# The Role of Congruence between Exploitative and Exploratory Knowledge Sharing in Enterprise Systems Project: Polynomial Modeling and Response Surface Analysis

*Short Paper*

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## Abstract

*In enterprise system (ES) project, knowledge sharing between client and ES vendor is a pivotal practice to ensure its success. However, it is a tradeoff for managers to balance two forms of knowledge sharing – exploitative and exploratory knowledge sharing. This study provides a preliminary insight by investigating the effects of congruence and incongruence of knowledge sharing on the success of ES project. Using data collected from 112 clients of an ES vendor, we apply polynomial modeling and response surface methodology for an in depth analysis. Our findings point out the importance of congruence between the two forms of knowledge sharing and we also find that exploratory knowledge sharing between client and ES vendor is a prerequisite to the success of ES project. In future research, we aim to examine how to balance the two forms of knowledge sharing and find out which kind of knowledge should be necessarily shared.*

**Keywords:** knowledge sharing, congruence, enterprise systems, polynomial modeling, response surface methodology

## Introduction

The failure enterprise systems (ES) project has drawn wide attention in academia (Chou and Chang 2008; Gorla and Somers 2014). Some researchers pointed out that the failure might be attributed to the knowledge sharing between client and vendor in an ES project (Chou and Chang 2008; Wang et al. 2007). Knowledge sharing during ES project mitigates the knowledge gaps between both parties, thereby leading to alignment between technical functions of ES and business processes (Shao et al. 2012; Wang et al. 2007). The two firms share knowledge to fine-tune functions of ES to accommodate to certain business processes (Park and Lee 2014). They also share knowledge to develop innovative solutions for business opportunities (Chou and Chang 2008). Conceivably, knowledge sharing in ES project is critical for firms to exploit existing competencies and to explore innovative functions of ES.

Although the above illustrates the potential benefits of exploitative knowledge sharing and exploratory knowledge sharing in successfully implementation of an ES project, the two forms of knowledge sharing are different. Formally defined, exploitative knowledge sharing (exploitative KS) is the exchange of knowledge between firms that focuses on fine-tuning functions of the system and pursuing risk-averse behavior (Im and Rai 2008). Exploratory knowledge sharing (exploratory KS) is the exchange of knowledge between firms that focuses on innovative functions of the system and pursuing risk-taking behaviors (Im and Rai 2008). However, exploration and exploitation are different strategies and require different routines and cognitive schemes (Levinthal and March 1993). They are self-reinforcing in that exploitation leads to more exploitation and exploration to more exploration, which would cause “success trap” or “failure trap” (Gupta et al. 2006). So, it is important to understand how the two forms of knowledge sharing influence the success implementation of an ES project.

Typically, we identify three gaps related to exploitation and exploration in knowledge sharing. First, prior research mainly focuses on how knowledge sharing influences successful ES implementation, few studies consider the influence of the two forms of knowledge sharing on ES implementation success (ESIS) simultaneously (Ko et al. 2005; Park and Lee 2014; Xu and Ma 2008). Second, past research examines the trade-off of exploration and exploitation in knowledge producing, but few study considers the balance between exploitative KS and exploratory KS in inter-organizational relationships (Sudhir 2016). Third, some research has highlighted the importance of effective knowledge sharing in exploiting existing competencies of ES and exploring innovative functions of ES (Ghobadi 2015), however, how the congruence between exploitative KS and exploratory KS influences ESIS is still a black box.

To address the three gaps identified above, we focus on the two forms of knowledge sharing and investigate the following research questions: (a) How does the incongruence between exploitative KS and exploratory KS influence ESIS? (b) How does the congruence between exploratory KS and exploitative KS influence ESIS? We use polynomial modeling and response surface methodology to address the two questions. The study addresses the gaps previously mentioned in the following ways: First, knowledge sharing was deeply characterized as exploitative KS and exploratory KS and the two forms of knowledge sharing were considered in influencing ESIS; Second, the study considered the balance between exploitative KS and exploratory KS in influencing ESIS in buyer-supplier relationships; Third, this study further examined how congruence and incongruence of exploitative KS and exploratory KS influence ESIS. We find that the incongruence between exploitative KS and exploratory KS negatively influence ESIS and the congruence between the two forms of knowledge sharing is important in enhancing ESIS. We also find that exploratory KS between client and ES vendor is a prerequisite to ESIS. Given these findings, we aim to further our understanding on how to balance the two forms of knowledge sharing and identify which kind of knowledge should be shared necessarily in future research.

