WHAT DRIVES INNOVATION CHOICES IN THE SMALL SATELLITE INDUSTRY? THE ROLE OF TECHNOLOGICAL RESOURCES AND MANAGERIAL EXPERIENCE

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PART ONE:

SMALL SATELLITE INDUSTRY OVERVIEW
Number of Large (>500kg) versus Small (<500kg) Satellites Successfully Launched (1957-2015)
Number of Launch Vehicles Available for Large and Small Satellites (1957-2015)
Number of Large and Small Satellite Operators (1957-2015)
Number of New Satellite Manufacturer Entries Per Year (1957-2015)
PART TWO:
WHAT DRIVES INNOVATION CHOICES IN THE SMALL SATELLITE INDUSTRY?
TWO INNOVATION CHOICES

1) What are the new technological designs and what are their key constituting components
2) How are these new designs useful and what are their application purposes

Product
Application Innovation
(Product Innovation
(Herderson and Clark, 1990)

Product Components
Application Innovation
(Darr & Talmud, 2003)
DRIVERS OF INNOVATION CHOICES

- Technological diversity: the range or breadth of technologies possessed by a firm
- Technological relatedness: the extent to which a firm’s knowledge base and the space industry knowledge base cover similar technology domains
- CEO experience diversity: the range or breadth of industries the CEO has worked in before joining the firm
- CEO experience relatedness: the extent to which a CEO has work experience in the space industry
DATA SOURCES


- CEO experience
  - LinkedIn Profile
  - Company Website
  - Bloomberg.com

- Final sample of 196 firms
MEASUREMENT

- IV: Technological diversity = $1 - p_i^2$, $p_i$ stands for the share of patents in class i (Lahiri, 2010; Quintana-Garcia and Benavides-Velasco, 2007; Schildt, Keil, and Maula, 2012)

- IV: Technological relatedness = $\frac{\sum C_{k,A}C_{k,B}}{\sqrt{\text{Patents}_A \times \text{Patents}_B}}$ the overlap of a focal company’s patents with those of emerging technologies in terms of patent class (Frankort, 2016; Schildt, Keil, and Maula, 2012)
  - Traced all the patent filings of small satellite firms, the top 50 patent classes are defined as small sat technology patent classes (Carnabuci and Operti, 2013)
MEASUREMENT

• **CEO experience relatedness** = # of years the CEO of the firm has worked in the space and aviation industry/# of total working years

• **CEO experience diversity** = # of different industries the CEO has worked in prior to joining the firm

• **Product/Application innovation** – either the firm has introduced a new product that focuses on small satellite components, system integration, launch systems, or applying small satellite technologies to other areas
SUMMARY OF FINDINGS

Technological Competence

- Technological Relatedness
  - H1a: +

- Technological Diversity
  - H1b: +

Managerial Experience

CEO Experience Relatedness

Managerial Experience

CEO Experience Diversity

Innovation choices

- Product Innovation
  - H2a: +

- Application Innovation
  - H2b: +

CEO Experience Diversity

CEO Experience Relatedness

H3a: -

H3b: -
Thank you!

Please email me if you have any questions or comments!

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## Results

<table>
<thead>
<tr>
<th></th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product</td>
<td>App</td>
<td>Product</td>
<td>App</td>
<td>Product</td>
<td>App</td>
</tr>
<tr>
<td><em>H1a: Tech Relatedness</em></td>
<td>3.408**</td>
<td>-3.357**</td>
<td>2.105*</td>
<td>-2.762**</td>
<td>0.490</td>
<td>-0.369</td>
</tr>
<tr>
<td><em>H1b: Tech Diversity</em></td>
<td>0.105</td>
<td>-0.265</td>
<td>0.366</td>
<td>-0.222</td>
<td>1.534</td>
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<tr>
<td><em>H2a: CEO Related Exp</em></td>
<td>1.259***</td>
<td>-0.923***</td>
<td>0.937***</td>
<td>-0.288</td>
<td></td>
<td></td>
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<tr>
<td><em>H2b: CEO Diverse Exp</em></td>
<td>0.521***</td>
<td>-0.667***</td>
<td>0.639***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H3a: Tech Related * CEO Diverse</em></td>
<td></td>
<td>1.737</td>
<td>1.737</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H3b: Tech Diversity * CEO Related</em></td>
<td></td>
<td>-1.711</td>
<td>-1.490**</td>
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Control variables included
# Hypotheses Development: Main Effects

<table>
<thead>
<tr>
<th>Knowledge diversity</th>
<th>Emerging industry product innovations</th>
<th>Emerging industry application innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength:</strong></td>
<td>Strength suffocated: willingness to accept novel ideas is not enough</td>
<td>Strength amplified: more distinct knowledge elements that could be used for combination and finding novel applications</td>
</tr>
<tr>
<td></td>
<td>More likely to identify, accept; More ways to combine novel knowledge</td>
<td></td>
</tr>
</tbody>
</table>

| Weakness:           | Weakness amplified: Need more industry specific knowledge; Less motivated to create product updates in an emerging industry | Weakness suffocated: Do not need deep industry specific knowledge for application; Increase motivation because of reduced cost of learning |
|                     | Lack technological expertise; Lack motivation | |

**Hypothesis 1:** Technologically diversified firms are more likely to pursue application innovations than product innovations
## Hypotheses Development: Main Effects

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</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength:</strong></td>
<td>Strength amplified: Learn industry specific technologies faster; Existing complementary resources;</td>
<td>Strength suffocated: The novel applications could be outside the firm’s existing technological trajectory</td>
</tr>
<tr>
<td>Increased speed of learning; More things to learn; Greater potential to improve performance based on the existing technological trajectory</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weakness:</strong></td>
<td>Weakness suffocated: Knowledge from related technological domains, firms have less problem noticing</td>
<td>Weakness amplified: Less distinct internal knowledge elements that could be combined, and don’t have the ability to identify other cognitively distant areas</td>
</tr>
<tr>
<td>Fail to identify and accept novel ideas that are cognitively distant; Less combinative opportunities inside the firm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypothesis 2:** Technologically related firms are more likely to pursue product innovations than application innovations.
### Moderating effects of CEO experiences

<table>
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<tr>
<th>CEO Experience</th>
<th>Diverse</th>
<th>Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse</td>
<td>Application Innovation</td>
<td>?</td>
</tr>
<tr>
<td>Related</td>
<td>?</td>
<td>Product Innovation</td>
</tr>
</tbody>
</table>

Technological Capability
CEOs with more diverse experiences are more likely to have wider knowledge bases
- Avoid “limited search” (Cyert & March, 1963)

More likely to view technologies as tools, but not the end product
Technological Diverse Firms X CEO with Related Experience

- CEO with more related experience are more likely to have an established understanding of the industry (Hambrick and Mason, 1984)
- Have more industry specific expertise to help firm develop related technological capability