CAPABILITY INTERACTIONS AND ADAPTATION TO DEMAND-SIDE CHANGE

Online Supplementary Material

Changes in budgets and solicitations

To understand the implications of the September 11 demand shock for our empirical context (the DoD and the SBIR program), we collected data on DoD agency budgets and SBIR solicitations in the time period before and after September 11. We report changes in DoD budgets in Exhibit 1. As that exhibit shows, following 2001 there was a significant reshuffling among the various DoD agencies with respect to total SBIR funding budget, number of Phase 1s awarded and topic solicitation (technology) areas. Not only was funding redirected across agencies as a result of the shock, but there was a change in topic composition, which resulted from changes in SBIR solicitations put forth by the various DoD agencies.

The most significant change occurred around the time of the 2001 shock, with significant variation across agencies with respect to the magnitude of funding shifts. For example, while funding for Navy awards increased by 26%, funding for awards from the agency dealing with Chemical and Biological Defense increased by 62%.

Next, in Exhibit 2, we replicate Figure 2 Panel B of the paper, which shows a demand shift using slow-growth and fast-growth 1996 keywords. We replicate that analysis using solicitation topics. We see a significant change around 2001, similar to what we see in Figure 2 Panel B of the paper.

Finally, in Exhibit 3, we examine some of the qualitative trends underlying SBIR topic solicitation changes around September 11. Part A reports several direct quotes showing that September 11 had a direct effect on solicitations arising from the DoD. Part B shows that certain areas clearly related to terrorism concerns also saw a very large increase post-September 11. For example, “sensors” increased by 7x and UAV (i.e., drones) by 5x in the two years following September 11. Part C shows that certain topics were *removed* directly as a result of September 11.

Alternative observation windows

We report results using an alternative set of observation windows (see Exhibit 4).

First, we removed 2002 from the sample to reduce noise caused by SBIR awards granted immediately after September 11 (the first two columns). The results are consistent with our main findings (H1, H2, and H3).

Second, we shortened the observation window compared to the 5-year window used in the paper to capture short-term vs. long-term effects of the demand shock. We report three sets of tests:

- 2-year balanced window: 1996-1997(pre) + 2002-2003(post) vs. 1996-1997(pre) + 2005-2006(post). We find that H1, H2, and H3 are strongly supported, although H1 and H2 are slightly weaker in the 1996-1997(pre) + 2005-2006(post) case because of the short-term effect of H1 and H2.

- 3-year balanced window: We compare 1996-1998(pre) + 2004-2006(post) with 1998-2000(pre) + 2002-2004(post). We find that H1, H2, and H3 are strongly supported, though H3 is slightly weaker for extension in the 1998-2000(pre) + 2002-2004(post) case because of the long-term effect of H3.

- Short-term versus long-term: Short-term post-shock (2002-2004) vs. long-term post-shock (2005-2006) with a different pre-shock window (1996-2000 vs. 1999-2000). We find temporal differences. H1 and H2 are stronger in the short-term, but H3 is stronger in the long-term.

Taken together, these robustness tests across a range of observation windows add support to our core findings and also produce additional insights into temporal variation.

Disentangling breadth and depth

We report a set of analyses in which we examine alternative formulations for customer-related capabilities. We begin by disentangling the depth and breadth components of our repeated customer proportion measure, which we use in the main analyses. The numerator of this construct reflects the depth of repeated relationships with existing customers, while the denominator captures the breadth of relationships with all existing customers who have at least one tie with the firm (both repeated ties as well as a single prior tie). To further examine the role of breadth of customer relationships, we treat the numerator and denominator as two separate variables, allowing them to interact with both preference-increased and preference-decreased technological capabilities.

Our results, shown in Exhibit 5, suggest that, consistent with our hypotheses in H1b and H2b, the depth of customer relationships measured by repeated customer count facilitates extension-based adaptation for preference-decreased technological capabilities, but hurts novelty-based adaptation for preference-increased technological capabilities. For example, in Model E5-1, the interaction between preference-decreased technological capabilities and repeated customer count has a positive effect on extension-based adaptation ($\beta = 0.338$, $p=0.029$), while in Model E5-2 the interaction between preference-increased technological capabilities and repeated customer count has a negative effect on novelty-based adaptation ($\beta = -0.638$, $p=0.000$).