## Theoretical Background and Hypotheses Development

Arguments in favor of the balance between exploration and exploitation are well established and accepted (Laureiro - Martínez et al. 2015; March 1991). Organizations divide their attention and resources between two kinds of activities: the pursuit of new knowledge (i.e., exploration) and the development of exist knowledge (i.e., exploitation) (Levinthal and March 1993). Organizational learning theory argues that a system pursues exploration to the exclusion of exploitation would suffer the costs of experimentation and gain less benefits, while a system pursues exploitation to the exclusion of exploration would be trapped in suboptimal stable equilibria (March 1991). Thus, it is important to purse exploration and exploitation ambidextrously as firms need to engage in activities that contribute to exploitative of existing knowledge and capabilities to ensure current viability and, at the same time, engage in activities that contribute to exploration of new knowledge and capabilities to ensure future viability (Lavie and Rosenkopf 2006; Levinthal and March 1993).

As the packaged software’s embedded functionality may not fit the firm’s certain business processes, knowledge sharing between client and ES vendors is important in bringing organizational processes into closer alignment with the functions of ES (Shao et al. 2012; Wang et al. 2007). When the two firms focus primarily on exploitative KS, they share more knowledge to refine the existing function of ES and seek low-risk, short-term improvements. However, the emphasis on exploitative KS will lock the ES in a situation that it cannot efficiently and immediately coordinate business process between different units for new business opportunities. Because high exploitative KS increases uncertainties about markets and technological changes and increases risks of lock-in with inferior functions of ES (Im and Rai 2008). When the two firms emphasize on exploratory KS, firms spend more energy in experimentation for innovative opportunities that involve significant risk and uncertainty. Thus, the implementation of ES may full of risk and the function of ES may in a mass. Besides, high exploratory KS should decrease the recognition of bottlenecks of the current ES in grasping new opportunities, lower the ability to perform routine tasks and increase coordination costs of ES (Im and Rai 2008). Emphasizing on either form of knowledge sharing also weakens trust between client and vendor and further impact the effectiveness of ES implementation process. Based on the discussion, we hypothesize:

**Hypothesis 1**: The incongruence between exploitative KS and exploratory KS would negatively influence ESIS.

We suggest that the balance between exploitative KS and exploratory KS will exhibit successful ES implementation. Client and ES vendor need both to explore and import knowledge, and also exploit knowledge that has already been accumulated and incorporated into appropriate routines, rules or procedures (Gabriel Cegarra-Navarro et al. 2011), so that achieve short-term and long-term improvements ambidextrously. The two forms of knowledge sharing not only impact ES performance mean but also impact its performance variance (March 1991). Gavetti and Levinthal (2000) argue that exploration evokes local and distant search for alternatives that significantly improve the current performance, while, exploitation focuses on steady improvements through evaluating the alternatives of neighborhood of current activities. Accordingly, balancing exploitative and exploratory KS should exhibit less ESIS variance and higher performance mean than emphasizing on either of them. According this, we propose the following hypothesis:

**Hypothesis 2**: The congruence between exploitative KS and exploratory KS would positively influence ESIS.

## Method

Drawing on the mass of research in organizational behavior literature, we use polynomial modeling and response surface methodology as approaches to address the research questions. Polynomial modeling maintains the distinction between the two component measures throughout the data analysis and it permits reveling complexities in theories of congruence (Venkatesh and Goyal 2010). Response surface methodology technique permits depicting the curvilinear relationships in an accurate picture so that subtle changes can be detected (Edwards 2002; Venkatesh and Goyal 2010). The two methods have been used widely in information systems (e.g.,Venkatesh and Goyal 2010), organizational behavior (e.g., Hecht and Allen 2005; Zhang et al. 2012), and marketing (e.g., Kim and Hsieh 2003).

