The Impact of System Appropriation-Related Factors on the Success of Data Warehousing Systems: Experience from the UAE

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***Abstract*-- The current study is an exploratory research aimed at identifying the factors that influence successful development of data warehousing (DW). Analysis of reviewed related studies together with the information gained from interviewing data warehousing experts constitute the basic foundation for the current study's theoretical framework. Five hundred and eighty data warehouse users in 34 companies were surveyed to obtain their perceptions of the extent that each of 132 items had actually contributed to their firms' DW success at different phases of development. The researchers have followed rigorous multivariate statistical analysis procedure to construct an overall model of DW success. The model has proven that all its independent variables have significant influence on the DW overall success and that system appropriation factors have significant impact on this success throughout the different phases of DW development.**

***Index Term*-- Data warehousing, Implementation, System Appropriation factors, Data Warehousing Success.**

INTRODUCTION

Although many studies in data warehousing (DW) were published [McCaskey, 1976; Zmud, 1979; Gordon and Narayanan, 1983; Meador, Guyote and Keen, 1984; Fulk, Steinfield, Schmitz, and Power, 1987; Sharda, Barr, and McDonnell, 1988; Alavi and Joachimsthaler, 1992; Adelman and Moss, 2001; Ariyachandra and Watson, 2005; to name a few], these studies were concerned more with technical issues. They did not however account for many other important dimensions [Agosta, 2006]. Business/culture/implication related issues are of interest and fall among these left for future studies. This study is an exploratory research aims at identifying the effect of system appropriation factors on the successful adoption & diffusion of data warehousing, thereby extending the body of knowledge concerning data warehousing success.

THE THEORETICAL FRAMEWORK

The current study uses a similar model to that of Cooper and Zmud [1990] to describe the DW completion process. The process consists of four phases: initiation & adoption, adaptation, acceptance & routinization, infusion. This approach usefully emphasizes the continual tension between efficiency and effectiveness in the use of IT [Cash et al., 1992].

Reviewed related literature and semi-structured interviews of data warehousing experts have suggested six groups of explanatory variables. Figure 1 depicts the model of DW success examined in the current study. The current paper examines the influence of the system appropriation-related factors in the model.

Success of the Data Warehousing System

Success of a data warehouse, is defined in terms of its ability to encompass the real information needs of the business [Golfarelli and Rizzi, 2009]. Four variables are used to measure success of the data warehouse systems through its different phases of development.

1. Data warehouse success at the initiation & adoption phase: match of DW with organization [Cooper & Zmud, 1990], timely DW decision to invest to exploit the new opportunity and make use of new technology, DW used in organization's work [Cooper & Zmud, 1990], DW answers new decision questions [Little, 1998], and DW is in long term business plan,
2. Data warehouse success at the adaptation phase: DW is ready to use [Cooper & Zmud, 1990], DW is responsive [Keen, 1988], and can identify different and sophisticated uses [Rogers, 1983],
3. Data warehouse success at the acceptance & routinization phase: how successful is the project team in resolving initiation issues [Tornatzky & Klein, 1982], expandable DW use (Rist, 1997), scaleable DW [Amoroso & Cheney, 1991], DW planned workability [Amoroso & Cheney, 1991], DW use encouraged [Cooper & Zmud, 1990], people induced to commit to DW use [Cooper & Zmud, 1990], how successful is the steering

committee in resolving integration issues [Goodhue, Wyo, & Kirsch, 1992], work practices are flexible modified [Heflin, 1992], DW viewed as asset [Sanders & Courtney, 1985], and DW changing executives' work [Money et al., 1988],

4. Data warehouse success at the infusion phase: the organizational systems adjusted for DW [Cooper & Zmud, 1990], and DW used to full potential [Cooper & Zmud, 1990].

