B.Comp. Dissertation

The Impact of Technical vs. Leadership Competency of the ISD Project Manager:

A *NK* Landscapes Fitness Modeling Approach

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Abstract

Although the success of ISD projects remains critical in current organizations, recent surveys have shown that the ISD project success rates are particularly low. The ISD project manager plays an important role in facilitating the ISD process and overseeing the whole project. Thus, it is critical for the ISD manager to possess leadership and technical competencies. Nevertheless, the relationship between the ISD project success rate and these two competencies have not been well examined by recent researches. In this study, the *NK* fitness landscapes model was used to explore the impact of the ISD project manager's leadership and technical competencies to the ISD process and ultimately the ISD performance. In practice, we try to answer questions such as how to strike a balance between leadership and technical competencies when it comes to assigning a project manager to the ISD project?

Keywords: Information System Development (ISD), *NK* fitness model, project management, leadership competency, technical competency

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Here I would like to show my great gratitude to my FYP supervisor Prof Hahn Jungpil for his enthusiastic encouragement, patient guidance, and valuable critiques of the research work.

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List of Figures

Table of Content

1 Introduction

Success in Information System Development (ISD) projects remains critical in many organizations as computer-based technology plays an increasingly important role in many functions in organizations. According to the Standish Group Chaos Report for 2009, overall 68% of surveyed ISD projects failed or were canceled because they could not be delivered on schedule, within budget or with the required functionalities (Standish Group International, 2009). Although the definition of ISD failures varies among IS professionals, the majority of ISD projects are considered unsuccessful (El Emam and Koru, 2008).

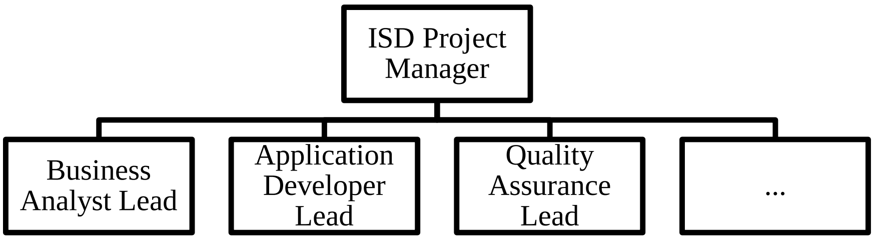
Project management experts from various industries have rated leadership competency as one of the top three most important skills and competencies for effective project managers (Schwalbe, 2011). Same as any leader, an ISD project manager should not only be able to focus on “big-picture” objectives and the overall success of the project, but also inspire project team members to reach a common goal. This is especially crucial in the context of ISD as ISD projects are categorized by both intra-domain and inter-domain interdependencies among decision factors (Hahn & Lee, 2012). How well the ISD project manager can leverage on the leadership competency to promote a common goal in the team definitely has an impact on the success of the project. Besides leadership competency, the ISD project manager must have technical competency related to the specific project in order to make good decisions and keep the ISD project on track (Schwalbe, 2011).

Although the topic about ISD project management has received considerable attentions from academics and practitioners and there is still a need to better understand the ISD project manager’s technical and leadership competencies; how exactly these two factors affect the success of the ISD project has not been well examined. There is no clear answers to questions such as how do organizations strike a balance between technology competency and leadership competency when they assign an IT project manager to an ISD project and does either one of these two competencies outweighs the other in the context of ISD. In order to answer these questions, a *NK* fitness landscapes model is used to theoretically explore how the ISD project manager’s technical and leadership competencies influence the ISD process thus ultimately affecting its performance and success.

2 Theoretical Background

2.1 Hierarchy Structure in ISD Project Team

Figure 1. Sample ISD Project Team Hierarchy Structure



As technologies keep evolving and the complexity of information systems increases, people working in the field of technology tend to specialize in some particular domains. Thus, it is a common practice to group ISD team members into functional sub-teams such as business analysis (BA) team and application development (AD) team, according to their domain knowledge and skill sets. There is a subordinate lead for each of the sub-teams who report to the ISD project manager (Figure 1). This forms the vertical hierarchy that embodies an overall ISD project manager, subordinate sub-team leads and a flow of information among them, which is similar to the common vertical hierarchy in many organizations (Rivkin & Siggelkow, 2003).

According to subordinate sub-team leads' specialties, the ISD project manager will delegate the duty of proposing solutions within each domain to corresponding subordinate sub-team leads. However, the ISD project manager has the power to decide whether to accept or reject proposals based on his own judgment. Being at the top of this vertical hierarchy, the ISD project manager's main objective is to move the whole project forward by adapting better decision sets until the ISD team reaches an acceptable configuration.

2.2 ISD As a Problem Solving Process

Conceptually, ISD can be seen as a problem solving process within a configuration space where information is collected and processed (Newell & Simon, 1972). Ultimately, the ISD team tries to achieve a system configuration that contributes to the organization in the best way. This process is generally iterative and incremental with current information systems development methodologies (ISDM).

Many experts agree that one of the greatest threats to the success of any project, especially information technology projects, is the failure to communicate (Schwalbe, 2011). This can lead to a lack of alignment between objectives of sub-teams and the overall ISD team because sub-team leads cannot take a holistic view of all decision factors in the ISD project. Due to the segregation of duties, sub-team leads do not have enough knowledge or information about what would happen beyond their own domains and the effects of his or her decisions beyond their domain. With this limitation, each sub-team lead can only propose desirable moves within their perceived configuration space (i.e. their delegated domains).

However, the combination of these individual “desirable” moves may not necessarily lead to overall better project performance. The reason lies in the complexity of the ISD project, namely, a significant amount of interdependencies among decision factors. It is possible that the efficacy of performing on tasks is affected not only by some intra-domain decisions, but also by some other inter-domain decisions. For example, when most of the developers involved in the project are most familiar with Java, the AD team lead may simply choose Java as the major programming language so developers can work more efficiently. However, if taking in to consideration the natural language processing requirement received by the BA team from the client, Python’s Natural Language Toolkit (NLDK) may be more suitable for the project. To prevent sub-team leads overlooking the effects of interactions of inter-domain decisions thus compromising the overall project performance, the ISD project manager plays a crucial role as a leader to encourage communication and coordination. This will be further discussed in the next section.

2.3 The ISD Project Manager’s Technical and Leadership Competencies

There is no doubt that the ISD project manager needs to have specific technical competency related to the particular ISD project which include both product knowledge and business domain knowledge (Schwalbe, 2011). This provides a basis for judgment when it comes to evaluating proposals, which is submitted by sub-team leads as discussed in the previous section. We call an ISD project manager with technical competency as an “active” manager, because he exercises discretion (Rivkin & Siggelkow, 2003). An active ISD project manager can fully understand the implications of technical decisions thus being able to gauge how the proposals submitted by sub-team leads (i.e. configuration of decision subsets) will contribute to the overall performance of the ISD team. He compares different combinations of proposals and then decides to accept some proposals while to reject the others in order to achieve a better tradeoff. In contrast, an ISD project manager without technical competency is called a “rubberstamping” manager as he simply accepts all proposals submitted by subordinate sub-team leads without knowing whether the configuration of one decision subset will undermine the efficacy of another decision subset (Rivkin & Siggelkow, 2003).