### *Polynomial Modeling*

Polynomial modeling provides a successful way in reveling complexities in theories of congruence (Venkatesh and Goyal 2010). It is based on a basic theoretical model $Z = f(X, Y)$. The general form of a quadratic equation is

$$Z = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2 + e. \quad (1)$$

Several stages of hierarchical analysis are involved in polynomial modeling. The first stage tests the linear relationship between lower-order variables (X and Y) and Z. In the second stage, higher-order variables ($X^2$, XY, and $Y^2$) are entered to test for the significance of curvilinear relationships. The third stage enters the cubic terms ($X^3$, $X^2Y$, $XY^2$, and $Y^3$) to test for the significance of higher-order curvatures (Edwards and Parry 1993). The analysis continues until the variance explained by the next stage of higher-order equation is not statistically significant (Edwards and Parry 1993). Polynomial modeling analysis has the advantage in examining the complex congruence, because it maintains the distinction between the two component measures (X and Y) throughout the data analysis.

### *Response Surface Methodology*

Response surface methodology (RSM) is a collection of mathematical and statistical techniques which involves analyzing features of surfaces corresponding to polynomial equations (Edwards 2007). The surface generated can be concave, convex or saddle and the contour of the plotted surface can be better understood through statistical tests. RSM focus on three basic features: stationary point, principal axes, and slops along relevant lines in the X, Y plane.

A stationary point is defined as a point at which the surface is flat (Edwards and Parry 1993). For a concave surface, the stationary point locates at the overall maximum of the surface. For a convex surface, the stationary point locates at the overall minimum of the surface. For a saddle surface, the stationary point locates at where the intersection of the lines along which the upward and downward curvatures of the surface are greatest. The principal axes describe the orientation of the surface in the X, Y plane. They run perpendicular to one another and intersect at the stationary point. For a concave surface, the downward curvature is minimum along the first principal axis and maximum along the second principal axis. For a convex surface, the upward curvature is maximum along the first principal axis and minimum along the second principal axis. For a saddle surface, the first principal axis runs along the line of maximum upward curvature, and the second principal axis runs along the line of maximum downward curvature. Besides, the confirmation axis (the axis along which the component measures are equal, Y = X) and the disconfirmation axis (Y = -X) are also lines of interest in RSM. If the first principal axis parallel to the Y = X line, its lateral shift from the Y = X can be calculated by the point at which the axis crosses the Y = -X line. Analogously, if the second principal axis parallel to the Y = X line, its lateral shift from the Y = X can be calculated by the point at which the axis crosses the Y = X line. The third response surface feature is the shape of the surface along lines in the X, Y plane, which is determined by the curvature of the surface along the Y = -X, Y = X, and two principal axes. For a detailed discussion on the techniques, see Edwards and Parry (1993) and Edwards (2002).

The combination of polynomial regression and RSM helps gain new insight from data analysis and reveal the complexity of the joint effect of the variables on an outcome in a clear way (Edwards 2007; Venkatesh and Goyal 2010). This technique permits depicting the curvilinear relationships between component measures and an outcome in an accurate picture so that subtle changes can be detected (Edwards 2002; Venkatesh and Goyal 2010). This method has been used in revealing complexities in theories of congruence and is recognized as an alternative to difference scores (Edwards 2002; Edwards 2007).

## *Data Collection*

We collaborated with BS Company (the largest ES service provider in Chinese garment industry) and its client firms. The client representatives of BS Company assisted us in distributing the questionnaire to its client firms, which is helpful in improving the quality and response rate. In order to improve the quality of the response, the client firms were informed that the answers were used for scientific research only and will not be used by ES Company to evaluate their performance. Out of a total t220 questionnaires, 135 were returned to us. After discarding 23 invalid questionnaires which are excessive missing information and outliers, we finalized 112 usable samples, with a response rate of approximately 56%. The demographic information is shown in Table 1.

