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Complementary Roles of IS Leadership: Mathematical Model

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ABSTRACT

The dynamism of business environments characterized by heightened competition and rapid technological change presents great challenge to IS- leadership roles in attaining a balance between innovation and stability, effectiveness and efficiency requirements of organizations. This paper presents a mathematical model based on structural path analysis to investigate the impact of IS- leadership roles on organizational change. The model presented in this study, first hypothesizes the relationship between three constructs namely: IS-transactional role, IS-transformational role and IT-enabled change and then develops a mathematical model of the relationship to test the hypotheses. The model was tested based on assumed data and a comparative analysis of the results of the model with IT-leadership success model based on empirical data collection was carried out. The results show that the proposed model is easier to use and compute than the IT-leadership success model.

INTRODUCTION

Fast changing global marketplaces characterized by rapid technological growth and heightened levels of competition have created a turbulent, unstable and competitive environment in which significant organizational change is imperative. This has forced organizations to embrace the effective use of information technology (IT) in order to remain competitive and have strategic advantage. Widespread changes in the marketplace have continuously altered and reshaped the roles and responsibilities of CIOs in organizations (Kiely 1991).

As organizations have become more dependent on IT, IS -leadership roles have grown in importance and visibility (Vedder &Guynes 2000, Mclean &Smith 1998). In the area of information systems, there are supporting evidence that IS executives perform both strategic and tactical roles (Planes & Castillo 2002). Another recent study of firms indicates that some CIOs posses sound technical expertise but lack significant understanding of the business (To &Lai 2001). One useful model of IS -leadership roles describes the IS- leadership role as, a technologist, an enabler, a strategist and an innovator (Mclean & Smith 1998).

As rapid changes in the environment take place, one of the issues facing IS-leadership roles is the uncertainty associated with rapid changing business and technological environments. This paper presents a mathematical model to investigate how IS-leadership roles influence organizational change process. The relationship among IS-transformational role, IS-transactional role and IT-enabled change is hypothesized in this paper. The paper is organized as follows: Section 2 deals with hypothesis formulation. Section 3: mathematical model. Section 4: hypothesis testing. Section 5: results and analysis and section 6 conclusions.

HYPOTHESES FORMULATION

This study hypothesized the relationship among: IS- transformational role, IS-transactional role and IT-enabled change. The foundations as well as the operationalization of these constructs were derived from the literature and a structural model of the relationships among the constructs is developed as shown in Figure 3. The premise of this model is that IS leadership styles are likely to influence IT-enabled change.

<u>IS- transformational role:</u> The IS leader requires transformational role (Bass 1995) to produce innovation and

effectiveness especially in the initiation phase of the change process where visionary and committed leadership is critical for success (Davenport 1993). Transformational leaders influence followers by setting challenging expectations, creating mutual respect, displaying exemplary behaviors, and focusing on followers' needs and higher-level motives (Avolio, Bass & Jung 1999).

Transformational role is measured by four interrelated and interdependent variables namely: intellectual stimulation, individualized consideration, inspirational motivation, and idealized influence (Bass & Avolio 1995). These variables are interrelated and interdependent and therefore affect IT-enabled change process. Therefore, keeping in mind the above discussions, it is hypothesized that:

H1: There is a positive relationship between IS- transformational role and IT- enabled change.

IS-transactional role: Transactional leader requires transactional skills to achieve stability and efficiency for the successful implementation of IT-enabled change initiatives without which the corporate existence of the firm might be threatened (Kotter 1990). Transactional leaders display contingent rewards and management by exception behaviors. Five interrelated and interdependent elements are used as indicators of IS-transactional role with four new ones developed: managing coordination, managing expectations, monitoring performance, and managing technical support while contingent reward has been adopted from Multi-Factor Leadership Questionnaire (MLQ) by (Bass & Avolio 1995). These five elements are interrelated and interdependent and therefore affect IT-enabled change. Therefore it is hypothesized that:

H2: There is a positive relationship between IS-transactional role and IT-enabled change.