Leadership competency is the key to tackling the problem mentioned in the previous section. Without communication and coordination, a subordinate sub-team lead will only evaluate the configuration of the decision subset within his domain without taking into consideration impacts of other sub-teams' decisions. As a result, he may make decisions that benefit the sub-domain at the expense of the overall project performance. Therefore, besides technical knowledge, the ISD project manager should also have the ability to inspire the team to reach a common goal by facilitating knowledge sharing and information flow among functional sub-teams. Thus, subordinate sub-team leads can better align their objectives with the team objectives. The level of the ISD manager's leadership competency will directly affect how "considerate" the sub-team leads to each other.

2.4 Hypotheses

Theoretically, as an active manager takes a holistic view of the technical aspects of the project and aims to achieve a better tradeoff among decisions made by sub-team leads, he is able to reject decisions that benefit certain sub-teams at the expense of the overall project performance. Hence, we hypothesize:

Hypothesis 1: An active manager will outperform a rubberstamping manager because he can lead the ISD team to achieve a better performance in the end of the project.

As discussed in the previous section, how well the subordinate sub-team leads can align their objectives with the overall team objectives depends on to what extend they are encouraged to communicate and coordinate among each other. Better communication and coordination is expected with higher level of the ISD manager's leadership competency. Thus, leadership competency is supposed to promote goal alignment and reduce chaos in the team:

Hypothesis 2: A manager with higher level of leadership competency will be more efficient since he is able to reduce chaos in the team thus leading the ISD team to arrive at the common goal faster.

Furthermore, when the project complexity increases, there are more interdependencies among decision factors. Chances of biased decisions made by a sub-team lead compromise the overall performance become higher. Therefore, it is more critical to have an ISD project manager who can oversee all the technical aspects of the project as well as encourage communication and coordination among sub-teams. As a continuation from H1 and H2, we hypothesize:

Hypothesis 3: The advantage of technical and leadership competencies will be more prominent in an environment with high project complexity.

To examine the three hypotheses above, we build a computational model of ISD model, which will be systematically explored using simulation techniques. The modeling approach is further elaborated in the next session.

3 An *NK* Fitness Landscapes Model of ISD

The *NK* fitness landscapes approach was developed to model adaptive agents' result-oriented problem-solving process in modular systems and statistically find out the speed and effectiveness of adaptation to an optimal performance (Davis, Eisenhardt & Bingham, 2007). As such, two primary modeling constructs must be specified – 1) the decision space (i.e., a fitness landscape), and 2) the agent's behavioral rules for result-oriented adaptation (Hahn & Lee, 2012). An ISD can be conceptualized as search within a configuration space (Newell & Simon, 1972); in other words, the ISD team members can be viewed as agents directed by the behavioral rules, striving to achieve (or "search for") the best outcome via configuring a set of decisions (i.e., the decision space). Therefore, the *NK* model is applicable and suitable in the context of ISD where N represents all the decisions that need to be made in the ISD process while K indicates the ISD project complexity, which is determined by the degree of interactions among ISD decisions. The modeling framework provides a systematic way to observe and track agents' result-oriented adaptation behaviors within the fitness landscape. By simulating many different agents' behaviors within various fitness landscapes, the researcher can analyze the statistical properties of results (e.g. average fitness level, average time to reach the ultimate performance, etc.) in different problem contexts.

3.1 Setting the Pattern of Interaction

The ISD project team must make N binary decisions about how to achieve a collective goal of delivering the information system. N indicates that a real ISD project team must make a large amount of decisions. It must decide, for instance, whether to use a certain framework or not, whether to accept certain user requirement or reject it, whether to build a real time system or a batch system, and so forth. An N-digit string of zeros and ones represents the whole decision set the ISD team makes that contributes to its performance. This can be modeled as $\boldsymbol{d} = <d_1, d_2, d_3, \ldots, d_N>$, which shows a particular ISD configuration. Each decision i makes a contribution C_i to the overall ISD project performance. The efficacy of each decision is affected not only by the choice (0 or 1) of itself, but also by the choices of K other decisions. Given this, $C_i = C_i(d_i | K\ other\ d_j)$. The number of interdependencies K

represents complexity of the ISD project. In the simulation, K can range from 0 to N–1. $K = 0$ implies that all decisions are independent. $K = N$-1 indicates that each decision is influenced by all the other decisions (i.e., full interaction).

A $N \times N$ influence matrix $\boldsymbol{I}$ reflects the interdependencies among decisions. Figure 2 shows some examples of interactions patterns of decision factors for $N = 6$. The $(i, j)^{th}$ entry of $\boldsymbol{I}$ is marked by $\boldsymbol{X}$ if row decision i is influenced by the contribution of column decision j and is blank otherwise.

Figure 2. Interaction Patterns of Decision Factors (*N*=6)

A. Independence

$$\begin{bmatrix} X & & & & & \\ & X & & & & \\ & & X & & & \\ & & & X & & \\ & & & & X & \\ & & & & & X \end{bmatrix}$$

B. Full Interaction

$$\begin{bmatrix} X & X & X & X & X & X \\ X & X & X & X & X & X \\ X & X & X & X & X & X \\ X & X & X & X & X & X \\ X & X & X & X & X & X \\ X & X & X & X & X & X \end{bmatrix}$$

C. Perfect Modularization

$$\begin{bmatrix} X & X & X & & & \\ X & X & X & & & \\ X & X & X & & & \\ & & & X & X & X \\ & & & X & X & X \\ & & & X & X & X \end{bmatrix}$$

D. Good Modularization

$$\begin{bmatrix} X & X & X & X & & \\ X & X & X & & X & \\ X & X & X & & X & \\ X & & & X & X & X \\ & X & & X & X & X \\ & & X & X & X & X \end{bmatrix}$$

3.2 Searching the Landscape

3.2.1 Decomposition: Allocation of Decisions

The ISD team is divided into S functional sub-teams, each of which is lead by one subordinate sub-team lead. Assuming decisions are equally allocated to all sub-teams, each sub-team lead is in charge of configuring a decision set with N/S decision factors.

3.2.2 Search Process

Search proceeds in a series of periods. Each period begins with the subordinate sub-team leads evaluating and comparing the performances of configurations of choices in his domain. Take N= 6 as an example, suppose the current configuration of the team choices is $\boldsymbol{d}$ = <1, 0, 1, 1, 1, 0> and there are only two sub-teams A and B (i.e., $S = 2$). This means that the current configuration of choices in subordinate lead A's domain is $\boldsymbol{d}_A$ = <1, 0, 1, ?, ?, ?> while the current configuration of choices in subordinate lead B's domain is $\boldsymbol{d}_B$ = <?, ?, ?, 1, 1, 0>. Subordinate lead A will consider all alternatives to $\boldsymbol{d}_A$ by making a single change to the configuration, namely, <0, 0, 1, ?, ?, ?>, <1, 1, 1, ?, ?, ?> and <1, 0, 0, ?, ?, ?>. By comparing the performance of the possible alternatives with the status quo, he will chose a better configuration and send the proposal to the project manager. After receiving all the proposals, the ISD project manager will decide whether approve or disapprove the proposals thus having a final say about next move. This ends one searching period and then the following periods will repeat this process.