**Table 1. Demographic information**

| | Frequency | Percent (%) |
|---|---|---|
| Number of employees | | |
| Less than 10 | 5 | 4.46 |
| 10-50 | 58 | 51.79 |
| 51-100 | 42 | 37.50 |
| More than 100 | 7 | 6.25 |
| Firm age | | |
| Less than 4 years | 11 | 9.82 |
| 4-6 | 46 | 40.07 |
| 7-10 | 40 | 35.71 |
| More than 10 | 15 | 13.39 |

| | | |
|---|---|---|
| Number of IT employees | | |
| Less than 2 | 66 | 58.93 |
| 2-5 | 37 | 33.04 |
| More than 5 | 9 | 8.04 |

**Table 1. Demographic information**

### *Measures*

We measured exploitative and exploratory knowledge sharing using items from the work of Im and Rai (2008). And the ESIS was indicated by the coordination improvements from the work of Chou and Chang (2008). An English questionnaire was first created with previously validated items from the existing literature. Following the criteria suggested by Brislin (1970), the questionnaire was then translated into Chinese by a translator who was not familiar with this research. Another translator unfamiliar with this research was hired to translate the Chinese questionnaire back into English. No semantic discrepancies were found when comparing the translated version with the original version. Five-point Likert scales were used for the measurement of all the constructs, ranging from "strongly disagree" to "strongly agree". Several measures were assessed with choice questions, such as number of employees and firm size.

## Results

The data of the measurement were scale centered by subtracting the midpoint of the scale, which can reduce the multicollinearity between the components and their associated quadric terms (Aiken et al. 1991). Table 2 and Table 3 shows the reliabilities, descriptive statistics, and correlations. Assessed using Cronbach's alpha, the reliabilities of the scales are greater than the benchmark value 0.7. The loadings of all items are higher than the suggested benchmark 0.7 and the values of composite reliability are also greater than the benchmark value 0.7. Harman's one-factor test was used to test the common method bias. The results indicate that the test can categorize the items into four constructs whose eigenvalues were higher than 1.0, accounting 62.13% of the variance totally. The first construct did not account for the majority of the variance (24.20%), providing the assurance that common method bias is not likely to be problematic.

**Table 2. Results of confirmatory factor analysis**

| | Items | Loadings | Cronbach's alpha | Composite reliability | AVE |
|---|---|---|---|---|---|
| Exploitative KS | 6 | 0.781-0.871 | 0.819 | 0.857 | 0.667 |
| Exploratory KS | 6 | 0.780-0.856 | 0.891 | 0.924 | 0.671 |
| ESIS | 4 | 0.722-0.837 | 0.784 | 0.863 | 0.612 |

**Table 2. Results of confirmatory factor analysis**

**Table 3. Means, standard deviation, and correlations**

| | Means | SD | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1. Exploitative KS | 1.344 | 0.427 | 0.817 | | |
| 2. Exploratory KS | 1.329 | 0.563 | 0.689** | 0.819 | |
| 3. ESIS | 1.409 | 0.393 | 0.367** | 0.428** | 0.782 |

| Note: *p < 0.05; **p < 0.01. The diagonal elements are square root of AVEs. |
|---|

**Table 3. Means, standard deviation, and correlations**

We did confirmatory polynomial regression analysis to see if the variance explained by the higher-order equation is significantly more than the variance explained by the linear model. The test results show in Table 4. The results show that the variance explained by the higher-order equation is significantly higher than the variance explained by the linear equation, indicating that the quadratic model is favorable than linear model.

| Table 4. Polynomial Regression Model | | | | | |
|---|---|---|---|---|---|
| | | First-order Linear Equation | | Second-order Quadratic Equation | |
| Dependent variable | Independent variable | β | $R^2$ | β | $R^2$ |
| ESIS | EPIKS | 0.023 | 0.218 | -0.860* | 0.405 |
| | EPRKS | 0.312** | | -0.327 | |
| | $EPIKS^2$ | | | -0.334 | |
| | EPIKS * EPRKS | | | 1.352*** | |
| | $EPRKS^2$ | | | -0.382** | |
| Note: *p < 0.05, **p < 0.01, ***p < 0.001; ESIS: ES implementation success; EPIKS: Exploitative knowledge sharing; EPRKS: Exploratory knowledge sharing. | | | | | |