IT-enabled change process: Organizational innovation or change has been described as multi-stage process broadly termed as Initiation, Development and Implementation. The initiation stage is normally associated with idea creativity and idea champions and hence is affected by transformational leadership role. Information processing is rapid and decision-making fast in the development stage. Information processing takes the form of discussions, conflict resolution, coordination and feedback accomplished through formal means such as functional groups, virtual teams and boundary –spanning roles (Tushman & Nodler 1986). Transactional leaders fosters effective information sharing among different units by establishing effective coordination mechanisms such as standard operating procedures, liason roles, tasks forces and oversight teams to promote collaboration (Bharadjwaj 2000) for the adoption of IT-enabled change initiative (Chatterjee et al 2000). The implementation stage requires user participation, involvement, motivation and support and hence is affected by both types of leadership roles. Therefore from the discussions above, it is hypothesized that:

H3: A balance response relationship between IS-transactional role and IS-transformational role influence IT-enabled change.

In this study IT-enabled change is the dependent variable and will be affected by IS-transformational role and IS-transactional role. The independent variables are IS-transactional role and IS-transformational role.

Figure1: The conceptual model of complementary roles of IS – leadership.

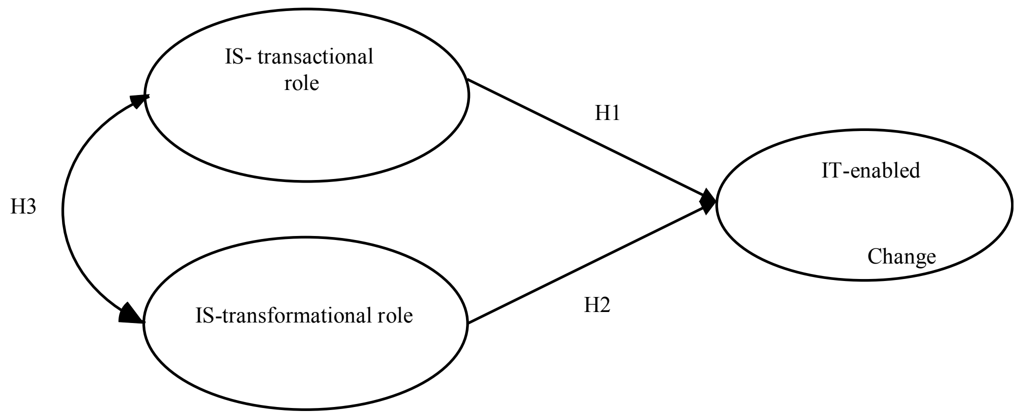


Figure2: The measurement model of complementary roles of IS-leadership constructs.