For the breadth of customer relationships (measured by total pre-shock customers), we see that high breadth hurts extension-based adaptation for preference-decreased technological capabilities, supporting H1b: as Model E5-1 shows, the interaction between preference-decreased technological capabilities and total customer count is negative ($\beta = -0.550$, $p=0.001$). This may be because firms with preference-decreased technological capabilities have limited resources and attention to manage a broader range of customers due to the need to balance declining and growing demand from different customers (Laursen & Salter, 2006; Leiponen & Helfat, 2010; Yli-Renko, Autio & Sapienza, 2001). On the other hand, high breadth facilitates novelty-based adaptation for preference-increased technological capabilities, further supporting H2b: as Model E5-2 shows, the interaction between preference-increased technological capabilities and total customer count is positive (β = 0.567, p=0.000). This may be because higher breadth enables more flexible routines and encourages experimentation with new partners.

Customer disaggregation analysis

Our next set of analyses allows us to develop greater insight into whether the enabling or constraining effects of repeated customer relationships occur with respect to the focal customer. In our main analyses we use a portfolio-based measure (repeated customer proportion), which allows us to parsimoniously include both depth and breadth in a single measure. In contrast with that portfolio-level measure, in Exhibit 6 we restructure our data at the firm-customer-year level (in contrast with the firm-year level of analysis). For the independent variable in this case we use the continuous measure of tie count with the respective customer, allowing us to further understand the depth of the relationship with the focal customer in question. Likewise, the dependent variable is measured as awards received from the same customer.

Our results, reported in Exhibit 6, are consistent with the pattern of results in our main tables: in Model E6-1 the interaction between preference-decreased technological capabilities and the number of relationships with the focal customer is positive for extension-based adaptation (β = 0.043, p=0.000), and in Model E6-2 the interaction between preference-increased technological capabilities and the number of relationships with the focal customer is negative for novelty-based adaptation (β = -0.038, p=0.000). In addition, the interaction between preference-decreased and preference-increased technological capabilities is positive for both extension-based adaptation (β = 0.317, p=0.000) and novelty-based adaptation (β = 0.176, p=0.000).

Degree of prior customer interaction when measuring customer depth

In a final analysis we further examine alternative formulations of the repeated customer relationships measure. We continue with the disaggregated analysis at the individual customer-level reported in Exhibit 6. In the Exhibit 6 models we did not consider potential differences between a single prior tie and multiple prior ties with the focal customer. Moreover, in our portfolio-level analyses we did not explicitly capture the effects of having customers with a single prior tie. Yet there may be important insights to be gained when comparing the effects of a single pre-shock relationship with multiple pre-shock relationships. Accordingly, in Exhibit 7 we break the number of ties with the focal customer into zero-ties, a single tie, and repeated-ties (in other words, where the number of pre-shock ties is greater than 1). As the results in Exhibit 7, Model E7-1, illustrate, consistent with H1b, both single-tie customer relationships (β = 0.287, p=0.000) and repeated-tie customer relationships (β = 0.386, p=0.000) exert stronger effects (via their interaction with preference-decreased technological capabilities) on extension-based adaptation as compared to zero-tie relationships (this is the omitted category), with the effect stronger for repeated-ties as compared to single-ties.

With respect to the implications of the analysis in Exhibit 7 for H2b, we see in Model E7-2 that the negative effect of prior customer relationships (via their interaction with preference-increased capabilities) in hindering novelty-based adaptation occurs only for the case of repeated ties where pre-shock ties are greater than one (β = -0.098, p=0.004), and not for the case in which the firm has a single pre-shock tie with the customer in question (β = -0.023, p=0.573). This suggests that in order for repeated customer relationships to result in a negative novelty-based adaptation effect for firms with preference-increased technological capabilities, there is minimum threshold of having more than one pre-shock relationship, as there is no difference between a single-tie and zero-ties in this constraining effect.

Keywords from topic modeling

In Exhibit 8 we report the final list of keywords we obtain from our topic modeling approach, as described in the manuscript (section "Customer preference shifts").