3.2.3 ISD Project Manager's Leadership Competency

DEGREE, a parameter that ranges from 0 to 1, represents the level of the ISD project manager's leadership competency. *DEGREE* reflects how well the ISD project manager can leverage on his leadership competency to facilitate knowledge and information sharing thus capturing the degree to which the subordinate sub-team lead cares about the ramifications of his actions on other sub-teams. *DEGREE* = 0 indicates that without ISD project manager's facilitation, a subordinate lead will only consider the effects of his changes within his own domain. *DEGREE* = 1 implies that a subordinate lead is able and is willing to consider the collective effects of changes within and outside his domain. Continuing with the $N = 6$ example, to assess the effect of alternatives, subordinate lead A will consider $P = \{[C_1(d_1'|K\ other\ d_j s) + C_2(d_2'|K\ other\ d_j s) + C_3(d_3'|K\ other\ d_j s)] + DEGREE \times [C_4(d_4|K\ other\ d_j s) + C_5(d_5|K\ other\ d_j s) + C_6(d_6|K\ other\ d_j s)]\}/6$, assuming that choices in the other sub-team will not change. Once he finds a configuration with better performance from his perspective, he will submit a proposal to the ISD project manager. If none of the sub-team leads can find any better alternative, the ISD team has reached a sticking point. A sticking point may not be the global peak but rather a local peak - a point where all the alternatives at the immediate neighborhood are inferior.

3.2.4 ISD Project Manager's Technical Competency

TECH, a parameter which either equals 0 or 1, represents the ISD manager's technical competency. *TECH* = 1 implies that the ISD manager is an active manager while *TECH* = 0 implies that he is a rubberstamping manager. An active manager is also an experienced technologist himself, so he is able to evaluate proposals submitted by subordinate team leads and decide to accept or reject proposals. Continuing with above example, if the previous configurations is $<d_1, d_2, d_3, d_4, d_5, d_6>$ and the proposals are $<d_1', d_2', d_3'>$ and $<d_4', d_5', d_6'>$, the ISD manager will choose the best configuration among $<d_1', d_2', d_3', d_4, d_5, d_6>$ (i.e., approve A's proposal), $<d_1, d_2, d_3, d_4', d_5', d_6'>$ (i.e., approve B's proposal), $<d_1', d_2', d_3' d_4', d_5', d_6'>$ (i.e., approve both A's and B's proposals) and $<d_1, d_2, d_3, d_4, d_5, d_6>$ (i.e., reject both A's and B's proposal). In contrast, a rubberstamping manager does not have enough technical knowledge to evaluate proposals, so he will simply approve both proposals submitted by subordinate lead A and B, which means the project manager will always choose <d_1', d_2', d_3' d_4', d_5', d_6'> as the next move.

The impact of ISD project manager's technical and leadership competencies on ISD performance will be analyzed experimentally by implementing the above formal model under various experimental conditions.

4 Experiment Design

4.1 Experiment Setting

Previous studies in the management literature using *NK* fitness landscapes model have used *N* ranging from 6 to 16 (i.e., Siggelkow & Rivkin, 2005; Siggelkow & Rivkin, 2006; Almirall & Casadesus-Masanell, 2010). When N = 16, there are 2^{16} (i.e., 65,536) possible configurations of the ISD project. It is impractical to search through all these configurations exhaustively. Hence, to generate fitness landscapes corresponding to ISD projects of sufficient size, *N* is set as 16 in this study. Each simulation will be run until the ISD project has reached a stable status, in other words, further improvements cannot be made.

Since ISD domain knowledge can be mainly divided into application knowledge and functional domain knowledge (Reich & Benbasat, 2000), the number of sub-teams (*S*) is set as 2 in the experiment. Thus, each ISD team consists of two sub-teams lead by subordinate lead A and B. Subordinate lead A is responsible for the first half of the *N* decisions and subordinate lead B is responsible for the other half. The configuration of each set of the decisions represents decisions made by the subordinate lead respectively. Subordinate A and B will submit one proposal each at the end of each period.

For the purpose of this experiment, *DEGREE* is set at discrete levels (i.e., *DEGREE* = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1) to represent 11 levels of the ISD manager's leadership competency and *TECH* is set to alternate between 0 and 1 to show an ISD manager without (i.e., "rubberstamping") or with (i.e., "active") technical competency.

In order to investigate the impact of the ISD project manager's leadership competency and technical competency, firstly both parameters *DEGREE* and *TECH* are manipulated at a certain level on ISD complexity (e.g. K = 8), which leads to 22 experimental conditions – 11 levels of *DEGREE* × 2 levels of *TECH*. To scrutinize the robustness of findings, the ISD complexity parameter *K* will be varied for N=16 (i.e., K=0, 1, 2, …, 15) to represent all levels of overall landscape complexity. Hence, there are 352 experimental conditions in total – 22 × 16 levels of *K*. Furthermore, 20 randomly generated influence matrix are used at each level of K except when K = 0 and K = 15. Thus, totally we have 6204 simulation runs. At each simulation run, multiple observations (e.g., 100) are made so the average performance can be computed at each period.

4.2 Performance Measurement

The results will be analyzed from two different perspectives – effectiveness and efficiency. Firstly, I will compare the ultimate status the ISD project team remained at. The higher the fitness value is, the better performance is achieved. Secondly, I will look at how many periods the ISD project team takes to reach the ultimate fitness level. The less the number of period is, the faster the ISD team reaches the final result, in other words, the more efficient the ISD team is.

5 Result Analysis

5.1 The Impact of Project Manager's Leadership Competency in ISD Process

In this section, we investigate the effects of the project manager's leadership competency with varied technical competency at moderate project complexity (*K*=8). Namely, we will examine a rubberstamping manager's and an active manager's leadership competency separately.

5.1.1 The Impact of Rubberstamping Manager's Leadership Competency

Figure 3a represents a series of simulations that examine the average performances of the ISD teams led by a rubberstamping manager with different degrees of leadership competency – from no leadership competency (*DEGREE*=0.0) to very high leadership competency (*DEGREE*=1.0). As mentioned in the previous section, ISD performance is measured as the average of the highest performance attainable (effectiveness) and the average time taken to finish the ISD project (efficiency). Figure 3a shows that a rubberstamping manager's leadership competency affects the ISD team's performance positively, especially in terms of efficiency. From Figure 3b, we see that the ISD team led by a rubberstamping manager with higher leadership competency achieves better results in the end. Specifically, the improvement is more observant at low degrees of leadership competency. Figure 3c shows that there is an exponential decay of time taken to finish the project when the level of leadership competency increases. Without an active manager closely oversees the technical aspects of the project across all the sub-teams, it is more critical that sub-team leads would align their objectives with the team objectives thus reaching the ultimate team performance faster.

