Research Journal of Applied Sciences, Engineering and Technology 5(9): 2707-2713, 2013
DOI:10.19026/rjaset.5.4795
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: September 18, 2012 Accepted: October 30, 2012 Published: March 20, 2013

Research Article

The Impact of Trust on Project Performance in Cross-functional Team: An Empirical Study

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Abstract: Team trust is critical for Cross-Functional Teams (CFTs) to facilitate performance improvement, yet the relationships between trust and performance are nonlinear and complex. This study aims to assess the influence of trust factors on project performance. An empirical survey is conducted to collect data regarding team trust factors and project performance. Then, Support Vector Regression (SVR) is implemented to establish the complex relationships between trust and performance by using trust factors as independent variables. After that, F-tests are adopted to examine the significance of the SVR model and to rank the relative weight of each trust factor. It is found in this study that for overall performance influencing factors, project process factors are more important than structural & contextual factors. And it is also found that team diversity is the least important factor that affects project performance.

Keywords: Cross-functional team, F-tests, project performance, support vector regression, trust

INTRODUCTION

As modern projects becoming more technically complex and innovative, Cross-Functional Teams (CFTs) are enjoying growing popularity (Love and Roper, 2009). Members of these teams represent different functional areas and they have different skills, experience and personal objectives. In practice, CFTs are facing several challenges, including diversity of members' goals and values, heterogeneous time allocations and multiple reporting relationships (Webber, 2002). As a result, project performance would be hindered if these challenges are not well addressed. Existing literature shows that the building of trust among teams is essential for CFTs to facilitate the realization of effective project performance (Costa, 2003; Dayan and Di Benedetto, 2010; Vangen and Huxham, 2003; Webber, 2002).

Referring to the previous research regarding the formative factors of team trust, two main interests can be found. One is related to the study of trust formation from the perspective of Project Process (PP). It confirms that trust is influenced by individuals' general psychological and behavioral aspects such as cognition, affection and cooperation (Costa and Anderson, 2011). And with the growing awareness on organizational issues, other interests are more focused on examining trust and project performance relationship on the Structural and Contextual factors (SC) of teams. These factors, for example, include team diversity, physical proximity and Procedural and Interactional justice (Dayan and Di Benedetto, 2010). It is vital the impacts of these factors on performance be estimated. However, there had been little study on considering both PP and SC factors with respect to trust-performance relationships. In addition, how important do these factors affect project performance is still rarely explored in the literature.

To assess the impacts of team trust on project performance in order to shed light on the complex relationships, an empirical study is conducted in several corporate and government organizations in China to obtain quantitative data regarding trust factors and project performance. Then, in accordance with the main effect models that team trust has an immediate positive effect on project performance, we apply Support Vector Regression (SVR) to establish the complex relationships between trust and performance by using trust factors as independent variables. Finally, F-tests are used to examine the significance of the SVR model and to rank trust variables with regards to their influence on project performance.

THEORETICAL BACKGROUND OF CROSS-FUNCTIONAL TEAM TRUST

Cross-functional team trust and project performance: Several studies have demonstrated that interpersonal trust is one of the most essential components of effective teams and successful projects

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(Dirks and Ferrin, 2001; Burke *et al*., 2007; Dayan and Di Benedetto, 2010). However, there are two different points on whether trust has a direct or indirect effect on project performance in the literature. The effect of trust and performance is indirect had been explained in Dirks'experiment that explores the connections between level of trust and group performance (Dirks, 1999). Other experimental study also suggested the indirect relationship of team trust and performance (Porter and Lilly, 1996). Dirks and Ferrin (2001) claim that as a moderator of team performance, trust facilitates or inhibits the direct effect of other variables on team performance.

However, a more widely accepted viewpoint is that interpersonal trust exerts a direct influence on performance. For instance, Erdem and Ozen (2003) establish the relationship between the cognitive and affective trust and the team performance and their findings show that there is a positive relationship between trust and the perceptions of team performance. Costa (2003) conduct a similar study regarding team trust and effective in social care institutions and the finding also support the direct and positive effect of trust on perceived task performance and team satisfaction. Dayan and Di Benedetto (2010) investigate on the effect of structural and contextual factors of trust on NPD project outcomes. It is found that these structure and context issues of teams are positively related to interpersonal trust and it is also demonstrated the direct impact of trust on team learning and product success (Dayan and Di Benedetto, 2010). Therefore, in accordance with these findings, the main effect model that team trust has direct impacts on project performance is applied in this study.