References

Laursen, K., & Salter, A. 2006. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. ***Strategic Management Journal***, 27(2): 131-150.

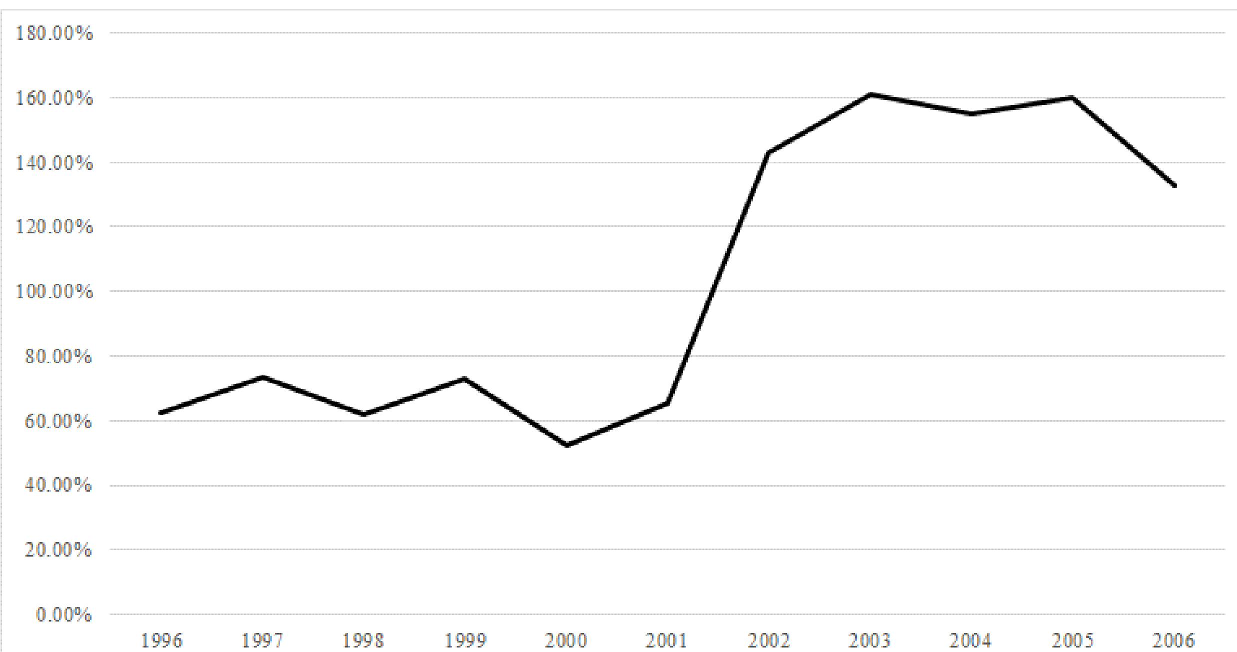
Leiponen, A., & Helfat, C. E. 2010. Innovation objectives, knowledge sources, and the benefits of breadth. ***Strategic Management Journal***, 31(2): 224-236.

Yli-Renko, H., Autio, E., & Sapienza, H. J. 2001. Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. ***Strategic Management Journal***, 22(6-7): 587-613.

<u>Exhibit 1</u>. Budgets and SBIR topic solicitations of selected DoD agencies

Panel A: Funding (amount)	1999	2000	2002	2003	2000 vs. 1999	2002 vs. 2000	2003 vs. 2002
Army	$105,853,000	$109,500,000	$151,473,000	$169,002,000	3%	38%	12%
Navy	$111,892,700	$125,433,300	$157,912,800	$196,624,000	12%	26%	25%
Air Force	$192,622,248	$184,792,000	$212,030,994	$264,217,520	-4%	15%	25%
DTRA	$5,586,000	$5,816,820	$6,474,371	$4,914,3%000	4%	11%	-24%
MDA	$56,650,943	$56,449,057	$136,889,000	$129,122,450	-0.4%	143%	-6%
CBD	$5,319,000	$5,602,000	$9,100,000	$9,070,000	5%	62%	-0.3%
Panel B: Phase 1 (count)							
Army	197	198	283	352	1	85	69
Navy	406	213	573	551	-193	360	-22
Air Force	416	367	427	449	-49	60	22
DTRA	26	20	23	7	-6	3	-16
MDA	170	230	522	454	60	292	-68
CBD	20	26	34	25	6	8	-9
Panel C: Topic (count)							
Army	169	167	251	243	-2	84	-8
Navy	114	126	207	221	12	81	14
Air Force	258	263	246	228	5	-17	-18
DTRA	17	18	10	8	1	-8	-2
MDA	16	16	50	102	0	34	52
CBD	18	26	19	20	8	-7	1