**Table 4. Polynomial Regression Model**

To clarity the relationships between the two forms of knowledge sharing and ESIS, the exploratory analyses are then conducted using polynomial modeling and response surface methodology. The results of the exploratory analysis are also shown in Table 4. Some the coefficients of the higher-order terms are significant, showing that the relationships are curvilinear. The response surface of knowledge sharing predicting ESIS was shown in Figure 1. Stationary point and principal axes for the surface are reported in Table 5 and the slopes along the lines of interest are reported in Table 6.

| Table 5. Stationary Point and Principal Axes | | | | | | |
|---|---|---|---|---|---|---|
| | Stationary Point | | First Principal Axis | | Second Principal Axis | |
| DV | $X_0$ | $Y_0$ | $P_{10}$ | $P_{11}$ | $P_{20}$ | $P_{21}$ |
| ESIS | 0.834* | 1.048* | 0.243 | 0.965** | 1.913* | -1.036** |
| Note: *p < 0.05, **p < 0.01. | | | | | | |

**Table 5. Stationary Point and Principal Axes**

| Table 6. Slopes Along Lines of Interest | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Y = X | | Y = -X | | First Principal Axis | | Second Principal Axis | |
| DV | $a_X$ | $a_{X^2}$ | $a_X$ | $a_{X^2}$ | $a_X$ | $a_{X^2}$ | $a_X$ | $a_{X^2}$ |
| ESIS | -1.187* | 0.636** | -0.533 | -2.068** | -1.026* | 0.615** | 3.579* | -2.145** |
| Note: *p < 0.05, **p < 0.01. | | | | | | | | |

**Table 6. Slopes Along Lines of Interest**

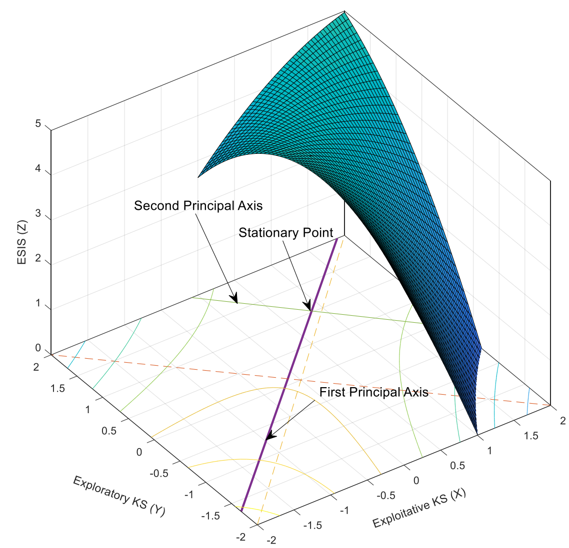


**Figure 1. Response Surface Analysis for ESIS**

The response surface of knowledge sharing predicting ESIS was saddle-shaped, as shown in Figure 1. The stationary point is just to the front of the Y = -X line ($X_0 = 0.834$, $p < 0.05$; $Y_0 = 1.048$, $p < 0.05$). The first principal axis (the line of maximum upward curvature) did not differ from the Y = X line, as evidenced by a slope ($p_{11} = 0.965$, $p < 0.01$) did not differ from 1.00 and an intercept ($p_{10} = 0.243$, n.s.) did not differ from 0.00. The quantity $-p_{10}/(p_{11}+1)$ (the lateral shift of the first principal axis from Y = X line) was -0.124, and its 95% confidence interval included zero, indicating that the first principal axis was not significantly shifted to the left of the Y = X line, which evidences that it goes along the congruence line. The second principal axis (the line of minimum downward curvature) was nearly parallel to the Y = -X line, as indicated by a slope ($p_{21} = -1.036$, $p < 0.01$) that did not differ from -1.00.