In short, leadership competency plays an important role in the performance of the ISD team led by a rubberstamping manager, especially with regard to efficiency.

Figure 3a. Rubberstamping Manager's Performance by Level of Leadership Competency (*N*=16, *K*=8)

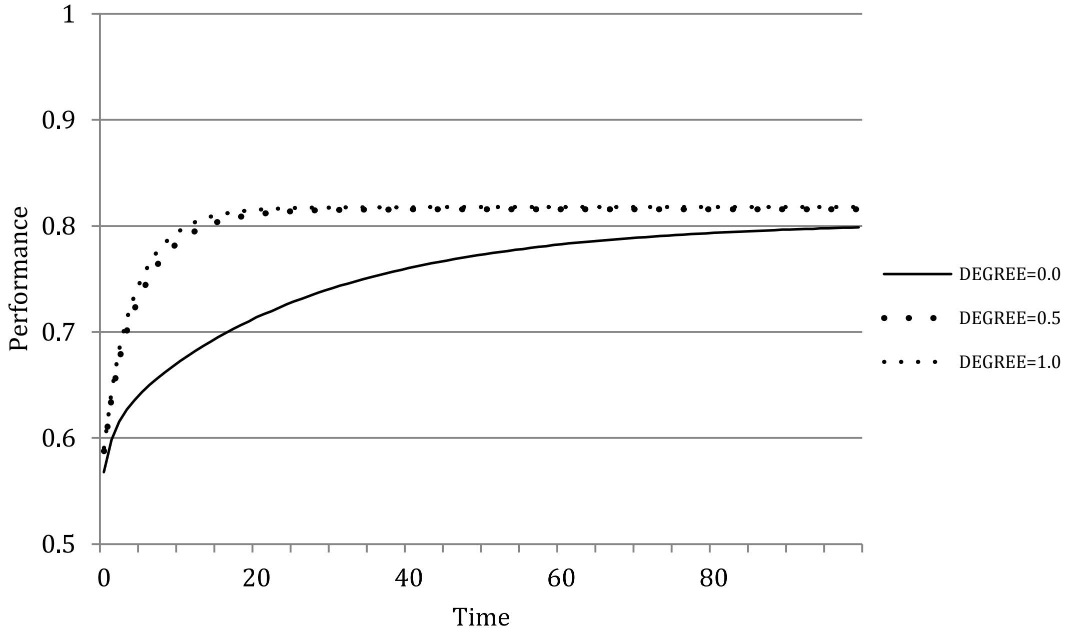


Figure 3b. Rubberstamping Manager's Effectiveness at Different Levels of Leadership Competency (*N*=16, *K*=8)

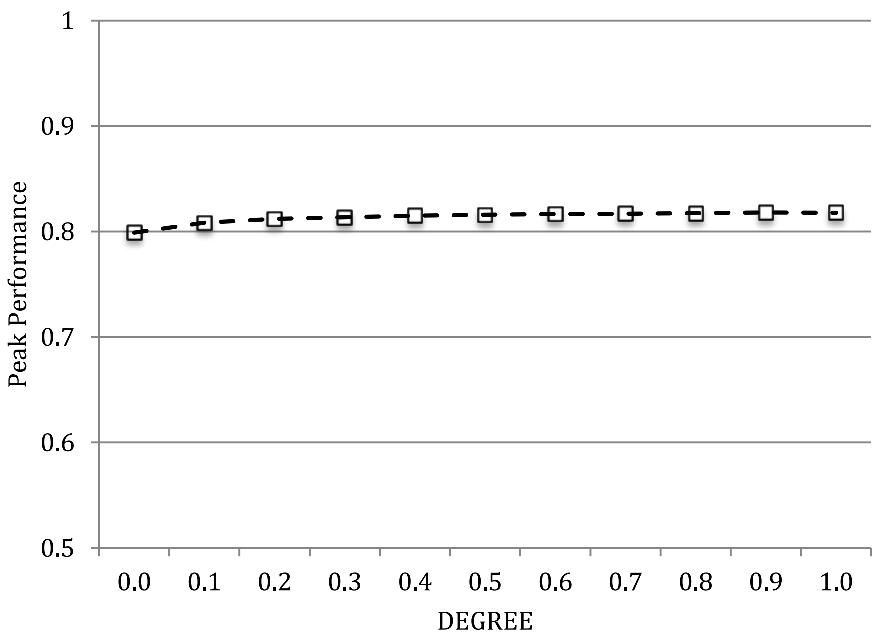
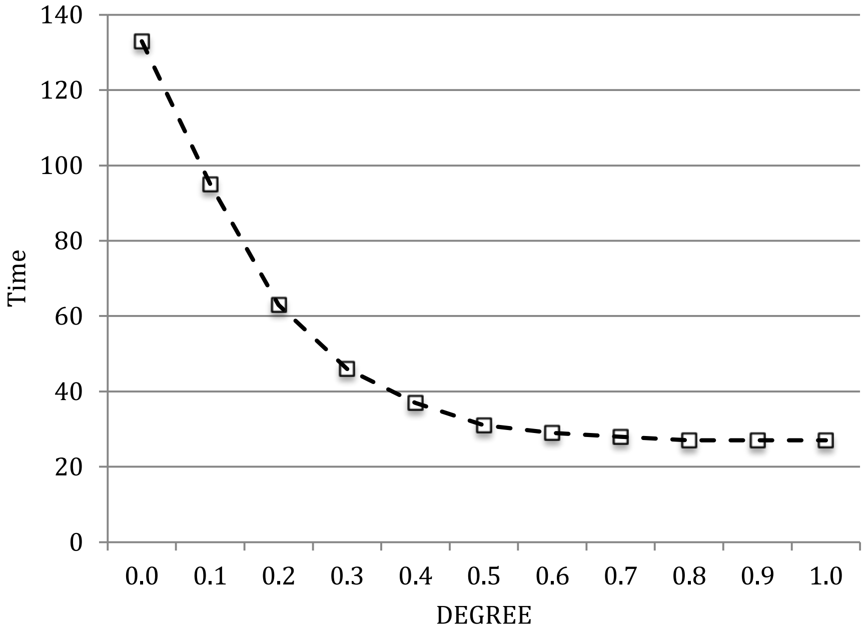


Figure 3c. Rubberstamping Manager's Efficiency at Different Levels of Leadership Competency (*N*=16, *K*=8)



5.1.2 The Impact of Active Manager's Leadership Competency

Similarly, Figure 4a represents a series of simulations that examine the average performances of the ISD team led by an active manager with different degrees of leadership competency – from no leadership competency (*DEGREE*=0.0) to very high leadership competency (*DEGREE*=1.0). From Figure 4a, the active manager's leadership competency positively affects the ISD team's performance. An ISD team led by an active manager with higher leadership competency performs better, in terms of both effectiveness and efficiency. From Figure 4b, we see that the ultimate performance is improving almost linearly when the level of leadership competency increases. Figure 4c shows that the ISD team led by an active manager with no leadership competency is the last to plateau in terms of speed. And the time to plateau decreases when the level of leadership competency increases and remains stable afterwards when the level of leadership competency reaches certain level.

