Supply Chain Coordination in New Product Development

Nov. 7, 2007

Chulsoon Park and Bowon Kim

Korea Advanced Institute of Science and Technology, Korea

INFORMS 2007 WC01
Supply Chain Coordination in NPD

- Supplier Involvement in New Product Development
  - Early supplier involvement is generally defined as a form of vertical cooperation in which manufacturers involve suppliers at an early stage in the product development and/or innovation process (Bidault et al., 1998).
  - Involving suppliers in NPD is one way of gaining strategic flexibility through reduced cost, reduced concept-to-customer development time, improved quality, and access to innovative technologies that can help firms gain capture market share (Handfield et al., 1999).
Research Motivation

- “Conflicting” Effects of Supplier Involvement
  - Companies have involved suppliers in their NPD processes, achieving *fast project times* (Clark, 1989; Clark and Fujimoto, 1991), *better product quality* and *lower project costs* (McGinnis and Vallopra, 1998; Ragatz et al., 1997).
  - However, other researchers have found that suppliers have *little practical influence* on the overall project technical success (Hartley et al., 1997), and *even a negative impact* on project development time if they delay their activities (King and Penleskey, 1992). Also, in a literature review of product development, Brown and Eisenhardt (1995) show that it is *not clear* exactly how or when it is appropriate to involve suppliers in the development process.
Research Objective & Question

- Investigate whether the supply chain coordination efforts improves the performance of new product development and, if so, whether there exists any moderators.
- Generate hypotheses that make it clearer the relationship between supply chain coordination and the performance of new product development project.

**NPD Characteristic**
- NPD Process
- Product definition
- Task interdependency

**SCM Characteristic**
- Timing of supplier involvement
- Supplier’s capabilities
- Strategic/organizational similarities

**Coordinated Project Performance**
Research Procedures

**Research question with basic framework**

**Meta-Analysis (Hunter and Schmidt (1990))**
- Search for relevant studies – basic literature review
- Extract data on variables of interest, sample size, and effect sizes
  - Code each study characteristics
- Determine the mean and variance of effect sizes across studies
  - Decide whether to search for moderator variables

**Detailed literature review for moderating variables**

**Generate hypotheses and an extended framework**
Meta-Analysis:
(1) Data Collection

- Electronic database
  - Computer search of the *National Digital Science Library (NDSL)* using the following Boolean expression based on a review of the abstracts
    - AB= supplier [AND] (involvement [OR] integration) [AND] product
  - Year: 1995 or later
  - Journals from the management, management science, marketing, operations management, service management, and technology management literature
- Reference sections of articles
  - Google scholar
- Published articles only in English

* NDSL is a Korean archive portal which collects famous electronic databases including EBSCO host, ScienceDirect, and ProQuest
### Meta-Analysis:
#### (2) Characteristics of Research Samples

<table>
<thead>
<tr>
<th>No.</th>
<th>Study</th>
<th>Methods</th>
<th>Country</th>
<th>Industry</th>
<th>Firm Size</th>
<th>Years</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ledwith and Coughlan (2005)</td>
<td>Correlation</td>
<td>Ireland, UK</td>
<td>Electronics</td>
<td>Mixed</td>
<td>N/A</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>Eisenhardt and Tabrizi (1995)</td>
<td>Regression</td>
<td>Mixed</td>
<td>Computer</td>
<td>N/A</td>
<td>N/A</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>Hartley et al. (1997a)</td>
<td>ANCOVA, Regression</td>
<td>US</td>
<td>Mixed</td>
<td>Small/Med</td>
<td>N/A</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>Tan and Tracey (2007)</td>
<td>Path Analysis</td>
<td>US</td>
<td>Manufacturing</td>
<td>Mixed</td>
<td>N/A</td>
<td>175</td>
</tr>
<tr>
<td>6</td>
<td>Sobrero and Roberts (2001)</td>
<td>Regression</td>
<td>Europe</td>
<td>Home appliances</td>
<td>N/A</td>
<td>N/A</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundson (2002)</td>
<td>Regression</td>
<td>N/A</td>
<td>Electronics</td>
<td>N/A</td>
<td>N/A</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>Zirger and Hartley (1996)</td>
<td>Regression</td>
<td>US</td>
<td>Electronics</td>
<td>N/A</td>
<td>N/A</td>
<td>44</td>
</tr>
</tbody>
</table>

Sample size
Meta-Analysis:
(3) Corrections for Artifactual Attenuation of Study Correlations

- Correction for sampling error
  - Corrected estimate of mean correlation: \( \bar{r} = \frac{\sum_i N_i r_i}{\sum_i N_i} \)
  - Corrected estimate of study correlation variability: \( S_r^2 = \frac{\sum_i \left[ N_i (r_i - \bar{r})^2 \right]}{\sum_i N_i} \)
  - Corrected estimate of sampling error variability: \( S_e^2 = \frac{K(1 - \bar{r}^2)^2}{\sum_i N_i} \) (\( K = \text{number of studies} \))
  - Corrected estimate of variability of the population correlation: \( S_\rho^2 = S_r^2 - S_e^2 \)
Meta-Analysis:
(4) Hunter and Schmidt’s Heuristics

