reported in the parentheses below the coefficient estimates. * denotes significance at 10 percent, ** denotes significance at 5 percent, and *** denotes significance at 1 percent.

	1	2	3	4	5	6
	ln (FIRM_Q)	ln (FIRM_Q)	ln (FIRM_Q)	EXCESS_VALUE	EXCESS_VALUE	EXCESS_VALUE
FIRM_GD × GOVSPEND			-3.632***			-4.443**
× HIGH_DIVERSITY			(-3.06)			(-2.42)
FIRM_GD × HIGH_DIVERSITY			15.217***			17.169**
			(3.32)			(2.51)
GOVSPEND × HIGH_DIVERSITY			0.055***			0.050
			(2.75)			(1.59)
FIRM_GD × GOVSPEND		1.219**	4.055***		-1.257	2.435
		(2.45)	(3.62)		(-1.45)	(1.41)
HIGH_DIVERSITY	0.022***		-0.210***	0.022*		-0.173
	(3.15)		(-2.71)	(1.78)		(-1.44)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35,527	35,527	35,527	36,855	36,855	36,855
R-squared	0.698	0.698	0.698	0.657	0.657	0.657

Table A5: Government Spending Shocks and Segment Investment

This table reports the regression results of segment investment on government spending shocks. The dependent variable is INVESTMENT. In Columns 1 and 2, OWN_GD and GOVSPEND are constructed using defense spending; in Columns 3 and 4, OWN_GD and GOVSPEND are constructed using overall spending. All other variables are defined in Table 1 in the paper. Standard errors are adjusted for clustering at the firm level, and the corresponding t statistics are reported in the parentheses below the coefficient estimates. * denotes significance at 10 percent, ** denotes significance at 5 percent, and *** denotes significance at 1 percent.

	Defense Spending		Total Spending	
	1	2	3	4
	INVESTMENT	INVESTMENT	INVESTMENT	INVESTMENT
OWN_GD × GOVSPEND	0.001	0.000	0.009**	0.008*
	(0.12)	(0.00)	(2.08)	(1.84)
OWN_GD	-0.017	0.007	-0.105	-0.086
	(-0.21)	(0.08)	(-1.45)	(-1.18)
SEGMENT_Q		0.009***		0.009***
		(20.04)		(20.04)
Segment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	239,634	239,002	239,634	239,002
R-squared	0.487	0.490	0.487	0.490

Table A6: Sample Firms Used to Estimate Table A7

This table lists firms that we use to estimate regressions in Table A7. Both weapon contractors and non-weapon contractors are firms that appear at least five times in the top 100 contractors of the Department of Defense from 2006 to 2016. The classification of weapon and non-weapon firms is based on the manual reading of the business description of each firm. The last column lists firms that are randomly selected from S&P 500.

Weapon Contractors	**Non-weapon Contractors**	**S&P 500 Firms**
1	2	3
Boeing	Cardinal	3M
General Dynamics	DXC Technology	ConocoPhillips
General Electric	Fluor	Kimberly-Clark
Honeywell	HP	Lennar
Lockheed Martin	IBM	Lowe's
Northrop Grumman	Jacobs Engineering	Marathon Oil
Raytheon	Royal Dutch	Newmont
Rockwell	URS	Occidental
United Technologies	Valero Energy	P&G

Table A7: Weapon Manufacturers and Non-weapon Manufacturers

This table reports the regression results of firm investment on the defense spending of the federal government from 1978 to 2016. The dependent variable is investment across all three columns. WEAPON is a dummy variable indicating if the firm is a weapon manufacturer; NONWEAPON is dummy variable indicating if the firm is a non-weapon manufacturer; DEFENSE_SPENDING is the level of defense spending in the previous year scaled by GDP in the previous year. The first column includes weapon firms (Column 1 of Table A6) and S&P 500 firms (Column 3 of Table A6); the second column includes non-weapon firms (Column 2 of Table A6) and S&P 500 firms (Column 3 of Table A6); the last column includes weapon firms (Column 1 of Table A6) and non-weapon firms (Column 2 of Table A6). Standard errors are adjusted for clustering at the firm level, and the corresponding t statistics are reported in the parentheses below the coefficient estimates. * denotes significance at 10 percent, ** denotes significance at 5 percent, and *** denotes significance at 1 percent.

Sample Firms	Weapon Firms+ S&P 500	Non-Weapon Firms+ S&P 500	Weapon Firms+Non-Weapon Firms
	1	2	3
	INVESTMENT	INVESTMENT	INVESTMENT
WEAPON × DEFENSE_SPENDING	0.019***		0.012**
	(3.51)		(2.54)
NONWEAPON × DEFENSE_SPENDING		0.007	
		(1.14)	
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	722	699	715
R-squared	0.570	0.520	0.589