In short, an active manager's leadership competency positively affects both the ISD team's efficiency and the ultimate result.

Figure 4a. Active Manager's Performance by Level of Leadership Competency (*N*=16, *K*=8)

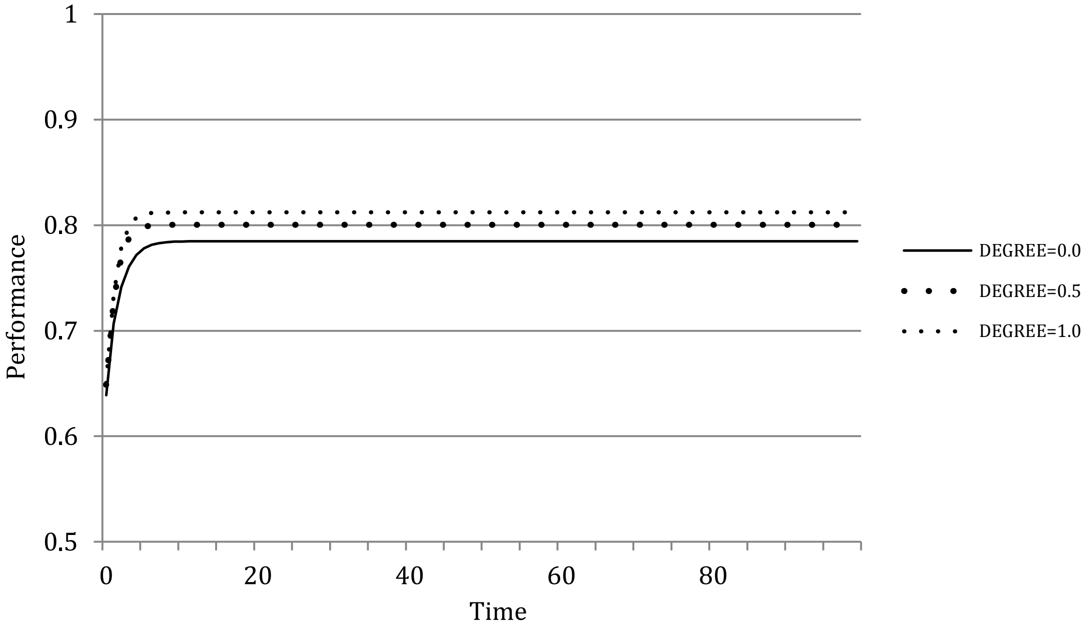


Figure 4b. Active Manager's Effectiveness at Different Levels of Leadership Competency (*N*=16, *K*=8)

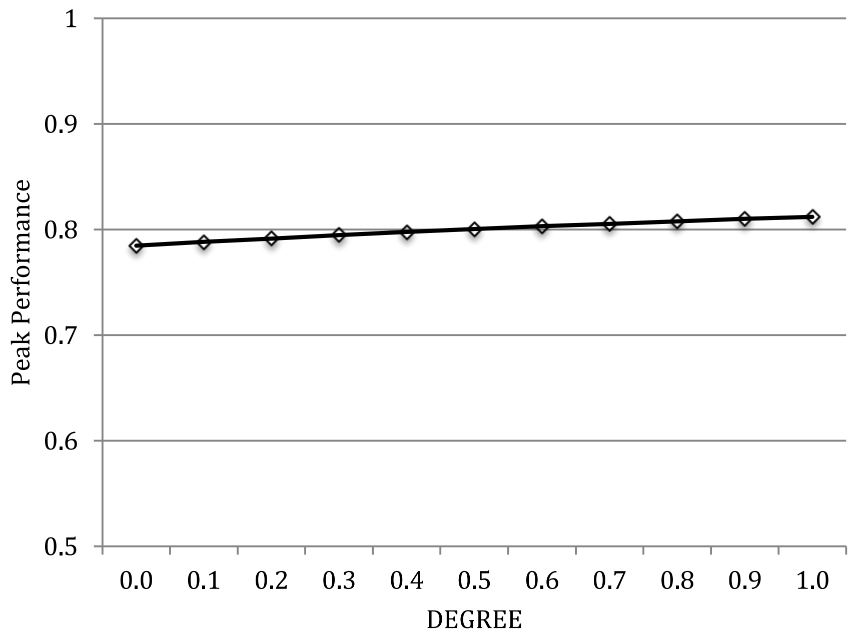
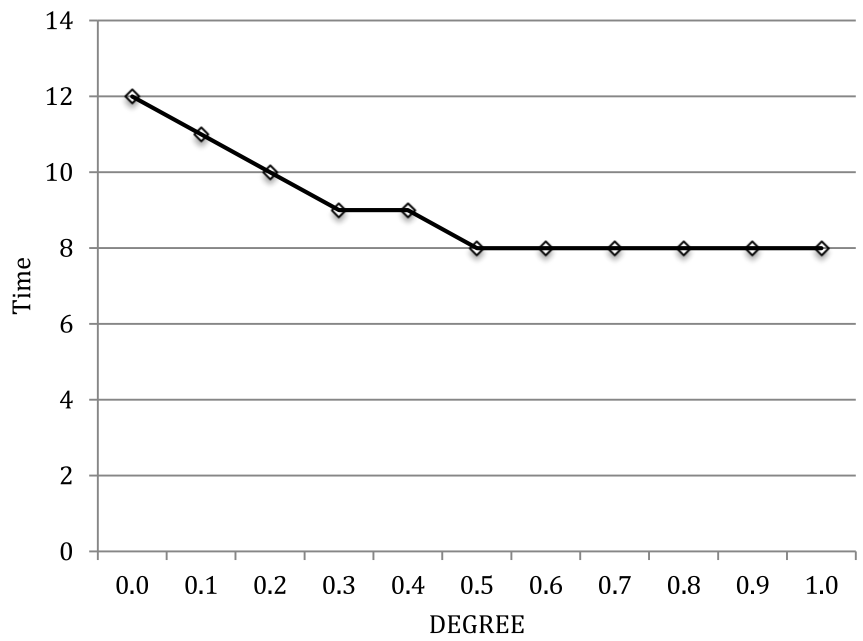


Figure 4c. Active Manager's Efficiency at Different Levels of leadership Competency (*N*=16, *K*=8)



5.2 The Impact of Project Manager's Technical Competency in ISD Process

In this section, we investigate the effects of the project manager's technical competency with varied leadership competency. We will compare the active manager's and the rubberstamping manager's performances at different degrees of leadership competency at a moderate project complexity (*K*=8), followed by further exploring the differences between the active manager's and rubberstamping manager's efficiencies and effectiveness at low (*K*=2), moderate (*K*=8) and high (*K*=14) project complexity.

