DISRUPTIVE AND SUSTANING TECHNOLOGY DEVELOPMENT APPROACHES IN DEFENSE ACQUISITION

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Research Background

- **US Department of Defense heavily invests in technology**
  - Most defense innovations are derivative ("sustaining")
  - Sustaining innovations drawn from existing technology base
  - "Disruptive" innovations potentially expand the technology base
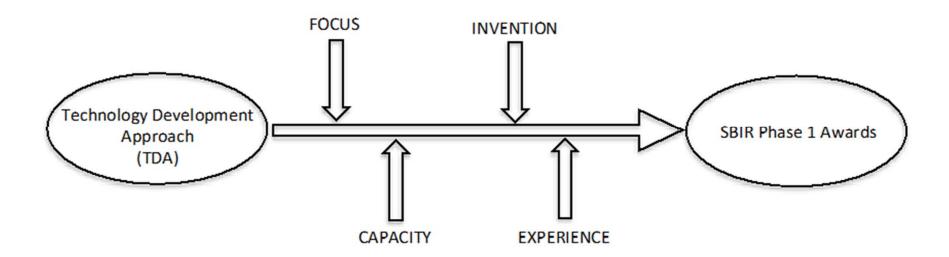 - May lead to new and advanced defense capabilities
- **Disruptive innovations are difficult to identify in advance**
  - Disruption defined by technology attributes and market effect
  - Market effect: a disrupted relationship among competitors
  - Technology attribute: existing technology in new architectural configurations
  - New configurations imply deliberate **technology development approach (TDA)**
  - Does knowing a company's TDA help with predicting disruptive innovations?

Methodology

- Non-experimental, quantitative, correlational research design
- Posit a relationship among TDA, company demographics, and winning SBIR Phase 1 contracts
- Survey SBIR participants to gather required information
  - Small innovative companies developing new technologies
  - DARPA SBIR Phase 1 awardees chosen as surrogate population
- New survey instrument gathers primary data:
  - Company demographic data (focus, inventiveness, experience, capacity)
  - TDA data (Likert-style responses to development preferences)
- Exploratory Factor Analysis (EFA) used to develop scales for sustaining and disruptive TDA
  - TDA score calculated for each company
  - TDA values used as independent variable in follow-on analyses
- Determine relationships
  - Correlation analysis
  - Regression analysis

Initial Concept Diagram

FOCUS

INVENTION

Technology Development
Approach
(TDA)

SBIR Phase 1 Awards

CAPACITY

EXPERIENCE

Research Questions & Hypotheses

- **Research Questions**
  - **RQ1** What is the relationship among the independent variables of TDA, company demographics, and the criterion variable of winning Phase 1 SBIR defense contracts?
  - **RQ2** What are the relative contributions of TDA, and company demographics to winning SBIR Phase 1 contracts?
- **Research Hypotheses**
  - **$H_0 1$** There is no significant difference between technology development approaches in winning SBIR Phase 1 defense contracts.
  - **$H_1 1$** There is a significant difference between technology development approaches in winning SBIR Phase 1 defense contracts.
  - **$H_0 2$** There is no significant relationship between TDA and the contribution of the demographics INVENTION, CAPACITY, FOCUS, and EXPERIENCE of companies who win SBIR Phase 1 defense contracts.
  - **$H_1 2$** There is a significant relationship between TDA and the contributions of the demographics INVENTION, CAPACITY, FOCUS, and EXPERIENCE of companies who win SBIR Phase 1 defense contracts.

TDA: Measuring a New Construct

- TDA is a new construct for measuring preference for architectural re-configuration
  - Existing surveys do not adequately measure TDA
  - New instrument required
- New instrument based on disruptive innovation and systems engineering theory
  - 12 Likert-style questions developed from disruptive innovation theory
  - Example: "Your company's technology development approach is based on improving component technology in existing system architectures"
- Measures an organization's preferred strategy for developing technology solutions:
  - Disruptive => architectural re-configuration with extant technology
  - Sustaining => incremental improvement along existing technology trajectory
- EFA used to determine sustaining and disruptive factors
- Develop scales for measuring disruptive and sustaining TDA
- Use measures of TDA in correlation and regression analyses