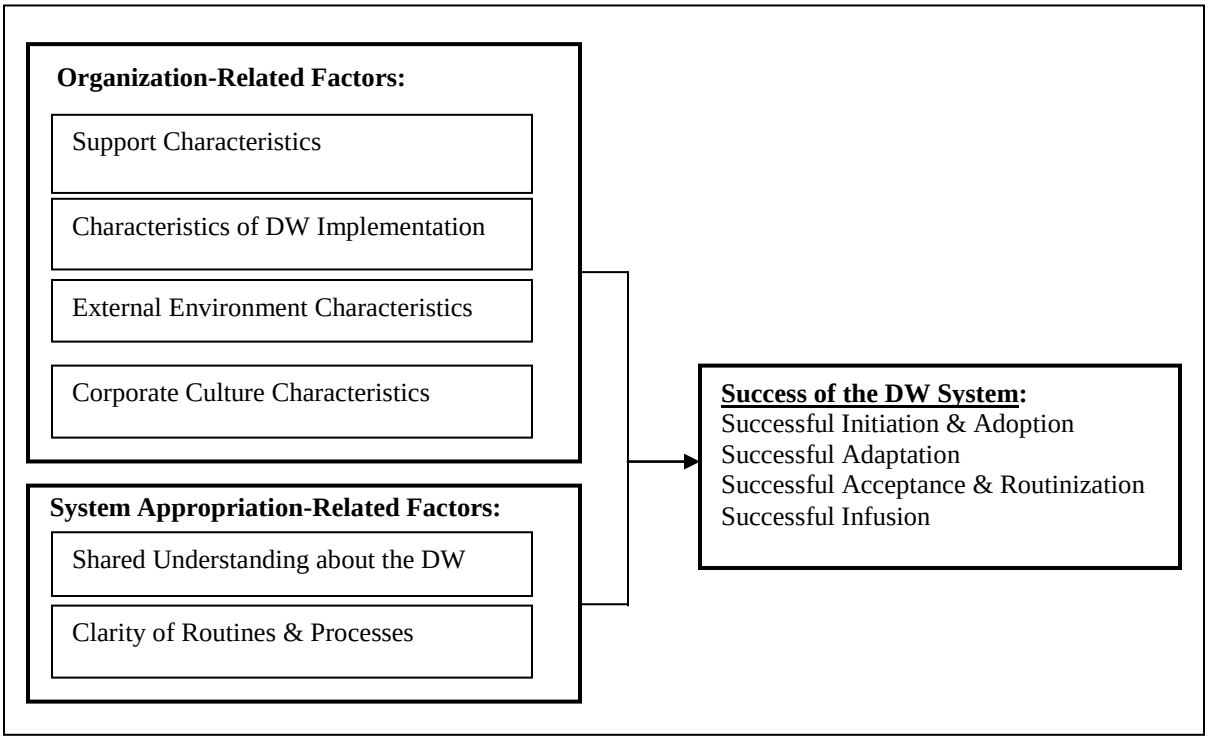

Fig. 1. Integrated Model of the Factors that Influence DW Success

Support Characteristics

Data warehousing projects are described in the literature as expensive, time-consuming undertakings [Hilebrand, 1995; Sakaguchi & Frolick, 1997; Watson & Haley, 1997; and Reeves, 2009]; therefore, having adequate resources should be critical to their success. Three variables are employed to measure the support characteristics:

1. Data management [Amoroso & Cheney, 1991]: Availability of data management tools to manipulate the data as necessary, availability of metadata to provide a detailed attribute map of all DW data,
2. IT suitability [Inmon, 1996]: Suitability of the DW platform, sophistication of IT networking in place, tuning each data mart for the particular function it provides for each business area ,
3. System reliability & support team responsiveness [Inmon, 1996]: High level of compatibility among hardware, network, and software, tuning each data mart for the particular function it provides for each business area.

External Environment Characteristics

The environment surrounding the DW is defined as the external environmental factors that influence its use of information. The existence of powerful forces affecting the enterprise such as turbulence in the economic, competitive or regulatory environments is a good example of such factors [Thompson, 1967, Galbraith, 1974; and Kimberly & Evanisko, 1981.] This variable is measured in terms of industry environmental pressures [Duncan, 1972; Hall, 1980] approximated by "volitality of the firm economic environment", "volitality of the firm competitive environment", "complexity of the firm competitive environment", and "volitality of the firm regulatory environment".