Firstly we examine the performances of both the active manager and the rubberstamping manager at moderate project complexity (*K*=8). Comparing Figure 3a and Figure 4a in previous sections, we have a big picture that although there are only subtle differences between an active manager's and a rubberstamping manager's ultimate performances, time taken to finish the project differ dramatically. A rubberstamping manager takes much more time to finish the ISD project although he can achieve slightly better results. Next we will take a close look at this result by studying effectiveness and efficiency separately at selected levels of project complexity.

Figure 5a shows the effectiveness differences between the active manager and the rubberstamping manager. At most of time, the rubberstamping manager outperforms the active manager. Without an active manager's interference, sub-team leads can make full advantage of their expertise and creativity thus achieving overall better results in the end. The difference between the peak performances is firstly increasing when leadership competency increases and then decreasing afterwards, which is observed at all selected levels of project complexity. This is not surprising when we look at Figure 3b and Figure 4b together. With increasing leadership competency, the increase in the active manager's effectiveness is almost linear while the increase in the rubberstamping manager's effectiveness is more prominent at low level of leadership competency. As discussed previously, a little consideration for other sub-teams plays an important role in increasing the ultimate result for the ISD team led by the rubberstamping manager since the manager does not oversee the project from the technical aspects. The active manager outperforms the rubberstamping manager at low project complexity and with low leadership competency, or at high project complexity and with high leadership competency. In the first case, none or little consideration for other sub-teams does not deeply affect the ISD team led by the active manager as he always evaluate all the decisions made by sub-team leads separately. In the second case, mutual considerations among sub-team leads are not enough because there are too many interdependencies among decision factors. Thus, the active manager's technical competency comes in to play to re-boost the team performance that is diminished by the increasing complexity of the project. What need to be noticed here is that although all these performance differences are statistically significant, they are not economically significant since the percentage increase is quite minimal (Figure 5c).

Figure 5b shows the active manager's and the rubberstamping manager's performance in terms of efficiency. The ISD team led by a rubberstamping manager takes much more time to complete the project, especially when the project is complex and the manager's leadership competency is low. On the one hand, the percentage increase in time taken to complete the project by the rubberstamping manager is unacceptable comparing the improvement in the performance (Figure 4e). On the other hand, within given deadline, the ISD team led by the rubberstamping manager may not even be able to achieve the theoretical ultimate performance.

In summary, a rubberstamping manager can achieve slightly better ultimate performance by allowing the sub-team leads to make full advantage of their expertise and creativity. However, this is achieved at a cost of manageability of the project. In order to increase about 1% of the peak performance, at least 50 times increase in time is observed (Figure 5c & 5d). Although a rubberstamping manager with higher leadership competency has better control of the project in terms of time management, he sacrifices too much in efficiency for effectiveness. An active manager definitely has better time management of the project and is still able to achieve a competitive result.

Figure 5a. Effectiveness Difference (Fitness (Rubberstamping Manager) – Fitness (Active Manager))

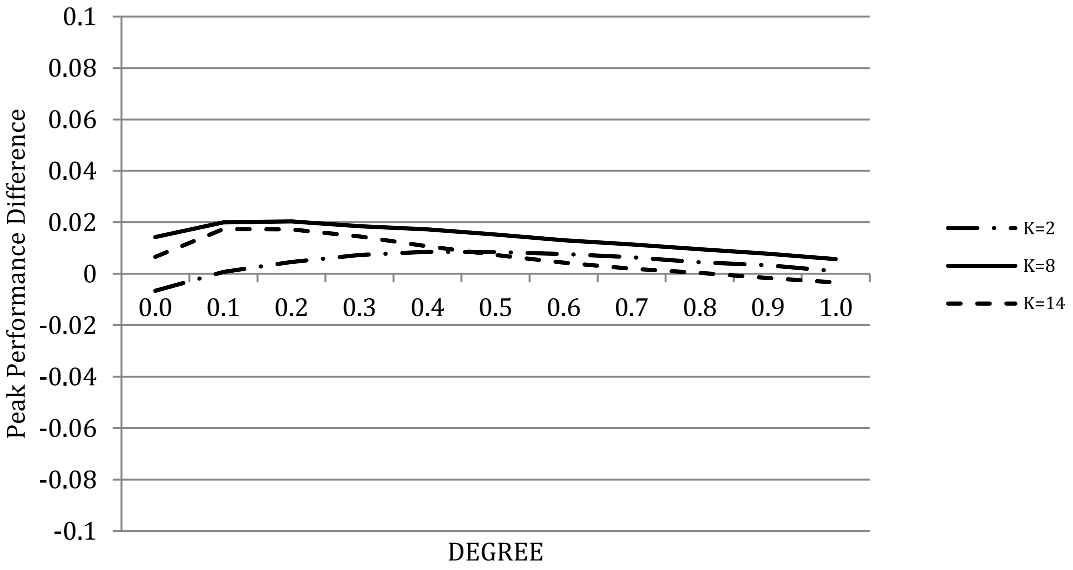


Figure 5b. Efficiency Difference (Time (Rubberstamping Manager) – Time (Active Manager))