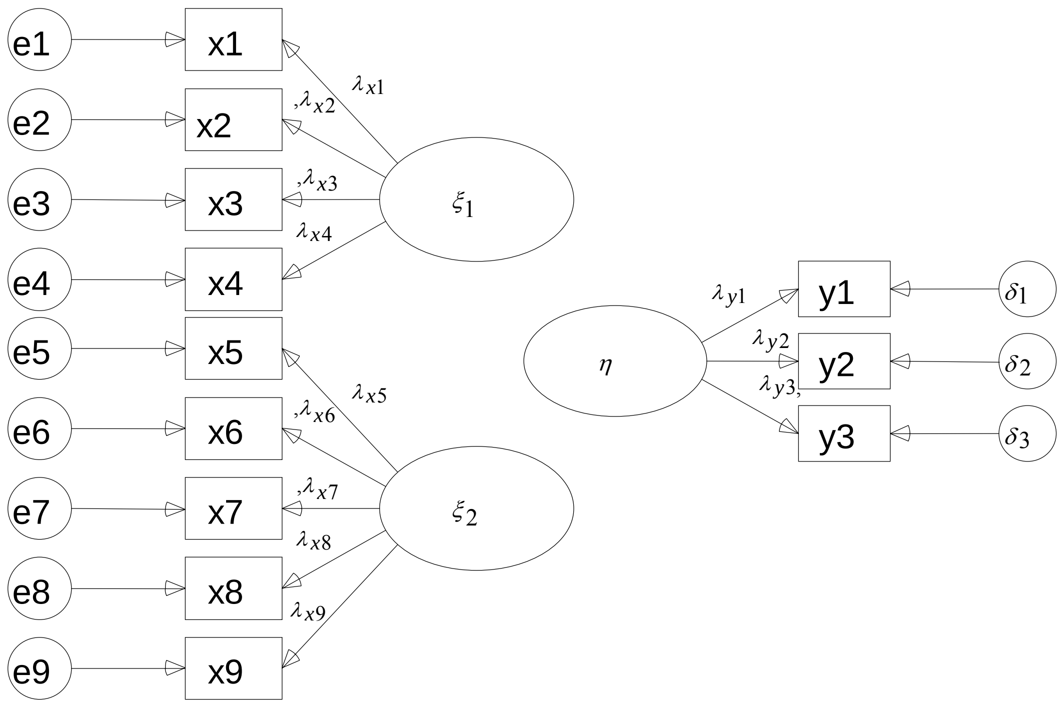
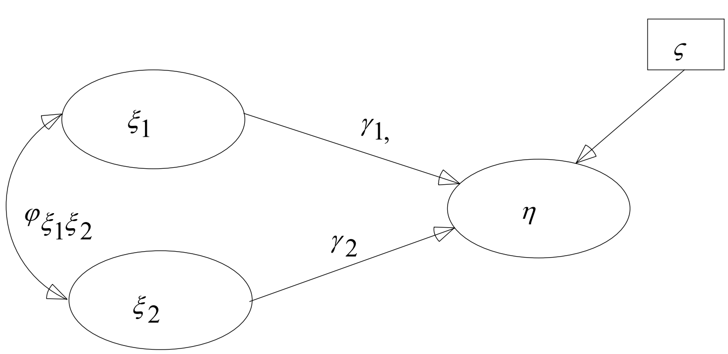


Figure3: The structural model of complementary roles of IS-leadership.



MATHEMATICAL MODEL

The complementary roles model has three distinct measurement sub-models as shown in Fig.2 to measure the three constructs namely: transformational role, transactional role and IT-enabled change.

Let: ξ_1 : IS-transformational role, ξ_2 : IS-transactional role, η : IT-enabled change and $\varphi_{\xi_1\xi_2}$: Correlation between ξ_1 and ξ_2

IS-transformational role

Let x_1 : Intellectual stimulation, x_2 : Individualized consideration, x_3 : Inspirational motivation and x_4 : Idealized influence. Variables x_1, x_2, x_3 and x_4 are indicators of IS-transformational role (ξ_1). Hence the measurement equations for the model are derived as:

$x_1 = \lambda_{x1}\xi_1 + e_1$ ………… (1) $x_2 = \lambda_{x2}\xi_1 + e_2$ ………... (2), $x_3 = \lambda_{x3}\xi_1 + e_3$ ………… (3) and $x_4 = \lambda_{x4}\xi_1 + e_4$ ………... (4)

Where $\left[e_1,\cdots e_4\right]$ = E_1 = Error variances of transformational role indicators.

$\left[\lambda_{x1},\ldots\lambda_{x4}\right]$ = Factor loadings of transformational role indicators.