<u>Exhibit 2</u>. Replication of Figure 2 Panel B chart using DoD solicitations data



<u>Exhibit 3</u>. Examples of SBIR topic solicitations related to anti-terrorism demand

Part A: Direct quotes from solicitation documents related to terrorist attacks

1. “Since 9-11 the specter of future terrorist attacks on the United States has increased.”
2. “The Homeland Defense and Homeland Security have become more complex for the law enforcement and safety agencies ever since the 9/11 attacks. Terrorism threats are becoming one of the greatest concerns among nations, causing fear and chaos. Complete situational awareness is paramount for the crime fighter to identify and react quickly to threats. Sensor system advancements are enabling the crime fighter to detect a variety of threats, such as intruder movements and chem/bio threats.”
3. “Since the events of 9/11, military operations in open civilian airspace have increased in frequency and in operations not necessarily related to training. This requires greater surveillance coverage from non-conventional (civilian) sources.”
4. “The anthrax attacks in the United States, shortly after the September 11 terrorist attacks on New York and Washington, DC, have made a theoretical biothreat hypothesis a stunning reality. In addition to early diagnostic tools, the appropriate vaccines, antidotes, and therapeutics are also very important for aftermath treatment and disaster management. There is an urgent need to develop and evaluate new therapies for anthrax.”
5. “The Department of Defense (DoD) is at a heightened state of awareness since the terrorist attack on September 11, 2001. Many military and civilian defense facilities need technology that will help them monitor and track potential terrorists before an attack takes place.”

Part B: Topics related to anti-terrorism demand post-9/11

Topic frequency	2000	2002	2003
“Sensor”	7	46	44
“UAV”	5	23	26
“Lightweight”	4	26	28
“Track”	3	47	32
“Wireless”	9	33	52

Part C: Removal of topic solicitations in 2002 immediately post-9/11

“Due to the events of September 11, 2001, the following Navy topics of the FY2002.1 SBIR Solicitation are no longer offered; N02-093, N02-094, N02-095, and N02-103.

1. N02-093 TITLE: Virtual-node Programming Environment.
2. N02-094 TITLE: Detection and Tracking of Low RCS Watercraft.
3. N02-095 TITLE: Detection and Classification of Drifting Mines.
4. N02-103 TITLE: Complex Network Route Analysis System.”