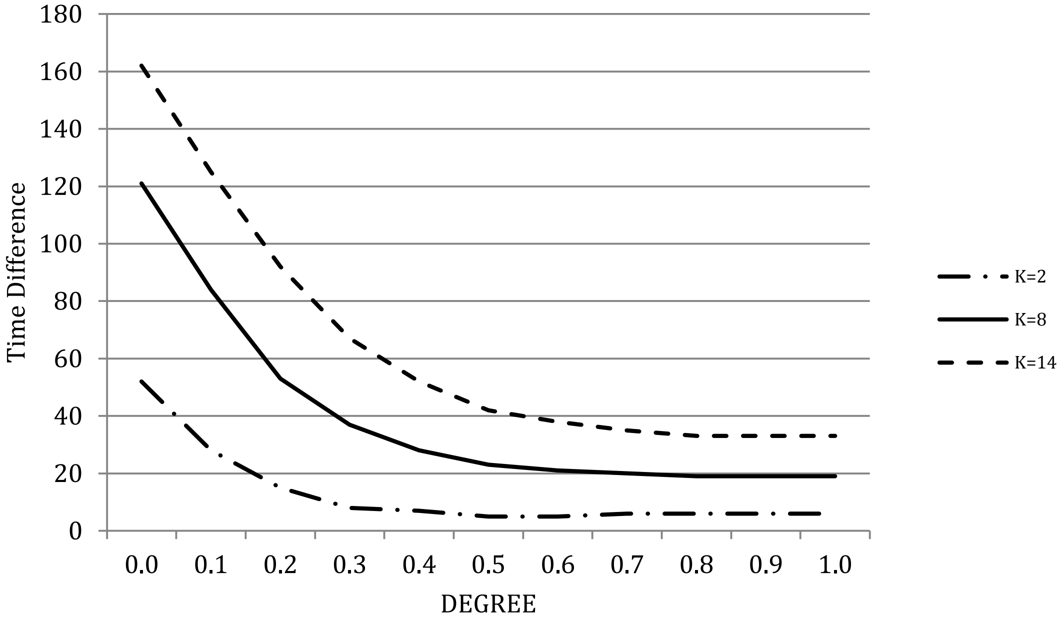


Figure 5c. Performance Increase Rate

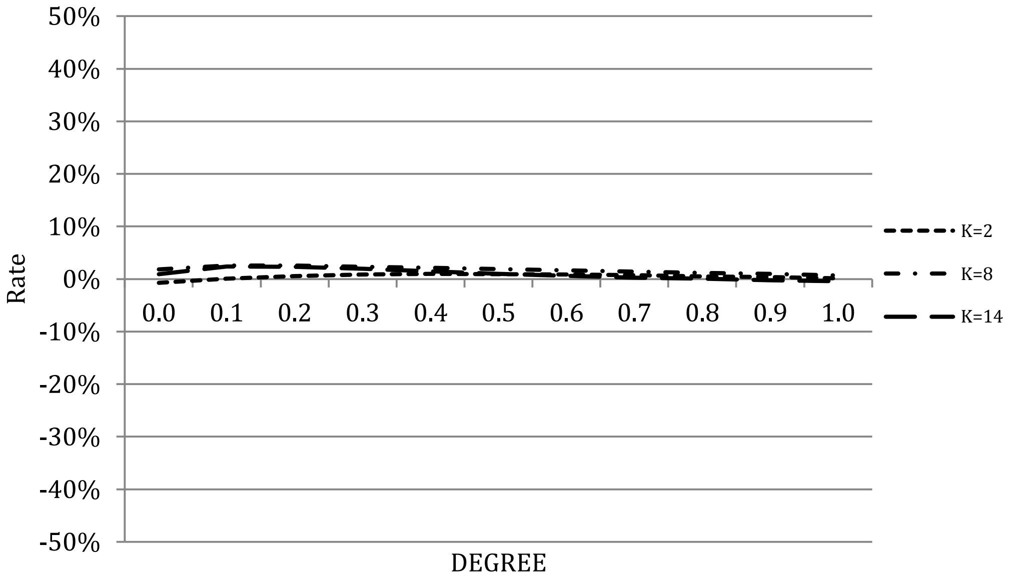
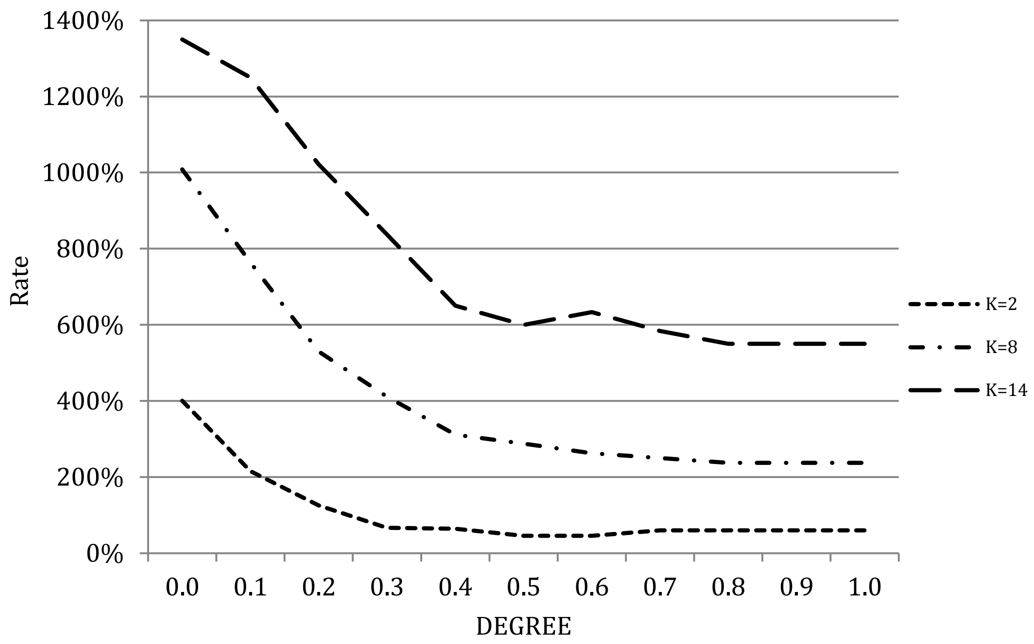


Figure 5d. Efficiency Decrease Rate



5.3 The Impact of Project Complexity in ISD Process

In this section, we vary project complexity to examine whether previous results remain robust with different levels of interdependencies among decision variables.

5.3.1 The Impact of Active Manager's Leadership Competency with Varied Project Complexity

We see that the plate in Figure 6a is slightly slanted, which means an active manager' ultimate result always slowly increases with higher leadership competency at all levels of project complexity. With the slope, it is obvious that when the project becomes more complex, it is more difficult to achieve a good result.

From Figure 6b, we see that an active manager's efficiency is increasing with increasing leadership competency as the time taken to finish the project decreases when the level of leadership competency increases. With increasing project complexity, the active manager maintains a good control of the time since the plane is relatively flat.

Figure 6a. Active Manager’s Effectiveness with Varied Leadership Competency and Project Complexity

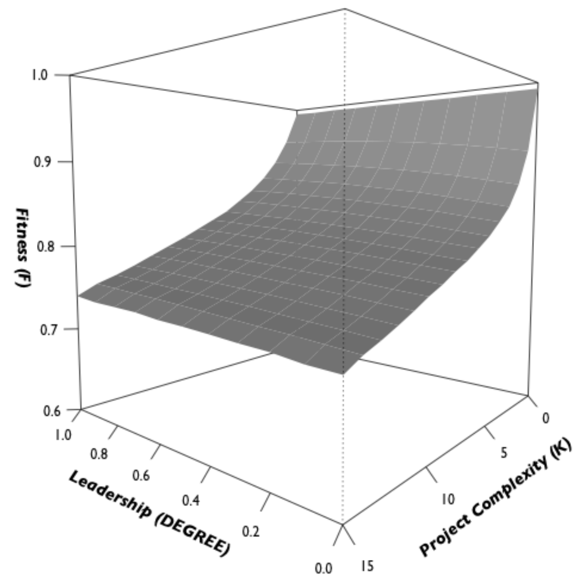
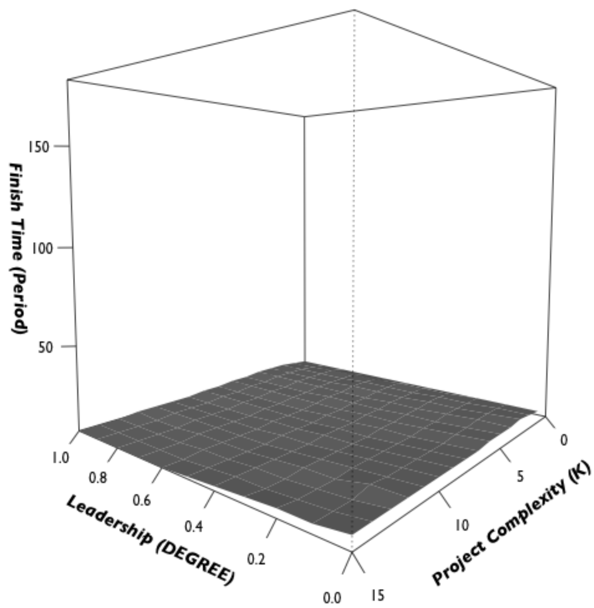