We observe that the surface was curved upward along the first principal axis (which is also the Y = X line) and showed negative linear ($a_x = -1.026$, $p < 0.05$) and positive quadratic ($a_{x^2} = 0.615$, $p < 0.01$). Along the second principal axis, the surface was curved downward and showed positive linear ($a_x = 3.579$, $p < 0.05$) and negative quadratic ($a_{x^2} = -2.145$, $p < 0.01$). Substantively, these results indicate that ESIS is minimized along the second principal axis and the surface curved downward along both second principal axis ($a_x = 3.579$, $p < 0.05$, $a_{x^2} = -2.145$, $p < 0.01$) and line Y = -X ($a_x = -0.533$, n.s., $a_{x^2} = -2.068$, $p < 0.01$). These means that the incongruence between exploitative KS and exploratory KS negatively influences ESIS, supporting Hypothesis 1. These results also indicate that ESIS is maximized along the line of perfect congruence (Y = X), and the curved upward surface ($a_x = -1.026$, $p < 0.05$, $a_{x^2} = 0.615$, $p < 0.01$) indicates that the congruence between exploitative KS and exploratory KS positively influences ESIS. Thus, H2 is supported. We also observe that exploratory KS without exploitative KS can also contribute to ESIS, however, exploitative KS without exploratory KS causes the sharp downward of ESIS to zero. These indicate that exploratory KS between client and ES vendor is a prerequisite to ESIS.

## Conclusion and Future Plan

In this study, we use polynomial modeling and responsive surface methodology to provide a more comprehensive and nuanced view on the relationship between interorganizational knowledge sharing and ESIS in an ES project. We find that the congruence between exploitative KS and exploratory KS is essential in enhancing ESIS and the incongruence between the two forms of knowledge sharing would negatively influence ESIS. We also find that exploratory KS between client and ES vendor is a prerequisite to ESIS in an ES project.

In future research, we will take a further step based on the existing analysis results. Specifically, we plan to identify which kind of knowledge is a prerequisite that need to be shared between client and ES vendor. A case study will be conducted to take a close look at the knowledge shared between parties in ES project. The categorization of knowledge is based on the evidence from case study. Then we will perform a survey in a large sample to figure out which kind or combination of knowledge is most important in facilitating the success of ES project. The framework is built on exploitative and exploratory KS in a more detailed manner. After finding the best combination of type of knowledge sharing, we aim to propose approaches to improve the congruence of knowledge sharing to help firms attain benefits from ES project.

There are some challenges in next steps. First, it is challenging to address the common method variance, e.g., social desirability bias, in this study as the data all collected through questionnaires. Social desirability bias may attenuate the strength of observed relationship in empirical research on ESIS as respondents may overreport ESIS. To deal with the problems generated by social desirability bias, we consider include measures of social desirability bias in data collection that employ self-reports or we consider to collect secondary data (e.g., system performance) to measure ESIS and combine with survey data (e.g., knowledge sharing) to address the potential social desirability bias in next steps (Nederhof 1985). Second, designing an appropriate complementary research based on the current works to investigate which kind of knowledge should be shared necessarily is also a challenge. Because the knowledge shared between firms are various and plentiful, a detailed categorization of the shared knowledge must be done accordingly. Third, it is difficult to build a whole theoretical framework or find a theoretical lens to explain the impact of congruence and incongruence of two forms of knowledge sharing on ESIS.

We expect to make theoretical contributions to extant literature on the understanding of effects that congruence and incongruence of the two forms of knowledge sharing exerted on the ESIS in an ES project. We also expect to contribute to understanding which kind of knowledge is necessarily to be shard to make sure ESIS. Our study will also make practical contributions. In particular, we highlight the importance of maintaining a good balance between exploitative KS and exploratory KS when implementing ES. Both client and ES vendor will benefit from balancing the two forms of knowledge sharing in implementing ES, because client and ES vendor can explore and import knowledge and, at the same time, exploit knowledge that has already been accumulated and incorporated into appropriate routines, rules or procedures, so that achieve short-term and long-term improvements ambidextrously. We will point out which kind of knowledge is a prerequisite to be shared and how to balance exploitative KS and exploratory KS.

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