Disruptive and Sustaining Technology Development Approaches in Defense Acquisition

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DISRUPTIVE AND SUSTAINING 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
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**
  • **H₀₁** There is no significant difference between technology development approaches in winning SBIR Phase 1 defense contracts.
  • **H₁₁** There is a significant difference between technology development approaches in winning SBIR Phase 1 defense contracts.
  • **H₀₂** 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.
  • **H₁₂** 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

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<thead>
<tr>
<th></th>
<th>Factor 1</th>
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<td>0.063</td>
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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

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<thead>
<tr>
<th>Factor</th>
<th>Cronbach's Alpha</th>
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<th>Item Deletion Sensitivity</th>
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<td>1</td>
<td>.833</td>
<td>.757 – .832</td>
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<td>.727</td>
<td>.601 – .753</td>
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<td>.227 – .526</td>
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<td>4</td>
<td>.762</td>
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Research Question 1, Hypotheses $H_{01}$ and $H_{11}$

- 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 $H_{01}$ and $H_{11}$
  - 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

FOCUS

INVENTION

TDA ↔ CAPACITY

EXPERIENCE

ASSESSMENT

SBIR Phase 1 Awards
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