Figure 6b. Active Manager’s Efficiency with Varied Leadership Competency and Project Complexity



5.3.2 The Impact of Rubberstamping Manager’s Leadership Competency with Varied Project Complexity

Figure 7a shows that at any level of project complexity, a rubberstamping manager’ ultimate result is increasing with higher leadership competency as discussed in the previous session. And the increase of performance is more obvious at low degrees of leadership competency.

Again, with higher project complexity, the ultimate performance decreases.

From Figure 7b, we see that a rubberstamping manager's efficiency is deeply affected by his leadership competency, especially at a high level of project complexity. And as discussed in the previous section, it is more prominent for a rubberstamping manager with poor leadership skills to improve his leadership competency, as he is not able to oversee the project across sub-teams from technical perspectives. This applies to all levels of project complexity so there is a jump in Figure 7b when *DEGREE* starts to increase from 0. When the project becomes complex, it is critical for the rubberstamping manager to obtain certain level of leadership competency in order to have a better time management of the project.

Figure 7a. Rubberstamping Manager's Effectiveness with Varied Leadership Competency and Project Complexity

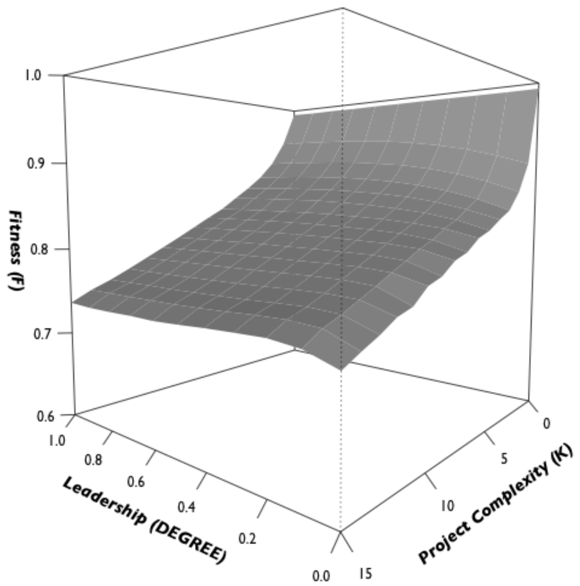
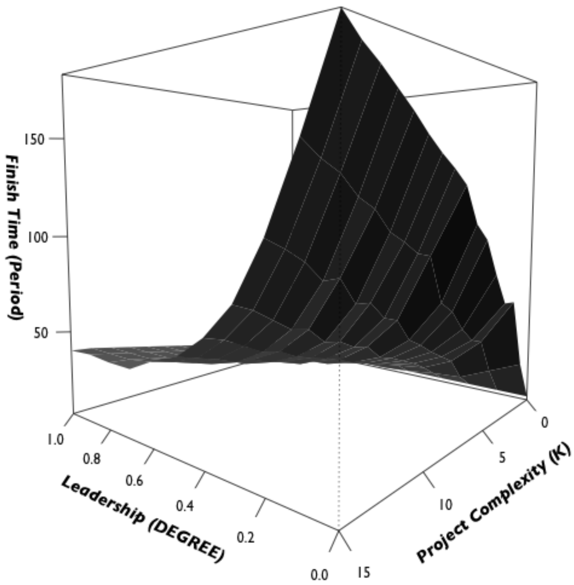


Figure 7b. Rubberstamping Manager's Efficiency with Varied Leadership Competency and Project Complexity



6 Discussion and Conclusion

In this research, the ISD process is conceptualized as a result-oriented problem solving process within a designed landscape. NK Fitness Landscape model is used to simulate how the ISD project manager's technical and leadership competencies impact the ISD process. The objective of this research is to derive theoretical insights into the relationship between the success of the ISD project and the ISD project manager's technical and leadership competencies. The results can provide guidelines for companies when they are hiring project managers or assigning project managers for ISD project teams. With an effective and efficient manager, the performance and success rate of the ISD project can be improved.

6.1 Summary of Results

The project manager's leadership competency always positively affects the ISD team's performance, in terms of both the ultimate result and the time taken to finish the project. Especially for the rubberstamping manager, efficiency exponentially increases with higher leadership competencies.

In respect of technical competency, a rubberstamping manager can achieve slightly better ultimate performance at a high cost of manageability of the project although the decrease in efficiency can be compensated by higher leadership competency. An active manager definitely has a much better control of the timespan of the project without sacrificing too much effectiveness.

The effect of increasing project complexity decreases both active manager's and rubberstamping manager's ultimate performances. Regarding the efficiency, an active manager is more resilient to the increase in the project complexity. For a rubberstamping manager, although he can have a better time management of the project with increasing leadership competency, his efficiency decreases more dramatically when the project becomes more complex.

6.2 Implications of Results

Now the questions posted at the beginning of this research can be answered. For a simple project, a manager without strong technical competency is good enough to manage the ISD project. He can rely on sub-team leads' expertise by delegating the responsibility of making technical decisions to them. With certain level of leadership competency gained from previous project management experience, he is able to achieve a good enough result at slightly lower but acceptable efficiency. When the project complexity increases, it is more critical for the company to hire a manager with a strong technical background unless there is no time limit to finish the project since an active manager is significantly more resilient to the project complexity. Without time constraint, a rubberstamping manager can achieve slightly better end results by allowing sub-team leads to make full advantage of their expertise and creativity. However, the ability to meet the deadline is an important project success criterion. Therefore, the rubberstamping manager may not be able to achieve the theoretical ultimate performance within given timeline in reality. Also, since labor cost is one of the major cost components of the ISD project, spending more time on the project would directly lead to higher cost, which is definitely not favorable.

6.3 Limitations and Further Research

In this paper, we have only looked at how the project manager's technical and leadership competencies affect performance of the ISD project with varied project complexity at a basic level. For example, the project size and the number of sub-teams were fixed for the simplicity of the project due to the time constrain. And sizes of the sub-teams are assumed to be equal. All these environmental parameters also can be varied to examine the robustness of current results. Moreover, other than simply divide the ISD managers into active managers and rubberstamping managers, managers with different levels of technical competency may influence the ISD process in many other ways. For instance, the ISD manager could offer technical advises and suggestions to sub-team leads thus affecting their decision making process. These potential behaviors are not examined in this paper thus there is still large room for further research.

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