Factors for trust formation: Previous research regarding factors that affect team trust mainly focuses on studying these factors from the perspective of project process (McAllister, 1995; Chowdhury, 2005; Dayan and Di Benedetto, 2010; Costa and Anderson, 2011). In other words, they point out that trust is influenced by individuals' general psychological and behavioral aspects on daily activities, such as cognition, affection and cooperation. Other research respecting trust factors concentrates on the structure & context of teams. Dayan and Di Benedetto (2010) find that these structure and context issues of teams are positively related to interpersonal trust. These include team diversity, team longevity, team proximity, Procedural and Interactional justice (Dayan and Di Benedetto, 2010). Table 1 shows the project process factors and structural and contextual factors of team trust used in our study.

Project performance: A considerable number of researchers have studied the criteria to assess project performance (Hackman, 1987; Cohen and Bailey, 1997; Hoegl and Gemuenden, 2001; Milosevic and Patanakul, 2005; Müller and Turner, 2007; Scott-Young and Samson, 2008; Blindenbach-Driessen *et al*., 2010). Shenhar *et al*. (2001) propose a universal framework of project performance assessment that use project efficiency, impact on the customer, direct business and organizational success and preparing for the future as the criteria. Malach-Pines *et al*. (2009) identify project success dimensions similar to Shenhar *et al*. (2001). Patrashkova-Volzdoska *et al*. (2003) use goal achievement, project efficiency and team cohesion to evaluate project performance in their research.

In this study, we choose internal and external performance as two dimensions of project performance. Internal performance includes members' attitude on team satisfaction and learning and external performance is consists of goal achievement and project efficiency. Goal achievement defined as whether the project has achieved its expected aim on schedule, cost, quality and other technical requirements. Project efficiency denotes that whether the project is undertaken in an effective way and whether team members complete high quality work without taking much effort.

ASSESSMENT OF TRUST FACTOR IMPORTANCE BY USING SVR AND F-TEST

Support vector regression methods: Support Vector Regression (SVR) is the mapping of input data into a higher-dimensional feature space by non-liner mapping ϕ, so a linear regression problem can be performed in this feature space. For this regression problems, suppose training data (x_i, y_i), $(i = 1,\ldots, l)$ are given, where x denotes a input with d dimensions and $x \in R^d$, $Y \in R$. The nonlinear regression model is expressed as follows:

$$f(x) = \langle \omega, \phi(x) \rangle + b, \quad \omega, x \in R^d, b \in R \qquad (1)$$

To measure the empirical risk, (Vapnik, 2000) we specify a ε-intensive loss function, which is defined as follows:

$$L_\varepsilon(y) = \begin{cases} 0, & |f(x) - y| \le \varepsilon \\ |f(x) - y| - \varepsilon, & otherwise \end{cases} \qquad (2)$$

And the optimal parameters w^* and ω^* in Eq. (1) can be calculated by solving the following optimization problem (Smola and Schölkopf, 2004):

$$\min \tfrac{1}{2} \|\omega\|^2 + C\sum_{i=1}^{l} (\xi_i + \xi_i^*) \qquad (3)$$
$$s.t. \begin{cases} \langle \omega, \phi(x_i) \rangle + b - y_i \le \varepsilon + \xi_i \\ y_i - \langle \omega, \phi(x_i) \rangle - b \le \varepsilon + \xi_i^* \end{cases}, \ \xi_i, \xi_i^* \ge 0, i = 1, \cdots, l.$$

where C is a given value that determines the trade-off between the flatness of $f(x)$ and the amount up to which deviations larger than the precision ε are tolerated. ζ and ζ^* are slack variables that denote the deviations from the constraints of the ε-tube.