In matrix form the equations can be summarized as:

$X_1 = \left[x_1,\ldots x_4\right]$ ………… (5) $E_1 = \left[e_1,\cdots e_4\right]$ ……. (6) and $\lambda_{X1} = \left[\lambda_{x1},\ldots\lambda_{x4}\right]$ …….(7)

This implies that: $X_{\xi 1} = \xi_1 \lambda_{X1} + E_1$ ……..(8)

IS-transactional role

The indicators for IS-transactional role are: x_5 : Managing coordination, x_6 : Managing expectations, x_7 : Monitoring performance, x_8 : Managing technical support and x_9 : Contingent reward. Hence the measurement equations for the model are: $X_5 = \lambda_{x5}\xi_2 + e_5$ ………(9), $X_6 = \lambda_{x6}\xi_2 + e_6$ ………(10), $X_7 = \lambda_{x7}\xi_2 + e_7$ ………(11) $X_8 = \lambda_{x8}\xi_2 + e_8$ ………(12) and $X_9 = \lambda_{x9}\xi_2 + e_9$ ………(13)

In matrix form this can also be summarized as: $X_2 = \left[x_5,\ldots x_9\right]$ ………… (14) $E_2 = \left[e_5,\ldots e_9\right]$ …………… (15) and $\lambda_{X2} = \left[\lambda_{x5},\ldots\lambda_{x9}\right]$ ……… (16). This implies that:

$X_{\xi 2} = \xi_2 \lambda_{X2} + E_2 \ldots$ (17)

IT-enabled change process

The measurement variables for the IT-enabled change are: y_1: Initiation, y_2: Adoption and y_3: Implementation. The measurement equations for this variable are derived as follows:

$y_1 = \lambda_{y1}\eta + \delta_1 \ldots$ (18) $y_2 = \lambda_{y2}\eta + \delta_2 \ldots$ (19) $y_3 = \lambda_{y3}\eta + \delta_3 \ldots\ldots\ldots\ldots\ldots$ (20)

In matrix form this is summarized as:

$Y = \left[y_1, \ldots y_3\right] \ldots\ldots\ldots.$ (21) $\lambda_Y = \left[\lambda_{y1}, \ldots \lambda_{y3}\right] \ldots$ (22) $\Delta = \left[\delta_1 \ldots, \delta_3\right] \ldots\ldots\ldots\ldots$ (23)

Where λ_Y represents the factor loadings of IT-enabled change measurement variables and Δ stands for the error variances of IT-enabled change measurement variables.
The equation is stated as:

$Y = \eta \lambda_y + \Delta \ldots\ldots\ldots$ (24).

Combining eqns. (8), (17) and (24) yields the structural model in fig.3. The structural model is defined by the structural equation:

$\eta = \xi_1 \gamma_1 + \xi_2 \gamma_2 + \zeta \ldots$(25)

Where: γ_1 and γ_2 represents the structural equation coefficients and ζ error variance for the structural model.

The structural equation describes the dependence relationships between IT-enabled change and IS-leadership roles i.e. IS-transformational role and IS-transactional role. The error term in the structural equation reflects the fact that the relationship between η, ξ_1 and ξ_2 is a statistical one and that ξ_1 and ξ_2 will not in general explain all the variances in η.

By standardizing the error term in the model (fig.3), the bivariate correlation between the constructs is the sum of the compound paths of the causal relationships connecting these points. This relationship forms three equations as follows:

$\xi_1 \xi_2 = \varphi_{\xi_1 \xi_2} \ldots\ldots\ldots\ldots\ldots$ (26), $\xi_2 \eta = \gamma_2 + \varphi_{\xi_1 \xi_2} \gamma_1 \ldots$(27) and

$\xi_1 \eta = \gamma_1 + \varphi_{\xi_1 \xi_2} \gamma_2 \ldots.$ (28).

METHODOLOGY

In order to investigate the significance of the relationships among the hypothesized constructs, the following assumptions were made for simplicity:

1. Linear relationship is assumed among all the variables
2. The values of correlation coefficient among all variables are assumed between –1 to +1
3. Standardized values (i.e.1) of both error and measurement variables are assumed.

Parameter Values

The values of the parameters to be estimated were selected to reflect a linear relationship among all the variables. These parameters include:

1. Correlation between ξ_1 and ξ_2 is assumed from –1 to +1 (i.e. $-1 \leq \varphi_{\xi_1\xi_2} \leq +1$)

2. Correlation between ξ_1 and η is from 0.2 to 1 (i.e. $0.2 \leq \xi_1\eta \leq 1$) while correlation between ξ_2 and η is assumed from 0.3 to 1 (i.e. $0.3 \leq \xi_2\eta \leq 1$).