Implementation Characteristics

Careful system implementation is defined as "the degree to which user training, data integration, benefits/costs relationship, selecting a pilot application, quick and frequent building of prototypes, incremental implementation, proactive and publicized reporting, and end-user involvement affect the data warehouse success" [DeLong & Rockart, 1986]. Three variables are frequently cited in related empirical studies to measure these characteristics:

1. End-user involvement & expectations [Barki & Hartwick, 1994]: Importance of user expectations about the DW potential capabilities to the DW

implementation, importance of the system user sponsorship to the DW implementation, importance of end-user involvement to the DW implementation,

2. Use of prototyping [Inmon, 1996; DeLong & Rockart, 1986]: Importance of quick and frequent building of prototypes to the DW implementation, importance of prototyping tools to the DW implementation,
3. Management commitment [Guimaraes et al., 1992]: A top manager who is a visionary or a leader supports the DW system, a top manager who believes that DW creates business opportunities supports the DW system, top management is strongly in favor of the concept of DW, a committed and informed executive sponsor supports the DW system, a committed and informed operating sponsor supports the DW system, top management support to increase IT infrastructure capabilities.

Corporate Culture Characteristics

Data warehousing raises a number of cultural issues such as the problems that arise when people are not used to sharing their data. IT staff can also be a problem. They need to be able to produce demonstration systems quickly and to think themselves into the shoes of line management without detailed requirement specifications [Bird, 1996: p. 72]. Two variables are chosen to measure these characteristics:

1. User partnership [Swanson, 1988; Bergerson et al., 1991]: The DW users, management, and IT group are partners in adopting the DW, the DW users, management, and IT group are co-operating in managing the DW,
2. User responsibility for system [Mumford, 1969]: Responsibility for the system lies with the business area that generates the data, responsibility for the system lies with the functional area, responsibility for the system is shared among all users.

Shared Understanding & Meanings of the DW Project

This variable deals with learning and shared understanding of what the DW project is about, what it means for its users, for the organization, for the different stakeholders [Turban et al., 1996]. Shared understanding & meanings of the DW project is measured in terms of "DW is aimed at executive use" [Ward & Griffiths, 1996] which is approximated by "the DW aims at improving the way managers conduct business", "the DW aims at allowing managers to share information with customers and vendors", and "the DW aims at integrating information for effective use by executives".

Clarity of Routines and Processes

This variable is defined as how clear are the procedures and organizational processes that relate to the DW, for organizing new data entry, for extracting reports, or if there are ambiguities in the way data is captured, processed and reported [Zmud, 1979; Amoroso & Cheney, 1991]. Clarity of procedures [Iiavari, 1987] is measured in terms of clarity about the organizational procedures of capturing data, and clarity about the organizational procedures of processing data.

METHODS

A random sample of data warehouse users is selected from each firm in the study population of firms that satisfied the research criterion. The sampling design is nearly proportionate stratified random sampling.

A detailed questionnaire is developed, reviewed, pilot tested, and revised. Reliability and confirmatory factor analyses are employed to check reliability and validity aspects of the dependent and independent side variables.

Multivariate variance analysis and multivariate regression analysis are utilized to examine the relationships between the dependent and independent variables in the study model and test the study hypotheses.

Cronbach's Alpha is employed to measure reliability for each of the dimensions determined from the factor analysis [Sethi & King, 1991; Lederer & Sethi, 1992; Sekaran, 1992; Hair et al., 1995]. Reliability analysis is performed on all the eleven independent variables. Only system reliability & support team responsiveness had lower Cronbach's Alpha than the predetermined cut off point of 0.70. It had an Alpha of 0.67, which is slightly below the acceptable 0.70 threshold, but still can be tolerated if the constructs make sense [Nunnally, 1978]. Thus, there will be 11 valid independent variables to use in all further analysis.

A confirmatory factor analysis [Sekaran, 1972; Churchill, 1979] is used to show that the variables have discriminant validity. This discriminant validity is confirmed if the pattern of items loading onto extracted factors should produce the items in the variables – and this happens if the loading of each item is high on the designated factor and low on other factors. In order to test validity of independent constructs, all the items of all the variables are entered into factor analysis where the number of factors extracted is equal to the number of variables. The eleven extracted factors explained 84.6% of the total variation in the data items. Analysis shows that the variables are satisfactory since they correspond to the four extracted factors (KMO is .848) and the off-factor weightings are all below 0.4. Therefore, there were four success variables to use in analysis.