Exhibit 4. Alternative observation windows

	Excluding 2002		1996-1997+2005-2006		1996-1997+2002-2003	
Fixed effects OLS models DV: logged awards	**Extension-based awards**	**Novelty-based awards**	**Extension-based awards**	**Novelty-based awards**	**Extension-based awards**	**Novelty-based awards**
Intercept	0.189 (0.098)	0.057 (0.475)	0.771 (0.000)	0.171 (0.181)	1.171 (0.000)	0.224 (0.092)
Pref-decreased tech * post-shock	-2.035 (0.000)	-0.393 (0.157)	-3.430 (0.000)	0.138 (0.752)	-4.660 (0.000)	-0.016 (0.972)
Pref-increased tech * post-shock	-0.188 (0.689)	0.210 (0.530)	-0.373 (0.613)	0.187 (0.721)	-0.358 (0.648)	0.881 (0.106)
Rep. customer ties * post-shock	0.000 (0.999)	0.012 (0.598)	-0.107 (0.042)	0.050 (0.184)	-0.167 (0.003)	-0.020 (0.614)
Pref-decreased tech * Rep. customer ties * post-shock (H1)	**1.236** **(0.025)**	-0.282 (0.471)	**1.737** **(0.045)**	-0.667 (0.276)	**4.129** **(0.000)**	-0.695 (0.276)
Pref-increased tech * Rep. customer ties * post-shock (H2)	0.390 (0.585)	**-0.907** **(0.072)**	0.176 (0.875)	**-1.661** **(0.036)**	0.333 (0.779)	**-2.501** **(0.002)**
Pref-decreased tech * Pref-increased tech * post-shock (H3)	**1.973** **(0.000)**	**2.104** **(0.000)**	**3.137** **(0.000)**	**3.047** **(0.000)**	**2.108** **(0.000)**	**1.821** **(0.000)**
Total award amount * post-shock	-0.010 (0.145)	0.002 (0.659)	-0.016 (0.112)	-0.015 (0.045)	-0.002 (0.853)	0.027 (0.000)
Last award years before shock * post-shock	-0.052 (0.000)	-0.036 (0.000)	-0.156 (0.000)	-0.059 (0.000)	-0.186 (0.000)	-0.065 (0.000)
Last award count * post-shock	0.054 (0.055)	0.053 (0.008)	0.133 (0.002)	0.039 (0.210)	0.117 (0.012)	0.050 (0.119)
Customer count * post-shock	0.031 (0.046)	0.030 (0.005)	-0.031 (0.205)	0.038 (0.026)	-0.028 (0.270)	-0.046 (0.010)
Patent count * post-shock	0.000 (0.235)	0.000 (0.395)	0.000 (0.148)	0.000 (0.830)	0.000 (0.237)	0.000 (0.966)
Hot patent ratio * post-shock	0.008 (0.890)	0.028 (0.492)	0.087 (0.347)	0.061 (0.351)	-0.014 (0.885)	0.103 (0.134)
Cold patent ratio * post-shock	0.056 (0.070)	0.051 (0.022)	0.076 (0.137)	0.044 (0.224)	0.058 (0.283)	0.035 (0.355)
Patent diversity * post-shock	0.023 (0.595)	0.014 (0.642)	0.029 (0.675)	-0.024 (0.629)	0.041 (0.583)	-0.025 (0.624)
Patent co-assignee count * post-shock	-0.026 (0.057)	-0.013 (0.188)	-0.033 (0.124)	-0.003 (0.834)	-0.029 (0.204)	-0.012 (0.458)
Alliance count * post-shock	-0.006 (0.206)	0.001 (0.788)	-0.006 (0.419)	0.000 (0.980)	-0.008 (0.325)	0.007 (0.212)
Successful phase 1 award ratio * post-shock	-0.023 (0.666)	-0.006 (0.880)	-0.100 (0.261)	-0.031 (0.624)	-0.102 (0.283)	0.011 (0.865)
R-square	0.441	0.439	0.577	0.570	0.591	0.582
F value	5.85	5.82	3.65	3.54	3.86	3.72
N	4693	4693	2028	2028	2028	2028

<u>Exhibit 4</u> (Cont.)