- **RATIO1**
  - \( \text{RATIO1}(= \frac{r}{S_p}) \geq 2 \Rightarrow \) reasonably safe to say "Corr_pop > 0"
  - The factor affects the performance positively

- **RATIO2**
  - \( \text{RATIO2}(= \frac{S_{e}^2}{S_r^2}) \geq 0.75 \Rightarrow \) reasonably safe to say "there is one Corr_pop"
  - Other variables are not likely to act as moderators
## Meta-Analysis:

### (5) Performance Measure and Supplier Involvement Characteristics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ledwith and Coughlan (2003)</td>
<td>Correlation</td>
<td>Project Success</td>
<td>Level of Cooperation</td>
<td>36</td>
<td>-0.122</td>
<td>No</td>
<td>Ireland</td>
<td>Electronics</td>
</tr>
<tr>
<td>2</td>
<td>Eisenhardt and Tabrizi (1995)</td>
<td>Regression</td>
<td>Development Time</td>
<td>Stage number of supplier involvement</td>
<td>72</td>
<td>-0.13</td>
<td>No</td>
<td>Mixed</td>
<td>Computer</td>
</tr>
<tr>
<td>3</td>
<td>Hartley et al. (1997a)</td>
<td>ANCOVA, Reg. Projects' overall delay</td>
<td>Supplier's technical capabilities</td>
<td>79</td>
<td>0.22</td>
<td>No</td>
<td>US</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hartley et al. (1997a)</td>
<td>ANCOVA, Reg. Projects' overall delay</td>
<td>Length of the supply relationship</td>
<td>79</td>
<td>0.04</td>
<td>No</td>
<td>US</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hartley et al. (1997a)</td>
<td>ANCOVA, Reg. Product quality</td>
<td>Supplier's technical capabilities</td>
<td>79</td>
<td>0.2</td>
<td>No</td>
<td>US</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hartley et al. (1997a)</td>
<td>ANCOVA, Reg. Product quality</td>
<td>Length of the supply relationship</td>
<td>79</td>
<td>0.14</td>
<td>No</td>
<td>US</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sanctor (1997)</td>
<td>Correlation, Reg. Alliance outcome</td>
<td>Prior relationship</td>
<td>98</td>
<td>0.24</td>
<td>No</td>
<td>Mixed</td>
<td>Chemical</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sanctor (1997)</td>
<td>Correlation, Reg. Alliance outcome</td>
<td>Strategic similarities</td>
<td>98</td>
<td>0.32</td>
<td>p&lt;0.05</td>
<td>Mixed</td>
<td>Chemical</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sanctor (1997)</td>
<td>Correlation, Reg. Alliance outcome</td>
<td>Organizational process similarity</td>
<td>98</td>
<td>0.01</td>
<td>No</td>
<td>Mixed</td>
<td>Chemical</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Tan and Tracy (2007)</td>
<td>Path Analysis Customer satisfaction</td>
<td>Collaborative NPD environment</td>
<td>175</td>
<td>0.35</td>
<td>p&lt;0.01</td>
<td>US</td>
<td>Manufacture</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sobeiro and Roberts (2001)</td>
<td>Regression Efficiency of relationship</td>
<td>Design scope of relationship</td>
<td>50</td>
<td>0.23</td>
<td>No</td>
<td>Europe</td>
<td>Home appli</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sobeiro and Roberts (2001)</td>
<td>Regression Efficiency of relationship</td>
<td>Level-of-task interdependency</td>
<td>50</td>
<td>-0.15</td>
<td>No</td>
<td>Europe</td>
<td>Home appli</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sobeiro and Roberts (2001)</td>
<td>Regression Learning of relationship</td>
<td>Design scope of relationship</td>
<td>50</td>
<td>0.49</td>
<td>p&lt;0.01</td>
<td>Europe</td>
<td>Home appli</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sobeiro and Roberts (2001)</td>
<td>Regression Learning of relationship</td>
<td>Level-of-task interdependency</td>
<td>50</td>
<td>0.37</td>
<td>p&lt;0.01</td>
<td>Europe</td>
<td>Home appli</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundsen (2002)</td>
<td>Regression Quality index</td>
<td>Supplier involvement</td>
<td>33</td>
<td>0.52</td>
<td>p&lt;0.05</td>
<td>N/A</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundsen (2002)</td>
<td>Regression Project speed</td>
<td>Supplier involvement</td>
<td>38</td>
<td>0.38</td>
<td>No</td>
<td>N/A</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundsen (2002)</td>
<td>Regression Projected R&amp;D budget</td>
<td>Supplier involvement</td>
<td>38</td>
<td>0.19</td>
<td>No</td>
<td>N/A</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundsen (2002)</td>
<td>Regression Time-to-market objective</td>
<td>Supplier involvement</td>
<td>38</td>
<td>0.03</td>
<td>No</td>
<td>N/A</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Primo and Amundsen (2002)</td>
<td>Regression Product cost objective</td>
<td>Supplier involvement</td>
<td>38</td>
<td>0.07</td>
<td>No</td>
<td>N/A</td>
<td>Electronics</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ziger and Hartley (1996)</td>
<td>Regression Development Time</td>
<td>Supplier involvement</td>
<td>44</td>
<td>0.017</td>
<td>No</td>
<td>US</td>
<td>Electronics</td>
<td></td>
</tr>
</tbody>
</table>
Meta-Analysis:  
(6) Funnel Plot