SETTING THE HYPOTHESES

Based on the above-mentioned integrative model of data warehousing success, two sets of functional relationships are hypothesized.

Shared Understanding & Meanings of the DW Project
Shared understanding and meaning of what the system does is an important aspect that may influence the system success [Zmud, 1979]. Existing ambiguity about the nature and purpose of the innovation should be reduced as much as possible. System orientation is a related concept. MIS literature reports positive associations between this factor and IS success [Neal & Radnor, 1973; Radnor & Bean, 1974; Radnor and Neal; Radnor et al., 1968.]

Consequently, one would expect:
H0(1-1a): The more the new system is oriented toward executive use, the more successful the new system adoption.
H0(1-1b): The more the new system is oriented toward executive use, the more successful the new system adaptation.
H0(1-1c): The more the new system is oriented toward executive use, the more successful the new system routinization.
H0(1-1d): The more the new system is oriented toward executive use, the more successful the new system infusion.

Clarity of procedures
Clarity of the organizational procedures and processes that relate to the IS, for organizing capturing and processing data have largely been used as design factor that influences the IS success [Iiavari, 1987; Ives, Olson, & Baroudi, 1983.] Researchers report positive associations between clarity of procedures and information systems success.

Thus, one would expect:
H0(2-1a): The clearer the new system organizational procedures to capture and process data, the more successful the new system adoption.
H0(2-1b): The clearer the new system organizational procedures to capture and process data, the more successful the new system adaptation.
H0(2-1c): The clearer the new system organizational procedures to capture and process data, the more successful the new system routinization.
H0(2-1d): The clearer the new system organizational procedures to capture and process data, the more successful the new system infusion.

THE MODEL DESIGN
The classical procedure of developing a multivariate analysis model of variance analysis was followed. First the main effects were determined, then the interaction effects, followed by the within terms, and finally the covariantes effect. The design reads as follows:

$$\begin{bmatrix} DW\ Success\ at\ initiation\ \&\ adoption \\ DW\ Success\ at\ adaptation \\ DW\ Success\ at\ acceptance\ \&\ routinization \\ DW\ Success\ at\ infusion \end{bmatrix} = Intercept + PHASE + JOB + PHASE*JOB + FIRM(PHASE) + X5DATA + X5GOODIT + X5SUPRT + X7ENVIRO + X8PRTCP + X9USEREX + X9PROTYP + X10COMIT + X13RESPN + X16EXECS + X17PROCS$$

Where,

PHASE	denotes DW phase of development,	JOB	denotes respondent job,
PHASE*JOB	denotes the interaction effect of DW phase and respondent job,	FIRM(PHASE)	denotes the firm effect within the different DW phases of development,
X5DATA	denotes data management,	X5GOODIT	denotes IT suitability,
X5SUPPRT	denotes system reliability & support team responsiveness,	X7ENVIRO	denotes industry environmental pressures,
X8PRTCP	denotes user partnership,	X9USEREX	denotes end-user involvement,
X9PROTYP	denotes use of prototyping ,	X10COMIT	denotes management commitment,
X13RESPN	denotes user responsibility for the system,	X16EXECS	denores DW is aimed at executive use,
X17PROCS	denotes clarity of procedures,		

ESTIMATION
MULTIVARIATE RESULTS
Table I reports estimation results of the above model at the multivariate level of analysis using collected data from 580 respondents. The results indicate that all the variables in the model are significant. Hence, the designed model is statistically dependable and can be used in analyzing the relationships between the criterion and predictor variable sets and further analysis is feasible.