	1996-1998+2004-2006		1998-2000+2002-2004		1999-2000+2002-2004		1999-2000+2005-2006	
Fixed effects OLS models DV: logged awards	**Extension-based awards**	**Novelty-based awards**	**Extension-based awards**	**Novelty-based awards**	**Extension-based awards**	**Novelty-based awards**	**Extension-based awards**	**Novelty-based awards**
Intercept	0.386 (0.007)	0.071 (0.489)	0.131 (0.314)	0.015 (0.874)	0.183 (0.167)	0.007 (0.947)	-0.032 (0.812)	0.020 (0.854)
Pref-decreased tech * post-shock	-3.221 (0.000)	-0.044 (0.901)	-1.221 (0.006)	-0.639 (0.057)	-0.438 (0.340)	-0.860 (0.018)	0.508 (0.276)	-0.610 (0.095)
Pref-increased tech * post-shock	-0.722 (0.218)	-0.539 (0.204)	0.408 (0.446)	0.893 (0.027)	0.964 (0.081)	1.755 (0.000)	1.151 (0.040)	1.556 (0.000)
Rep. customer ties * post-shock	-0.068 (0.101)	0.050 (0.092)	0.036 (0.330)	-0.012 (0.662)	0.076 (0.048)	-0.016 (0.605)	0.112 (0.004)	0.031 (0.316)
Pref-decreased tech * Rep. customer ties * post-shock (H1)	**1.370 (0.047)**	-0.531 (0.286)	**1.604 (0.009)**	-0.226 (0.633)	**1.373 (0.034)**	-0.050 (0.921)	**0.383 (0.560)**	-0.176 (0.732)
Pref-increased tech * Rep. customer ties * post-shock (H2)	0.509 (0.567)	**-1.102 (0.086)**	0.046 (0.955)	**-1.169 (0.041)**	0.070 (0.933)	**-1.402 (0.033)**	-0.470 (0.580)	**-0.759 (0.254)**
Pref-decreased tech * Pref-increased tech * post-shock (H3)	**2.798 (0.000)**	**2.998 (0.000)**	**0.558 (0.168)**	**0.826 (0.007)**	0.274 (0.512)	0.288 (0.382)	**0.928 (0.029)**	**1.034 (0.002)**
Total award amount * post-shock	-0.002 (0.782)	-0.009 (0.122)	0.002 (0.829)	0.025 (0.000)	-0.012 (0.114)	0.030 (0.000)	-0.027 (0.001)	-0.005 (0.379)
Last award years before shock * post-shock	-0.082 (0.000)	-0.040 (0.000)	-0.016 (0.202)	-0.027 (0.006)	-0.029 (0.029)	-0.032 (0.002)	-0.011 (0.394)	-0.029 (0.005)
Last award count * post-shock	0.070 (0.044)	0.037 (0.143)	0.005 (0.867)	0.044 (0.069)	0.019 (0.565)	0.044 (0.088)	0.033 (0.317)	0.037 (0.156)
Customer count * post-shock	-0.003 (0.867)	0.052 (0.000)	0.042 (0.016)	-0.002 (0.894)	0.057 (0.001)	-0.008 (0.560)	0.058 (0.001)	0.045 (0.002)
Patent count * post-shock	0.000 (0.248)	0.000 (0.434)	0.000 (0.817)	0.000 (0.475)	0.000 (0.667)	0.000 (0.624)	0.000 (0.431)	0.000 (0.618)
Hot patent ratio * post-shock	0.017 (0.820)	0.023 (0.666)	-0.042 (0.522)	0.027 (0.584)	-0.009 (0.889)	0.049 (0.358)	0.095 (0.162)	0.004 (0.946)
Cold patent ratio * post-shock	0.070 (0.077)	0.043 (0.133)	0.033 (0.340)	0.041 (0.119)	0.030 (0.407)	0.042 (0.138)	0.046 (0.210)	0.056 (0.050)
Patent diversity * post-shock	0.040 (0.465)	0.012 (0.758)	0.022 (0.657)	0.039 (0.298)	0.016 (0.751)	0.043 (0.291)	-0.031 (0.554)	0.021 (0.612)
Patent co-assignee count * post-shock	-0.037 (0.030)	-0.011 (0.386)	-0.026 (0.092)	-0.016 (0.159)	-0.013 (0.401)	-0.015 (0.224)	-0.021 (0.203)	-0.005 (0.703)
Alliance count * post-shock	-0.003 (0.576)	-0.002 (0.619)	-0.003 (0.591)	0.002 (0.666)	-0.005 (0.349)	0.004 (0.410)	-0.004 (0.443)	-0.001 (0.795)
Successful phase 1 award ratio * post-shock	0.017 (0.808)	0.002 (0.965)	0.034 (0.577)	0.024 (0.597)	-0.058 (0.352)	-0.029 (0.558)	-0.126 (0.047)	-0.069 (0.167)
R-square	0.536	0.519	0.514	0.492	0.576	0.564	0.501	0.539
F value	5.29	4.95	5.05	4.61	5.19	4.95	2.88	3.35
N	3094	3094	3198	3198	2665	2665	2132	2132

<u>Exhibit 5</u>. Customer depth (repeated customer count) and breadth (total customer count)