- Funnel shaped → sampling error decreases as sample size increases → satisfying the assumption that there is one underlying effect size
Meta-Analysis:
(7) Results of the Meta-Analyses

- Corrected Estimates
  \[ \bar{r} = 0.198, \ S_r^2 = 0.021, \ S_e^2 = 0.013, \ S_\rho^2 = 0.007 \]

- Does supplier involvement improve the project’s outcome?
  \[ \text{RATIO1}(=\frac{\bar{r}}{S_\rho})=2.319 \geq 2 \Rightarrow \text{reasonably safe to say "Corr_{pop} > 0"} \]
  \[ \Rightarrow \text{Supplier involvement improves the project’s outcome} \]

- Is there any moderator to affect the improvement?
  \[ \text{RATIO2}(=\frac{S_e^2}{S_r^2})=0.646 < 0.75 \Rightarrow \text{Not safe to say "there is one Corr_{pop}"} \]
  \[ \Rightarrow \text{Other variables are likely to act as moderators} \]
Extended Framework

Product Strategy of Players
- Competitive priorities
- Cost/Quality/Time/Flexibility

Fitness of Players
- Business model fit
- Fit of strategy

Capabilities of Players
- Manufacturer's capability
- Supplier’s capability

NPD Characteristic
- NPD Process, Product Def.
- Organization/Teaming

SCM Characteristic
- level of responsibility
- degree of information sharing

Coordinated Project Performance

Moderators
Hypothesis 1

H1a: In the *mature* industry, *early* supply involvement improves the coordinated project performance.

H1b: In the *mature* industry, supplier having *more responsibility* improves the coordinated project performance.
Hypothesis 2

H2a: In developing the *innovative* product, *early* supply involvement improves the coordinated project performance.

H2b: In developing the *innovative* product, supplier having *more responsibility* improves the coordinated project performance.
Contribution

- Through the meta-analysis of relevant literatures, this research shows that it is reasonably safe to say “the supplier involvement improves the performance of new product development project”
- Based on the detailed literature review, we find the highly possible moderators that change the effect size of supplier involvement.
- Generate the hypotheses that can identify the relationship between the supplier involvement and new product development.
Limitation and Future Research

- For meta-analysis
  - Small numbers of studies that provide the correlation information between relevant variables.
  - Performance are not measured with same dimension.
  - Little literature have studied the performance of coordinated product development project with the perspective not only of supply chain but also of new product innovation.
- Empirical studies are needed to test the hypotheses we proposed.
Thank You For Listening

Questions or Comments?
Supplier Involvement Model

quality level

100%

Supplier Involvement

Jump

NPD Team

Manufacturer Only

Manufacturer & Supplier

Time

t₁

T
Variables

- **Control Variables**
  \( t_1 \) = timing of supplier involvement,
  \( u(t) \) = investment efforts of manufacturer at time \( t \).

- **State Variable**
  \( x(t) \) = product quality level (or technology achievement level) at time \( t \).
  \( x^+(t_1) \) = product quality level after the supplier involvement
  \( x^-(t_1) \) = product quality level before the supplier involvement

- **Notations**
  \( T \) = duration of NPD project
  \( b \) = decay rate of technology achievement
  \( P(T,x(T)) \) = lump sum profit at time \( t \)
  \( f(t,x,u) \) = cost function of product development during project period
Optimal Control Model

\[
\max_{u \geq 0, 0 \leq t \leq T} \int_0^T f(t, x, u) \, dt - \sigma(t_1)(x^+(t_1) - x^-(t_1)) + P(T, x(T))
\]

subject to
\[
\dot{x} = u - bx,
\]
\[
x(0) = x_0 > 0, \quad x(T) \text{ free},
\]
\[
u \geq 0,
\]
\[
x(t) = \begin{cases} 
  x(0) + \int_0^t (u(s) - bx(s)) \, ds, & 0 \leq t \leq t_1 \\
  x(0) + \int_0^t (u(s) - bx(s)) \, ds + (x^+(t_1) - x^-(t_1)), & t_1 < t \leq T
\end{cases}
\]
References


References (cont’d)