Population and Sampling

- **Target Population**
  - US companies of employing < 500
  - Engaged primarily in technology development
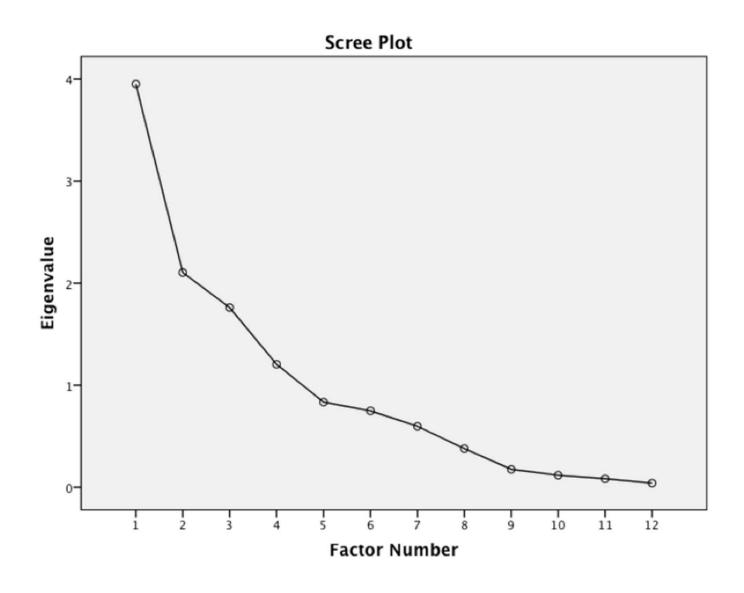 - Desire to contract with US Department of Defense
- **Sampling Frame**
  - Companies receiving a DARPA SBIR Phase 1 contract
  - Phase 1 awards from 2007 – 2013
  - 462 companies and over 600 Phase 1 Awards
  - DARPA solicitations relatively open-ended
  - Covers a wide variety of issues and invites innovative solutions
  - Sufficient number of companies to conduct pilot and full-scale surveys
- **Sampling Results**
  - Companies contacted: 70
  - Companies expressing interest: 36
  - Companies requesting email link: 18
  - Usable responses: 16
  - Response rate: ~23%

Establishing TDA – Factor Extraction

Establishing TDA – Factor Loading & Interpretation

	Factor			
	1	2	3	4
TDA16	.813	.118	-.074	.537
TDA21	.774	-.139	-.236	.500
TDA17	.716	-.243	.206	.037
TDA15	.617	-.264	-.325	-.238
TDA19	.508	-.411	-.463	.248
TDA26	.725	-.783	-.223	-.093
TDA23	.363	-.708	-.150	.045
TDA22	-.017	-.607	-.211	-.149
TDA20	.024	-.529	.388	-.027
TDA24	.150	.091	.710	.157
TDA18	-.341	.176	.649	.096
TDA25	.062	.063	.134	.793

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Scale Development

- Developed from 12 Likert-style questions on technology development
- Four factors extracted; candidate scales developed
  - Factor #1: accurate characterization of sustaining TDA (sTDA)
  - Factor #2 & #3: mixed elements of sustaining and disruptive TDA
  - Factor #4: redundant with Factor #1

Factor	Cronbach's Alpha	Cronbach Alpha Range	Item Deletion Sensitivity
1	.833	.757 – .832	0
2	.727	.601 – .753	3
3	.448	.227 – .526	n/a
4	.762	.532 – .803	2

Research Question 1, Hypotheses $H_0 1$ and $H_1 1$

- RQ1: highly correlated and significant relationship among demographics and SBIR success
  - Strong correlations among demographics and SBIR success
  - Company age, experience, and focus show strongest relations
  - Weaker, but still significant, correlation with sTDA
- Study results unable to address $H_0 1$ and $H_1 1$
  - Scale successfully developed for sustaining TDA
  - No reliable scale developed for disruptive TDA
  - Candidate scales fell short in two areas:
    - Sensitivity to item deletion
    - Contained mixed elements of disruptive and sustaining TDA

Research Question 2, Hypotheses $H_0 2$ and $H_1 2$

- RQ2: results successfully quantify the contribution of TDA and demographic variables to SBIR Phase 1 success
  - SBIR Phase 1 success regressed against company demographics and TDA
  - Company age, focus, inventiveness, TDA, and capacity best predicted SBIR Phase 1 success
- Regression analysis supports rejecting $H_0 2$ and accepting $H_1 2$
  - ~87% of SBIR success explained by independent variables
  - Regression model coefficients performed significantly better than the null hypothesis of "0" values for linear model coefficients