Fixed effects OLS models DV: logged awards	**Extension-based awards E5-1**	**Novelty-based awards E5-2**
Intercept	0.274 (0.011)	0.054 (0.489)
Pref-decreased tech * post-shock	0.100 (0.809)	-0.042 (0.887)
Pref-increased tech * post-shock	-1.394 (0.009)	-1.159 (0.003)
Pref-decreased tech * Rep. customer count * post-shock	**0.338 (0.029)**	0.034 (0.761)
Pref-decreased tech * Total customer count * post-shock	**-0.550 (0.001)**	-0.158 (0.170)
Pref-increased tech * Rep. customer count * post-shock	-0.710 (0.000)	**-0.638 (0.000)**
Pref-increased tech * Total customer count * post-shock	0.689 (0.000)	**0.567 (0.000)**
Pref-decreased tech * Pref-increased tech * post-shock	**2.782 (0.000)**	**2.024 (0.000)**
Rep. customer count * post-shock	0.060 (0.001)	0.023 (0.071)
Total customer count * post-shock	-0.017 (0.309)	-0.001 (0.925)
Total financial amount * post-shock	0.005 (0.474)	0.014 (0.013)
Last award year before shock * post-shock	-0.050 (0.000)	-0.034 (0.000)
Last year awards * post-shock	0.036 (0.176)	0.039 (0.045)
Patent count * post-shock	0.000 (0.255)	0.000 (0.578)
Hot patent ratio * post-shock	-0.015 (0.790)	0.023 (0.568)
Cold patent ratio * post-shock	0.059 (0.047)	0.049 (0.021)
Patent diversity * post-shock	0.019 (0.655)	0.016 (0.588)
Patent co-assignee count * post-shock	-0.030 (0.019)	-0.010 (0.284)
Alliance count * post-shock	-0.006 (0.163)	0.000 (0.938)
Successful phase 1 award ratio * post-shock	-0.057 (0.265)	-0.010 (0.792)
R-square	0.452	0.452
F value	6.86	6.87

Note: 5,226 firm-year observations from 1996 to 2006 with 2001 excluded. 533 firms. Firm and year fixed effects are included, and robust standard errors are used. Coefficients in bold are for hypothesis testing and p-values are in parentheses.

<u>Exhibit 6</u>. Customer disaggregation and its effects on adaptation

	Awards from focal customer	
Fixed effects OLS models DV: logged awards	**Extension-based awards E6-1**	**Novelty-based awards E6-2**
Intercept	0.209 (0.000)	0.010 (0.734)
Pref-decreased tech * post-shock	-0.109 (0.000)	-0.082 (0.000)
Pref-increased tech * post-shock	-0.138 (0.000)	0.009 (0.732)
Number of relationships with focal customer * post-shock	-0.027 (0.000)	-0.001 (0.543)
Pref-decreased tech * Number of relationships with focal customer * post-shock	**0.043 (0.000)**	-0.001 (0.745)
Pref-increased tech * Number of relationships with focal customer * post-shock	-0.100 (0.000)	**-0.038 (0.000)**
Pref-decreased tech * Pref-increased tech * post-shock	**0.317 (0.000)**	**0.176 (0.000)**
Total financial amount * post-shock	0.002 (0.000)	-0.002 (0.001)
Last award year before shock * post-shock	-0.011 (0.000)	-0.006 (0.000)
Last year awards * post-shock	0.008 (0.030)	0.009 (0.001)
Customer count * post-shock	0.003 (0.069)	0.007 (0.000)
Patent count * post-shock	0.000 (0.201)	0.000 (0.489)
Hot patent ratio * post-shock	0.006 (0.444)	0.006 (0.309)
Cold patent ratio * post-shock	0.009 (0.038)	0.009 (0.004)
Patent diversity * post-shock	0.005 (0.398)	0.001 (0.796)
Patent co-assignee count * post-shock	-0.004 (0.018)	-0.001 (0.389)
Alliance count * post-shock	-0.001 (0.354)	0.000 (0.994)
Successful phase 1 award * post-shock	-0.005 (0.474)	0.003 (0.572)
R-square	0.295	0.274
F value	3.66	3.30

Note: 41,808 firm-customer-year observations from 1996 to 2006 with 2001 excluded. 533 firms. Firm-customer and year fixed effects are included, and robust standard errors are used. Coefficients in bold are for hypothesis testing and p-values are in parentheses.