The corresponding dual problem, obtained through the minimization of the Lagrange function, is as follows:

$$\begin{aligned} &\max -\tfrac{1}{2} \\ &\sum_{i=1}^{l}\sum_{j=1}^{l}(\alpha_i - \alpha_i^*)\left(\alpha_j - \alpha_j^*\right) K(x_i, x) + \\ &\sum_{i=1}^{l} Y_i(\alpha_i - \alpha_i^*) - \varepsilon \sum_{i=1}^{l}(\alpha_i + \alpha_i^*) \\ &\text{s.t.} \sum_{i=1}^{l}(\alpha_i - \alpha_i^*) = 0 \\ &0 \le \alpha_i, \alpha_i^* \le C, i = 1, \ldots, l \end{aligned} \tag{4}$$

where α_i and α_i^* are the Lagrange multiplier and they can be solved in the above function. For nonlinear regression models, a kernel function K is used that satisfies Mercer's condition and performs the nonlinear mapping. (Vapnik, 2000)The final form of function $f(x)$ that depends on α_i and α_i^* is as follows:

$$f(x) = \sum_{i=1}^{l} (\alpha_i - \alpha_i^*) K(x_i, x) + b \tag{5}$$

Various types of Kernel functions are used in SVR include the polynomial kernel, Radial Basis Function (RBF) and sigmoid kernel. In this study, we use the RBF kernel function which is presented as follows:

$$K(x_i, x_j) = \exp\left(-\gamma \left\| x_i - x_j \right\|^2\right) \tag{6}$$

In many cases, the setting of parameters C and ε will considerably influence the generalization performance of SVR and the parameter γ in RBF kernel function should be carefully selected.

Strategies of using SVR and F-test to analyze importance of trust factors: To assess the importance of each trust factor on project performance, we adopt SVR and F-test. At first, we implement nonlinear screen of trust factors based on SVR (Yuan and Tan, 2010). For given n samples and m trust factors as the input of the regression model with single output of project performance, we successively eliminate indistinctive variables according to the mean squared error (MSE) in the SVR model. Leave-One-Out method is employed to find optimal parameters of C, ε and γ and establish the SVR model. In the first-round screening of the trust factors, F_j can be given as follows:

$$F_j = \frac{Q_j - Q}{Q/(n - m - 1)}, \quad j = 1, 2, \cdots, m \tag{7}$$

where (1, n-m-1) is the degree of freedom and $Q = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2$ is the residual sum of squares, Q_j is the residual sum of squares without the *jth* factors and $\hat{y}_i$ is the fitted value of the *ith* sample that substitutes into the SVR model. If min $F_j > F_\alpha$ (1, n-m-1), it means that there is no factors to eliminate and the screening is ended. Otherwise, the *jth* factors is eliminated and then go to the next round of screening and the number of trust factors is m-1. The above screening procedures continue until there is no factors be eliminated. The number of the retained factors is m' and we use these factors to construct the SVR model.

Then, we test the significance of the regression model by using the following F-statistic:

$$F_{SVR} = \frac{U/m'}{Q/(n - m' - 1)} \tag{8}$$

where, U = $\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2$ is the regression sum of squares and Q = $\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$ is the residual sum of squares. If $F_{SVR} > F_\alpha(m', n\text{-}m'\text{-}1)$, it indicates that the nonlinear regression of the model is significant at the α level.

After that, the importance of each factor is examined based on SVR. Let $\hat{y}$ be the value of predicted output, if input x_j has major impact on the output, the value of $\hat{y}$ will alter considerably with the change of x_j. So we fix x_j as $\bar{x}_j$ and then import it into the SVR model to obtain the value of regression sum of squares U_j and the residual sum of squares Q_j using the predicted $\hat{y}_j$. And the contribution of regression sum of squares from factor x_j is U - U_j. In an multiple linear regression model, the sum of squares is defined by $SSy = \sum_{i=1}^{n}(y_i - \bar{y})^2 = Q + U$. Yet in an SVR model, $SSY \neq Q+U$ and $SSY \neq Q_j + U_j$. To make the importance of each factor comparable, the relative value of Q`$_j$ and $\acute{U}_j$ are calculated by $Q'_j = \frac{Q_j}{Q_{j+}U_j} \times SSy$ and $U'_j = \frac{U_j}{Q_{j+}U_j} \times SSy$ and Q'_j and U'_j are normalized into $SSy = Q'_j + U'_j$. Similarly, Q and U are normalized into SSy$\neq Q'+U'$ Then, another F-statistic is formulated as follows:

$$F = \frac{V_j}{Q'/(n - m' - 1)} \tag{9}$$

where, $V_j = U' - U'_j = Q'_j - Q'$ and the degree of freedom is (1, n-m'-1). Thus, the relative importance of each factor can be obtained and compared according to the test of significance.

EMPIRICAL ANALYSIS

Data collection: A total of 67 cross-functional teams from corporate and government organizations in China participated in this study. These CFTs had finished their projects in the past year. We have contact persons from each organization, who agreed to distribute the questionnaires in accordance with our request.

The questionnaires were administered in Chinese language and consist of two parts. The brief contextual

Table 1: The project process factors and structural& contextual factors of team trust

Trust factors	Definition	Reference
Project Process factors (PP)		
Cognitive-based Trust	Trustor's confidence to rely on trustee's professional credentials and reliability	Lewis and Weigert (1985), McAllister (1995) and Chowdhury (2005)
Affective-based Trust	The social and emotional interactions between trustor and trustee	Chowdhury (2005), Dayan and Di Benedetto (2010)
Cooperation	The positive actions that reflect the willingness of be vulnerable to others whose actions does not control	Costa and Anderson (2011)
Monitoring	Team members' monitoring, checking, and surveillance behaviors they exert on other members	Costa and Anderson (2011)
Structural and Contextual factors (SC)		
Team diversity	The functional and demographic difference of team members	Brown and Eisenhardt (1995) and Colquitt *et al.* (2002)
Team longevity	How team members arechangingduring the project process	Akgün and Lynn (2002) and Dayan and Di Benedetto (2010)
Team proximity	The closeness of team members in face to face working environment	Hoegl and Proserpio (2004)
Procedural justice	The fairness in the decision making processes that resolves disputes	Colquitt (2004)
Interactional justice	Whether members are treated with politeness, dignity, and respect by team managers	Posdakoff and Mackenzie (1994) and Dayan and Di Benedetto (2010)

Table 2: Input variables of the SVR model

Trust factors	Variable symbol
Project Process factors (PP)	
Cognitive-based Trust (4 items)	x1
Affective-based Trust (3 items)	x2
Cooperation (4 items)	x3
Monitoring (2 items)	x4
Structural and Contextual factors (SC)	
Team diversity (2 items)	x5
Team longevity (3 items)	x6
Team proximity (2 items)	x7
Procedural justice (3 items)	x8
Interactional justice (3 items)	x9

information of each team was requested in the first part and the second part regarded the data collected in this study. The questionnaires were pre-tested in several CFTs and some expressions were slightly modified to be more simple and clearer. The respondents of the study are CFT members who were considered to be taken major responsibility in the team by our contact persons, an average of three respondents in each team were encouraged to participate in the study. In total, we received 201 responses, yet 15 of them were inappropriate, so the overall sample was 186, with a