Parameters to be estimated are the structural correlation coefficients i.e. γ_1, and γ_2 from the model. Using hand calculation and the Mat lab the following values were obtained as in table 1 and graphically represented in figure 4.

Table 1: Calculated parametric values of constructs.

No	φξ1ξ2	ξ1η	ξ2η	γ1	γ2
1	0.10	0.20	0.30	0.18	0.28
2	0.20	0.30	0.40	0.23	0.35
3	0.30	0.40	0.50	0.27	0.45
4	0.40	0.50	0.60	0.30	0.48
5	0.50	0.60	0.70	0.33	0.53
6	0.60	0.70	0.80	0.34	0.59
7	0.70	0.80	0.90	0.33	0.67
8	0.80	0.90	1.00	0.26	0.79
9	0.90	1.00	1.00	0.52	0.53
10	1.00	0.00	0.00	0.00	0.00

Figure 4: Relationship between Parametric Values.

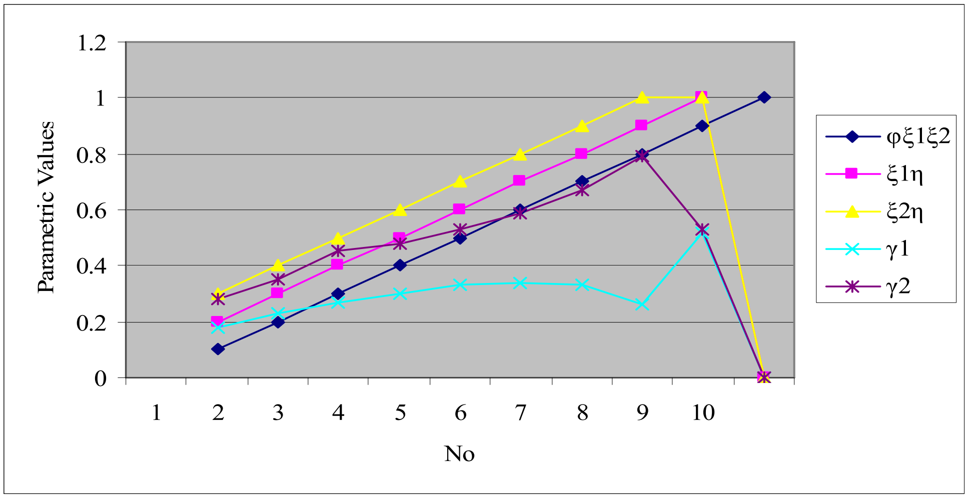


Figure 5: Results of the structural model.

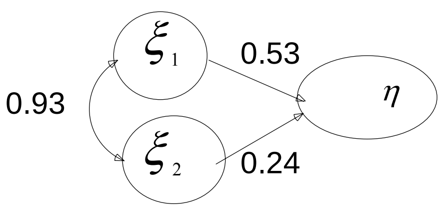
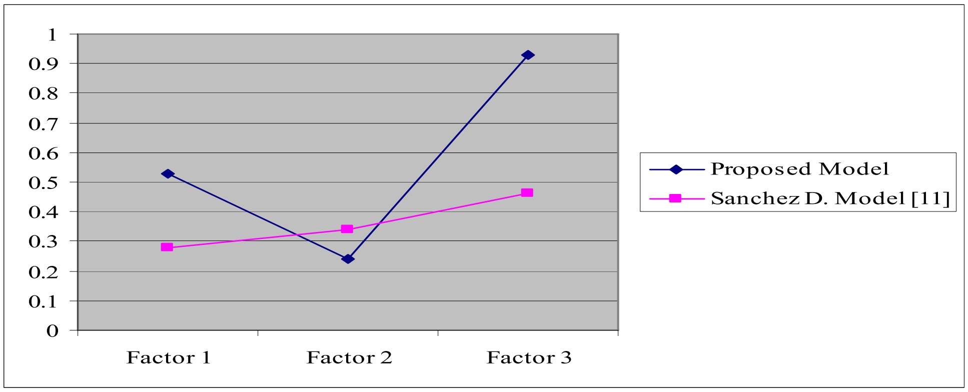


Table 2: Comparative results.

