Assessing the Relationships among Information Technology Project Complexity, Project Complication, and Project Success

Summary of a Research Study
Conducted as part of the requirements for the degree Doctor of Philosophy Capella University by David J. Williamson In cooperation with the Project Management Institute Information Systems Community of Practice October, 2011
Introduction to the Study

- **Problem:** The low success rate of information technology (IT) projects in the U.S.
- **Causes:** Project complexity is an underdiagnosed cause of IT project failure
- **Theory:** Most existing schools of project management theory are based on the rational systems view; however, for projects with a high degree of complexity, a complex adaptive systems view more effectively describes the full range of project behavior
- **Methodology:** A quantitative, correlational study that distinguished between IT project complexity and IT project complication, then investigated their interrelationship and their relationships with IT project success
- **Survey:** A survey instrument was developed, field tested and pilot tested, and administered to the U.S.-based membership of the Project Management Institute’s Information Systems Community of Practice (PMI IS CoP)
- **Results:** IT project complexity and IT project complication were positively correlated, but IT project complexity had a greater negative correlation with IT project success
- **Implications:** Implications for practice and future research include identifying and mitigating project attributes related to IT project complexity to increase the likelihood of IT project success

(Brockhoff, 2006; Cavaleri & Reed, 2008; Standish Group, 1994, 1999, 2009)
## Complication vs. Complexity

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Complication</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
<td>Complication is caused by size, detail, number of parts</td>
<td>Complexity is caused by interactions between the parts</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>Complicated entities and systems can be decomposed, analyzed, and described in terms of their components and parts</td>
<td>Complex entities and systems cannot be analyzed and described completely as separate components</td>
</tr>
<tr>
<td><strong>Behavior</strong></td>
<td>Complicated system behavior tends to remain consistent and predictable over time</td>
<td>Complex system behavior tends to respond and adapt to environmental changes</td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>Complicated systems tend to respond linearly and predictably to external events</td>
<td>Complex systems tend to respond non-linearly and unpredictably to external events, evolve and change over time, and exhibit emergent behaviors</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>Complication can be managed with rational systems approaches</td>
<td>Complexity cannot be managed directly—it can only be accommodated or mitigated</td>
</tr>
</tbody>
</table>

(Benbya & McKelvey, 2006; Cilliers, 1998; Hass, 2009)
Purpose: Investigate Relationships

- Identify project characteristics that contribute to IT project complexity (ITPCx) and IT project complication (ITPCn)
- Select a definition for IT project success (ITPS)
- Investigate relationships among:
  - ITPCx – ITPCn
  - ITPCx – ITPS
  - ITPCn – ITPS
  - ITPCx – ITPS vs. ITPCn – ITPS
- Provide evidence that complexity and complication are related but different sets of project characteristics, with different relationships to project success

Legend:
- Primary Relationship
- Secondary Relationship
## Research Questions and Hypotheses

| RQ1: ITPCx – ITPCn | H1\(_0\): IT project complexity is not correlated with IT project complication  
H1\(_A\): IT project complexity is correlated with IT project complication |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------|
| RQ2: ITPCx – ITPS  | H2\(_0\): IT project complexity is not correlated with IT project success  
H2\(_A\): IT project complexity is correlated with IT project success |
| RQ3: ITPCn – ITPS  | H3\(_0\): IT project complication is not correlated with IT project success  
H3\(_A\): IT project complication is correlated with IT project success |
| RQ4: ITPCx – ITPS vs. ITPCn – ITPS | H4\(_0\): IT project complication has an equal or greater correlation with IT project success than does IT project complexity  
H4\(_A\): IT project complexity has a greater correlation with IT project success than does IT project complication |
Construct Factors and Elements: IT Project Complexity

Thirteen elements with 1 to 6 factors:

- Project objectives: Clarity
- Opportunity: Clarity and familiarity
- Solution: Familiarity and availability
- Team: Experience and track record
- Methodology: Formality and consistency
- Schedule: Reasonableness and flexibility
- Requirements: Clarity and stability
- Project environment: Political, strategic, stakeholders, dependencies, regulatory, legal
- Information technology: Complexity and innovation
- Technology: Degree of change
- Organizational change: Business processes and scope
- Project staffing: Number of organizations
- Integration: Number of interfaces

Construct Factors and Elements: IT Project Complication

Nine elements with 1 to 3 factors:

- Project leadership: Experience and competence
- Project duration
- Project team size
- Project cost: Planned cost and flexibility
- Project scope
- Technology content
- Organizational support: Executives and users
- Organizational units
- Contractors: Number, familiarity, and track record

Construct Factors and Elements: IT Project Success

Three elements with 2 to 3 factors:

- Project completion: percent completed and percent implemented
- Project performance vs. initial baseline: percent of schedule, budget, and scope
- Project performance vs. final baseline: percent of schedule, budget, and scope

(Baccarini, 1999; Glass, 2006; Standish Group, 1994, 1999, 2009)
Data Collection: Survey Instrument

Instrument

- No existing instruments assessing the relationships between IT project complexity, complication, and success were identified in the literature review
- A new Internet survey instrument was developed for the study
- Survey design was consistent with best practices (Dillman, 2000)
- The survey had not been previously validated; therefore both field testing and pilot testing were indicated

Field Test

- Qualitative review in a seminar on agile project management methods
- Quantitative review using a sample of the instrument with a brief feedback page
- Feedback was incorporated into the survey design, instructions, layout, and questions

Pilot Test

- IRB approval was obtained before pilot testing
- Pilot survey responses $n = 42$ exceeded the minimum of $n = 35$ to 40 (Johanson & Brooks, 2010)
- Responses were well-distributed; non-response rate was minimal
Data Collection: Population and Sample

Population
- The target population was U.S. IT project managers
- The PMI IS CoP has over 15,000 members worldwide, approximately 40% to 50% of whom reside in the U.S.
- Other studies have used this population to investigate current IT project management practice:
  - Xia and Lee (2005)
  - Mishra, et al. (2009)
- Response rates ranged from 6% to 15%

Sample
- U.S. members of the PMI IS CoP yielded a study population \( N = 6,000 \)
- A 100% probability sample was used
- A priori power analysis indicated minimum sample size \( n = 115 \) for bivariate normal correlation \((\alpha = .05, 1-\beta = .95, r = .30)\)
- Post hoc power analysis for \( n = 235 \) actual qualified responses was \( 1-\beta \) error probability = .9989 \((r = .30)\)
- Overall response rate was 3.9%
Data Collection: Survey Responses

Survey
- Hosted by SurveyMonkey
- Invitations sent by PMI IS CoP

Responses
- Total qualified responses $n = 235$ exceeded minimum of $n = 115$ indicated by power analysis
- Response rate indicated data collection period could have been shortened
- Follow-up reminders could have increased total response
Descriptive Statistics: Demographics

- **Responses:** 235 qualified responses; organizations ranging from fewer than 10 to more than 10,000 employees, annual budgets less than $10 million U.S. to more than $5 billion U.S.

- **Job Titles:** Project Manager (46%), Program Manager (17%)

- **Project Roles:** Project manager (55%), program manager (25%), project team member (7%).

- **PMP Certification:** 76%

- **Industries:** Finance, insurance, and banking (22%), information technology (20%), healthcare (11%), other (10%) including pharmaceuticals, media, government

- **Project Types:** Information technology (39%), software development (33%), application package implementation (11%)
Data Analysis: Construct Distributions

- ITPCx distribution was not significantly non-normal

- ITPCn distribution was not significantly non-normal

- ITPS distribution was significantly non-normal, required a normal transform; NITPS distribution was not significantly non-normal
Data Analysis: Construct Relationships

- Chi-square ($\chi^2$) crosstab results indicated significant relationships for all construct pairs

<table>
<thead>
<tr>
<th>Paired constructs</th>
<th>$\chi^2$</th>
<th>$df$</th>
<th>$R$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITPCx-ITPCn</td>
<td>57.846$^a$</td>
<td>6</td>
<td>.435</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCx-ITPS</td>
<td>44.005$^b$</td>
<td>12</td>
<td>-.339</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCn-ITPS</td>
<td>24.036$^c$</td>
<td>8</td>
<td>-.177</td>
<td>.006</td>
</tr>
<tr>
<td>ITPCx-NITPS</td>
<td>61.710$^d$</td>
<td>15</td>
<td>-.354</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCn-NITPS</td>
<td>40.013$^e$</td>
<td>10</td>
<td>-.218</td>
<td>.000</td>
</tr>
</tbody>
</table>

Note. Based on normal approximation.