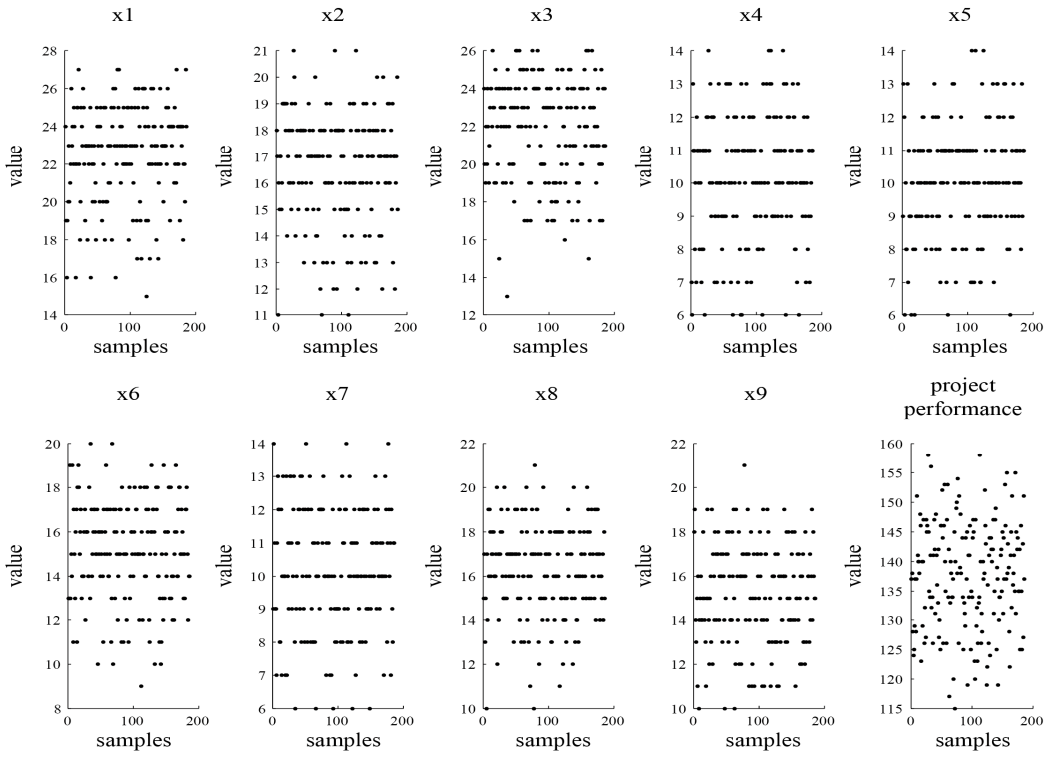

Fig. 1: The fractal dimensions from samples of input and output

Table 3: Screening of trust factors based on their MSE values

Round	MSE before screening	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Factor discarded
1	4.30	12.67	11.07	12.99	11.01	8.27	10.70	9.42	9.70	11.89	-

2.5% response rate. Of the 67 participated organizations, 59 (88%) are corporate organizations and 8 (12%) are government organizations.

Measures: Measures for team trust and project performance were developed on the basis of a thorough literature review. Multiple items were used to measure each variable and a 7-point Likertscale was used to rate each item, in which "7" represents "to a very great extent" and "1" refers to "to a very small extent". All the factors of team trust were used as the input variables of the SVR model, which are shown in Table 2.

Multiple items were also used to rate Project Performance y, the output of the SVR model. It is the sum of Goal achievement (6 items), project efficiency (5 items) and members' attitude (7 items). Figure 1 shows the fractal dimensions from samples of input and output in SVR model.

RESULTS

Firstly, we run nonlinear screening of trust factors based on SVR. As mentioned above, team trust factors are used as independent variables of the SVR model and project performance is used as dependent variable. The screening results are shown in Table 3.

It is noted that min $F = F_5 > F_{0.05}(1, 176) = 4.30$ and there is no factor be eliminated in the first round. This indicates that all trust factors has significant impact on project performance. Then, these factors are used as input of the SVR model and the regression model is constructed. The significance of the regression model can be calculated by using Eq. (8). The result shows that $F_{SVR} = 246.408 > F_{0.05}(9.176) = 2.51$, which indicates that the regression model is fairly significant. The comparisons of the value of original y and predicted $\hat{y}$ in descending order are shown as Fig. 2.

Then, we calculate the F-values of trust factors by using Eq. (9) and the results are 182.31 for x1, 137.04 for x2, 191.50 for x3, 135.50 for x4, 57.83 for x5, 126.59 for x6, 90.52 for x7, 98.52 for x8, 160.23 for x9.To express the *F*-values of trust factors with their relative value w_j, we normalize each value by the following equation:

$$w_j = \frac{F_j}{\sum_{j=1}^{9} F_j}, \quad j = 1, 2, \cdots, 9. \tag{10}$$

The results are shown in Table 4 and Fig. 3, which also indicates the impact of each trust factor on project performance or the relative importance of each trust factor.