Model	Factor 1	Factor 2	Factor 3
Proposed Model	0.53	0.24	0.93
Sanchez D. Model	0.28	0.34	0.46

Figure 6: Comparative Analysis of Proposed Model and Sanchez D Model.



RESULTS

Structural path analysis was conducted to test hypotheses H1 through H3, which hypothesized a relationship between the two independent variables: IS-transformational role (ξ_1), IS-transactional role (ξ_2) and a dependent variable: IT-enabled change (η). All the two independent variables were entered into the structural model at the same time. The results of the model are as shown in figure 5 and discussed below.

The result of the analysis supports the hypothesized relationships (H3, H2 and H1) among all the constructs. Path analyses of all significant relationships among various constructs together with structural correlation coefficients are summarized as follows:

IS-transformational role and IT-enabled change = $\xi_1 \eta$

$$\gamma_1 = 0.53$$

IS-transactional role and IT-enabled change = $\xi_2 \eta$

$$\gamma_2 = 0.24$$

IS-transformational role and IS-transactional role = $\varphi \; \xi_1 \xi_2$

$$\gamma_3 = 0.93$$

The result of the structural model shows that IS - leadership roles have significant influence on IT-enabled change particularly transformational role (0.53) has greater impact on organizational change than transactional role (0.24). The correlation between the two roles i.e. transactional and transformational roles (0.93) indicates that for strategic implementation of change initiatives, organizations need a balance response between both transformational role and transactional role in order to achieve success in all strategic change management initiatives. This explains the need for stability and effectiveness, innovation and efficiency.

COMPARATIVE ANALYSIS

The result of the proposed model is compared with IT leadership - success model (Sanchez et al 2004) as in table 2 and graphically represented in figure 6.

The IT – leadership success model (Sanchez et al 2004) hypothesized the relationship among three factors namely: organizational leadership (factor1), IS Success (factor2) and IT leadership (factor3) to assess empirically the impact of organizational leadership and IT leadership in achieving IS Success while the proposed model considers IS-transformational role, IS-transactional role and IT-enabled change to assess the impact of IS-leadership roles in achieving successful organizational change. The IT-leadership success model is based on the collection of empirical data and the use of LISREL 8.54 software for analysis while the proposed model is based on assumed data and the computation of correlation coefficients among the constructs. Both models however have the same structural path relationships among various constructs hence the bases for comparison between the two models.

The results of both models provide support for the hypothesized relationships among constructs. However, the proposed model saves a lot of time and the complexity associated with empirical data collection and analyses using LISREL. Hence the proposed model is easier and faster to use in hypotheses testing than the IT-leadership success model.

CONCLUSION

This research presents a mathematical model to investigate the impact of IS leadership roles on organizational change. The results of the model show that IS-transformational roles are more likely to influence organizational change than IS-transactional role.

The proposed mathematical model is based on assumed data and the computation of correlation coefficients among constructs while the IT-leadership success model is based on empirical collection of data and analyses using LISREL. Both models provided the same structural path relationship among various constructs hence the bases for comparative analyses.

The results of the analyses give support for the hypothesized relationship among constructs of both models. However, the proposed model is easier to compute and analyze than the IT-leadership success model and hence saves a lot of time and complexity associated with the empirical collection of data and analysis.

The research makes novel contribution in understanding how IS- leadership roles can impact organizational change. First it hypothesizes the relationship among different roles of IS leadership and how they can affect organizational change and then derived a mathematical relationship among these constructs based on structural path analysis.

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