Research Observations

- Initial Concept Framework
  - Assumed TDA is primary determinant of SBIR success
  - TDA may only be a minor, contributing factor
- Characterizing Disruptive TDA
  - Survey instrument reliably characterized sustaining TDA
  - Disruptive TDA lacked distinct, clear definition
  - Elements of disruptive TDA evident in all extracted factors
- Sample Size
  - Sample set of 16 responses sufficient for exploratory work
  - Larger samples improve all aspects of analysis
  - Insufficient to develop a disruptive TDA scale with existing instrument
- Sample Frame Composition
  - Initial inclusion criteria: <500 employees, at least one SBIR contract, DARPA solicitations
  - Wide variety of technology types, e.g., software, hardware, services
  - Different technology focus may mean varying TDA
- External Validity
  - Results may be unique to sampling frame
  - DARPA solicitations broadly written; encourages wider variety of technology solutions
  - Sustaining TDA may be more prevalent in SBIR solicitations from different federal agencies

Discussion and Theory Implications

- **Disruptive Technology: Intrinsic Attribute or Market Effect?**
  - Evidence for sustaining TDA as an intrinsic corporate attribute
    - Homogeneous description
    - Easily factored from survey instrument results
    - Strong loading in factor interpretation process
  - Disruptive TDA – possibly a blend of intrinsic and market effects
    - Mixed composition of sustaining and disruptive attributes
    - Intrinsic => part of a technology development strategy
    - Market effects => feedback from the market informs development strategy
    - Essence of the "organizational learning" business strategy
  - Better characterization of disruptive TDA required to separate intrinsic properties from market effects

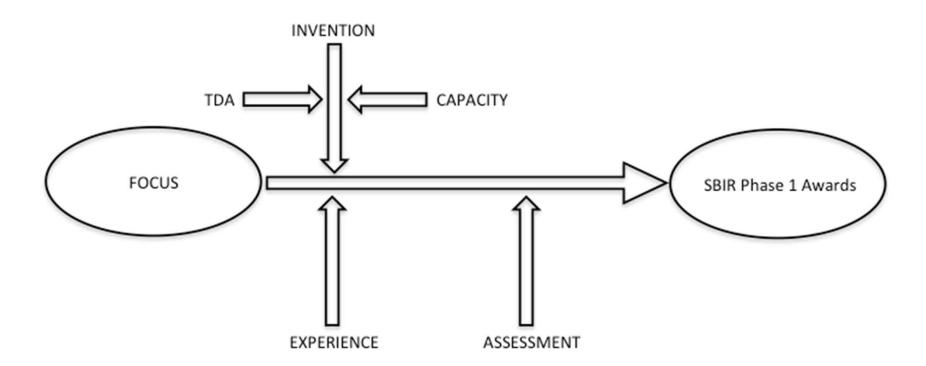# Discussion and Theory Implications – cont.

- **Role of TDA in Company Strategy**
  - Extracted factors displayed disruptive and sustaining components
  - Technology companies use different strategies for developing technology solutions
  - TDA may be a flexible tool in a broader technology development strategy
  - Companies may shift between sustaining and disruptive approaches depending on project requirements
    - Ambiguous project requirements => learning-by-doing/disruptive TDA
    - Clarified project requirements => sustaining TDA
- **TDA and Bias in Defense Acquisition**
  - SBIR proposal assessments may bias toward sustaining TDA
  - Assessment process may not recognize disruptive TDA
  - Sustaining technologies dominate in defense acquisition
  - Proposal assessments focused on most familiar technology solutions

Modified Concept Diagram

Recommendations For Future Research

- Increase Sample Size
  - Increase sample size to ~200 company responses
  - Decrease ambiguity regarding disruptive TDA; increase precision
  - Increase reliability of regression analysis
- Controlled Sample Frame Composition
  - Sample frame included a variety of technologies
  - Control for different technology solutions, e.g., hardware vs. software
  - Achieved through study inclusion criteria or in regression analysis
- Survey Instrument Enhancement
  - Incorporate results from increasing sample size and controlling sample frame composition
  - Compare with original instrument
- Enhanced Concept Framework
  - Modify framework to align with previous research results
  - Shift from exploratory to confirmatory analysis
  - Use structural equation modeling to quantify relationships
- Expansion to Commercial Domain
  - Generalize the enhanced framework to non-defense companies
  - Test the framework in a larger environment