<u>Exhibit 7</u>. Customer-level analyses with customer tie breakdown

Fixed effects OLS models DV: logged awards	**Extension-based awards E7-1**	**Novelty-based awards E7-2**
Intercept	0.185 (0.000)	0.008 (0.768)
Pref-decreased tech * post-shock	-0.014 (0.624)	-0.117 (0.000)
Pref-increased tech * post-shock	-0.117 (0.007)	0.014 (0.639)
Single-tie dummy * post-shock	-0.033 (0.000)	-0.001 (0.619)
Repeated-tie dummy * post-shock	-0.057 (0.000)	-0.003 (0.492)
Single-tie dummy * Pref-decreased tech * post-shock	**0.287 (0.000)**	-0.052 (0.114)
Repeated-tie dummy * Pref-decreased tech * post-shock	**0.386 (0.000)**	-0.077 (0.173)
Single-tie dummy * Pref-increased tech * post-shock	-0.065 (0.273)	**-0.023 (0.573)**
Repeated-tie dummy * Pref-increased tech * post-shock	-0.364 (0.001)	**-0.098 (0.004)**
Pref-decreased tech * Pref-increased tech * post-shock	**0.430 (0.000)**	**0.264 (0.000)**
Total financial amount * post-shock	0.000 (0.808)	-0.001 (0.104)
Last award year before shock * post-shock	-0.010 (0.000)	-0.006 (0.000)
Last year awards * post-shock	0.009 (0.015)	0.009 (0.001)
Customer count * post-shock	0.006 (0.001)	0.006 (0.000)
Patent count * post-shock	0.000 (0.114)	0.000 (0.622)
Hot patent ratio * post-shock	0.006 (0.449)	0.006 (0.303)
Cold patent ratio * post-shock	0.009 (0.036)	0.008 (0.008)
Patent diversity * post-shock	0.004 (0.455)	0.001 (0.737)
Patent co-assignee count * post-shock	-0.005 (0.004)	-0.001 (0.596)
Alliance count * post-shock	-0.001 (0.413)	0.000 (0.998)
Successful phase 1 award * post-shock	-0.005 (0.495)	0.003 (0.619)
R-square	0.294	0.271
F value	3.64	3.24

Note: 41,808 firm-customer-year observations from 1996 to 2006 with 2001 excluded. 533 firms. Firm-customer and year fixed effects are included, and robust standard errors are used. Coefficients in bold are for hypothesis testing and p-values are in parentheses. Zero-tie dummy is left out as the baseline group.

Exhibit 8. Keywords from topic modeling

Increasing-demand word	Post-shock / Pre-shock	Decreasing-demand word	Post-shock / Pre-shock
Aerospace	1.32	Aluminum	0.69
Hybrid	1.54	Crystal	0.42
Missile	2.25	Diamond	0.38
Ship	2.00	Fabrication	0.62
Shipboard	1.38	Film	0.41
Suite	1.39	Magnetic	0.50
Vehicle	1.58	Material	0.60
Automatic	1.31	Metal	0.70
Battery	1.64	Nitride	0.51
Detection	1.39	Oxide	0.48
Hydrogen	1.89	Polymer	0.61
Intelligence	1.34	Powder	0.31
Lightweight	1.58	Semiconductor	0.60
Lithium	1.37	Silicon	0.66
Mems	1.71	Synthetic	0.62
Sensor	1.33	Analog	0.60
Surveillance	1.71	Antenna	0.61
Track	1.62	Broadband	0.70
UAV	2.25	Fiber	0.58
Unmanned	3.10	Laser	0.65
Amplifier	1.36	Microwave	0.48
Network	1.31	Optics	0.68
Security	1.96	Wave	0.63
Web	2.54	Waveguide	0.41
Wideband	1.30	Wavelength	0.64
Wireless	2.14		

Note: For increasing-demand words, the threshold used in post-shock/pre-shock is 1.30 (at least 30% higher after the shock than before the shock). For decreasing-demand words, the threshold used in post-shock/pre-shock is 0.70 (at least 30% lower after the shock than before the shock); we also include different formats of the word (sensor vs. sensors, track vs. tracking) and the post-shock/pre-shock ratio is based on the total count of all formats. We conducted sensitivity analyses using alternate threshold values of 20% and 40%, finding consistent results.