$^a$4 cells (33.3%) with expected count less than 5.
$^b$10 cells (50.0%) with expected count less than 5.
$^c$5 cells (33.3%) with expected count less than 5.
$^d$13 cells (54.2%) with expected count less than 5.
$^e$7 cells (38.9%) with expected count less than 5.
Data Analysis: Construct Correlations

- Statistically significant Pearson’s product-moment correlations between all construct pairs and construct-transform pairs
- Statistically significant rank order nonparametric correlations between all pairs, with the exception of the ITPCxITPCn and NITPS pair

<table>
<thead>
<tr>
<th>Paired constructs</th>
<th>Pearson’s</th>
<th>Kendall’s tau&lt;sub&gt;b&lt;/sub&gt;</th>
<th>Spearman’s rho</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>r&lt;sup&gt;2&lt;/sup&gt;</td>
<td>p</td>
</tr>
<tr>
<td>ITPCx-ITPCn</td>
<td>.530</td>
<td>.281</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCx-ITPS</td>
<td>-.356</td>
<td>.127</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCn-ITPS</td>
<td>-.247</td>
<td>.061</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCx-NITPS</td>
<td>-.350</td>
<td>.123</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCn-NITPS</td>
<td>-.228</td>
<td>.052</td>
<td>.000</td>
</tr>
<tr>
<td>ITPCxITPCn-NITPS</td>
<td>-.185</td>
<td>.034</td>
<td>.004</td>
</tr>
</tbody>
</table>
Results: Research Question 1

RQ1: ITPCx – ITPCn
To what extent, if any, is IT project complexity related to IT project complication?

- Pearson’s correlation analysis confirmed a positive correlation existed between IT project complexity and IT project complication, $r = .530$, $r^2 = .281$, $p < .001$.
- Nonparametric rank order correlation was also confirmed with Kendall’s tau_b $\tau = .338$, $p < .001$ and Spearman’s rho $r_s = .483$, $p < .001$.
- **Finding 1: H1<sub>0</sub> rejected.** IT project complexity was positively correlated with IT project complication; $p = .000$ was less than the significance level .05 for bivariate normal correlation indicated by post hoc power analysis.

H1<sub>0</sub>: IT project complexity is not correlated with IT project complication – **Rejected**

H1<sub>A</sub>: IT project complexity is correlated with IT project complication – **Accepted**
Results: Research Question 2

RQ2: ITPCx – ITPS
To what extent, if any, is IT project complexity related to IT project success?

- Pearson’s correlation analysis confirmed a negative correlation existed between IT project complexity and IT project success, $r = -.350$, $r^2 = .123$, $p < .001$.
- Nonparametric rank order correlation was also confirmed with Kendall’s tau $\tau = -.256$, $p < .001$ and Spearman’s rho $r_s = -.363$, $p < .001$.
- **Finding 2: $H_2_0$ rejected.** IT project complexity was negatively correlated with IT project success; $p = .000$ was less than the significance level .05 for bivariate normal correlation indicated by post hoc power analysis.

$H_2_0$: IT project complexity is not correlated with IT project success – **Rejected**

$H_2_A$: IT project complexity is correlated with IT project success – **Accepted**
Results: Research Question 3

RQ3: ITPCn – ITPS
To what extent, if any, is IT project complication related to IT project success?

H3₀: IT project complication is not correlated with IT project success – **Rejected**
H₃ₐ: IT project complication is correlated with IT project success – **Accepted**

- Pearson’s correlation analysis confirmed a negative correlation existed between IT project complication and IT project success, \( r = -0.228, r^2 = 0.052, p < 0.001 \).
- Nonparametric rank order correlation was also confirmed with Kendall’s tau \( \tau = -0.123, p < 0.01 \) and Spearman’s rho \( r_s = -0.181, p < 0.01 \).
- **Finding 3: H3₀ rejected.** IT project complication was negatively correlated with IT project success; \( p = 0.000 \) was less than the significance level .05 for bivariate normal correlation indicated by post hoc power analysis.
Results: Research Question 4

<table>
<thead>
<tr>
<th>RQ4: ITPCx – ITPS vs. ITPCn – ITPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent, if any, is IT project complexity more strongly related to IT project success than is IT project complication?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H4₀: IT project complication has an equal or greater correlation with IT project success than does IT project complexity – <strong>Rejected</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H₄ᴬ</strong>: IT project complexity has a greater correlation with IT project success than does IT project complication – <strong>Accepted</strong></td>
</tr>
</tbody>
</table>

- Pearson’s correlation coefficient for IT project complexity and IT project success, \( r = -.350, r^2 = .123, p < .001 \) had a greater negative value than did Pearson’s correlation coefficient for IT project complication and IT project success, \( r = -.228, r^2 = .052, p < .001 \).
- Nonparametric rank order correlations for IT project complexity and IT project success, Kendall’s \( \tau_b = -.256, p < .001 \) and Spearman’s rho \( r_s = -.363, p < .001 \) also had greater negative values than did nonparametric correlations for IT project complication and IT project success, Kendall’s \( \tau_b = -.123, p < .01 \) and Spearman’s rho \( r_s = -.181, p < .01 \).
- **Finding 4: H₄₀ rejected.** IT project complexity had a greater negative correlation with IT project success than did IT project complication.
Results: Summary