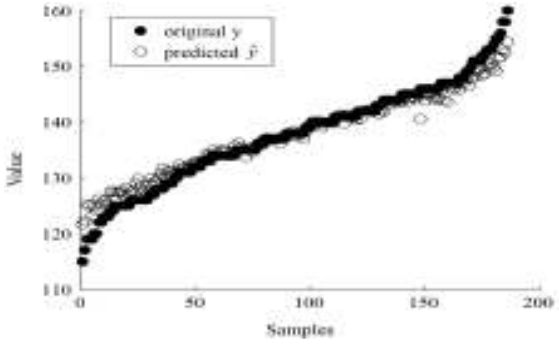

Fig. 2: The value of original y and predicted $\hat{y}$in descending order

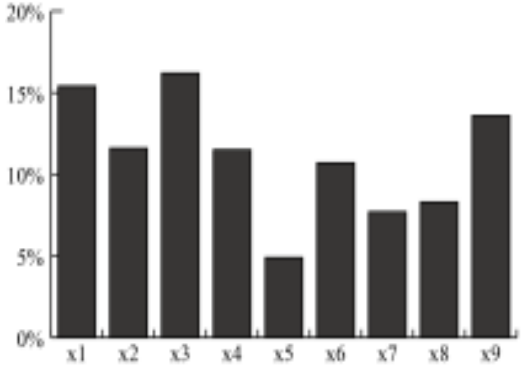

Fig. 3: The relative importance of trust factors

Table 4: The relative importance of each factor

Variables	Trust factors	(%)
x3	Cooperation	16.2
x1	Cognitive-based trust	15.4
x9	Interactional justice	13.6
x2	Affective-based trust	11.6
x4	Monitoring	11.5
x6	Team longevity	10.7
x8	Procedural justice	8.3
x7	Team proximity	7.8
x5	Team diversity	4.9

DISCUSSION AND CONCLUSION

Previous literature shows that team trust is important for project performance in CFTs, yet the degree of each trust factors' influence has not been fully studied. This research examines the relevance of each trust factors to project performance. Therefore, we conducted a survey to collect data on factors of team trust formation and project performance and proposed a project performance prediction model by using SVR and the significance of the trust factors are examined by F-test.

Results show that on the whole, project process factors are more important than structural and contextual factors with respect to their influencing on project performance. At first, cognitive-based and affective-based trust are suggested by many previous research as the key factors for project performance and our findings are consistent with these research. Moreover, the importance of cooperation is found to be the most important factors in the study. This indicates that in CFTs, to create a cooperative atmosphere will foster team trust, so that team members keep their integrity and are more willing to help others or look for advice from others. Furthermore, it is noted in the study that the monitoring behaviors has negative impact on project performance, because most members in CFTs are reluctant to work under surveillance and dislike other people to frequently check whether they have done their work. In addition, interactional justice concerns interaction between managers and team members, if managers are not able to eliminate personal bias and treat members unfairly, team trust atmosphere and member's attitude would suffer. Besides, study also found that team longevity is significant, this indicates that the composition of CFTs should be changed too frequently and thus members could have enough time to develop and maintain team trust. Also, procedural justice and Team longevity are also indispensable for project performance. All procedures must free of bias and be applied consistently in CFTs. And with more and more convenient ways of communication, it is not necessary for team members to keep face-to-face contact to performance project tasks. Finally, it is surprisingly in our study that team diversity has the least impact on project performance, the possible explanation may be that people different in functional areas and demography is a common phenomenon of in CFTs and other project teams and members are able to handle this diversity competently.

Our study makes several practical contributions. To study team trust and performance relationships, the study considers both project process factors and structural & contextual factors, which are the extension of the previous research that only considers one of them. In addition, the impact of each trust factor on project performance is examined, so that project managers could acquire a better understanding of the relevance of each factor on performance, which will help them improve management skills. In future studies, we will consider the use of these trust factors to design a performance management system, in order to help project managers to achieve the dynamic management and early warning of project performance.

ACKNOWLEDGMENT

The work described in this study is supported by the National Science Foundation of China (NSFC, Project No.70871088 and No.71272146).

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