Results

• All null hypotheses rejected
• ITPCx and ITPCn were positively correlated ($r = .530$, $r^2 = .281$, $p < .001$) to a greater degree than either variable and ITPS
• ITPCx and ITPS were negatively correlated ($r = -.350$, $r^2 = .123$, $p < .001$) to a greater degree than were ITPCn and ITPS ($r = -.228$, $r^2 = .052$, $p < .001$)

Revised conceptual model

Legend:
- Primary Relationship
- Secondary Relationship

ITPCx

ITPCn

ITPS

$r^2 = .123$

$r^2 = .281$

$r^2 = .052$
Discussion

Results confirmed

• Positive correlation between IT project complexity and IT project complication
• Negative correlation between IT project complexity and IT project success
• Negative correlation between IT project complication and IT project success
• Stronger negative correlation between IT project complexity and IT project success

Generalizability may have been limited by a number of factors

• Nature of the sample
• Structure of some of the survey questions
• Relative immaturity of the variable constructs
• Non-normal distribution for IT project success
• Lower effect size of the correlations between IT project complexity and IT project complication, respectively, and IT project success
Discussion: ITPCx – ITPCn

Results confirmed the hypothesis with a positive correlation between ITPCx and ITPCn

Heteroscedasticity:
• Indicated the constructs were related but distinct
• IT projects present differing degrees of complexity and complication

Unexpected stronger correlation than between any other variables:
• Possible comingling of factors or negative intra-scale correlations
• Other moderating or confounding variables

Implications:
• More research into factors contributing to IT project complexity and IT project complication
• More effective models for analyzing IT project complexity
Discussion: ITPCx – ITPS and ITPCn - ITPS

Results confirmed the hypotheses with a negative correlation between ITPCx and ITPS, and a negative correlation between ITPCn and ITPS

Weaker effect size than expected:
• Possible intra-scale correlations
• Other moderating or confounding variables

Implications:
• Need for further study into factors, constructs, and relationships
• Application of project screening and assessment models
Discussion: ITPCx – ITPS vs. ITPCn – ITPS

Results confirmed the hypothesis with a stronger negative correlation between ITPCx and ITPS than between ITPCn and ITPS

Implications:
- IT project complexity and IT project complication are related but distinct sets of IT project characteristics; there is a difference between complexity and complication
- Complexity has a stronger negative relationship with IT project success than does complication
- Focus on identifying, mitigating, and accommodating IT project complexity in order to increase the likelihood of IT project success
Conclusions

- Confirmed other studies showing a negative correlation between IT project complexity and IT project success (Xia and Lee, 2004; Burkatzky, 2007)
- Extended and tested the project complexity model developed by Hass (2009)
- Distinguished between project complexity and project complication (Baccarini, 1996; Cilliers, 1998)
- Provided a comprehensive overview of project management theory from historical, organizational, analytical perspectives
- Applied systems paradigms from organizational theory to project management theory; extended the framework with a complex adaptive systems view
- Provided empirical evidence of a distinction between project complication and project complexity, and their differing relationships with project success

There is a difference between complexity and complication.
Limitations

Population and Sample
• The study population may not have been representative of the target population, U.S.-based IT project managers
• Possible non-response bias was present in the sample

Survey Questions
• Single response choice to indicate N/A or Unknown
• Possible lack of clarity in the wording of some questions

Construct Elements and Factors
• Distribution for the ITPS construct was not normal
• Possible flaw in the scales used to assess IT project success

Construct Correlations
• Weak correlations between the independent variables and the dependent variable
• Moderate effect sizes of the correlations and high degree of heteroscedasticity
Recommendations

Recommendations from Results

• Refine the distinction between complexity and complication
• Develop more specific and useful models of the factors contributing to project complexity and project complication
• Extend research into other types of projects

Recommendations from Limitations

• Identify a more representative study population
• Include survey participants from other geographic locations
• Shorten the survey response period, or increase overall response with follow-up reminders
• Test and refine survey questions
• Revise scales for IT project success to include an equal number of positive and negative categories
• Use factor analysis or structural equation modeling to refine factors and constructs

Recommendations from Delimitations

• Use different definitions and criteria for project success to clarify relationships between complexity and project success
• Investigate correlations between individual factors of IT project complexity and different measures of IT project success to identify dimensions of project complexity most strongly related to specific project success criteria
• Investigate relationships between the project and systems development methodologies used and the likelihood of success on complex IT projects

Recommendations for Further Investigation

• Develop a tested and reliable instrument for assessing IT project complexity and complication
• Extend analysis to include effects of additional project characteristics such as methodology selection, technology platforms, project staffing, communication methods, and team composition on success rates for complex IT projects
References