Table I
Multivariate Tests

Effect	Pillai's Trace		Hypothesis df	Error df	Sig.
	Value	F			
Intercept	0.050	6.621	4.000	508.000	0.000
FIRMNUM(PHASE)	0.625	3.156	120.000	2044.000	0.000
PHASE	0.528	27.234	12.000	1530.000	0.000
JOB	0.236	5.346	24.000	2044.000	0.000
PHASE * JOB	0.188	1.396	72.000	2044.000	0.017
X5DATA	0.073	9.983	4.000	508.000	0.000
X5GOODIT	0.264	45.630	4.000	508.000	0.000
X5SUPPRT	0.027	3.582	4.000	508.000	0.007
X7ENVIRO	0.045	6.047	4.000	508.000	0.000
X8PRTCP	0.261	44.770	4.000	508.000	0.000
X9USEREX	0.066	8.933	4.000	508.000	0.000
X9PROTYP	0.078	10.775	4.000	508.000	0.000
X10COMIT	0.535	145.919	4.000	508.000	0.000
X13RESPN	0.122	17.725	4.000	508.000	0.000
X16EXECS	0.220	35.814	4.000	508.000	0.000
X17PROCS	0.072	9.825	4.000	508.000	0.000

PARAMETER ESTIMATES

Literature review, expert interviews, and statistical analysis reported in previous section led to the choice of two sets of variables (dependent and independent.) Regression parameters generated by the GLM procedure will be discussed in light of statements of prior expectations concerning the parameters of the model. Table II presents the results for estimating X constructs' parameters.

Table II
Parameter Estimates – Convariate Terms

Dependent Variables	YINIT	YADAPT	YACCEPT	YINFUSE
Intercept	0.504	-1.235 *	0.338	0.893
X5DATA	0.183 *	0.169 *	0.020	-0.036
X5GOODIT	0.173 *	-0.191 *	0.198 *	0.221 *
X5SUPPRT	0.061	0.004	-0.095 *	-0.177 *
X7ENVIRO	0.052	0.075	0.095 *	0.183 *
X8PARTCR	0.172 *	-0.090 *	0.121 *	-0.184 *
X9USEREX	0.061 *	0.074 *	0.034	0.228 *
X9PROTYP	-0.085 *	0.154 *	0.005	0.143 *
X10COMIT	-0.001	0.238 *	0.653 *	-0.143 *
X13RESPN	0.090 *	0.169 *	-0.010	0.283 *
X16EXECS	0.205 *	0.139 *	0.085 *	-0.201 *
X17PROCS	-0.070 *	0.111 *	0.002	0.234 *

* Significant at 0.05 level.

Most of the independent covariates estimated parameters are positive, suggesting a positive relationship; only few are negative. Also, most of these parameters are significant at ($p < 0.05$) level indicating strong relationship between these constructs and DW success at various phases of development.

RESULTS FOR THE HYPOTHESES

DW success at the initiation phase is positively affected by six characteristics – data management (X5DATA), suitability of IT (X5GOODIT), user participation (X8PARTCP), end-user involvement & expectations (X9USEREX), responsibility for system (X13RESPN), and DW aimed at executive use (X16EXECS). This supports hypothesis 1-1a. There are two characteristics that require

careful attention at this phase because of their unexpected negative impact: use of prototyping (X9PROTYP), and clarity of procedures (X17PROCS).

At the adaptation phase, DW success is positively influenced by seven characteristics – data management (X5DATA), end-user involvement & expectations (X9USEREX), use of prototyping (X9PROTYP), management commitment (X10COMIT), responsibility for system (X13RESPN), DW aimed at executive use (X16EXECS), and clarity of procedures (X17PROCS). This supports hypotheses 1-1b, and 2-1b. There are two characteristics that need careful handling at this phase: suitability of IT (X5GOODIT), and user participation (X8PARTCP) because of their negative impact on this phase success.

However, success at the acceptance & routinization phase is positively affected by the following five characteristics – suitability of IT (X5GOODIT), industrial environmental pressures (X7ENVIRO), user participation (X8PARTCP), management commitment (X10COMIT), and DW aimed at executive use (X16EXECS). This result supports hypothesis 1-1c. Only responsiveness of IT and support team (X5SUPPRT) needs careful attention at this phase because of its negative effect on success.

Still, success of the DW at the infusion phase is positively influenced by the following six characteristics - suitability of IT (X5GOODIT), industrial environmental pressures (X7ENVIRO), end-user involvement & expectations (X9USEREX), use of prototyping (X9PROTYP), responsibility for system (X13RESPN), and clarity of procedures (X17PROCS). This result supports hypothesis 2-1d. Three characteristics have negative influence on success at the infusion phase: responsiveness of IT and support team (X5SUPPRT), user participation (X8PARTCP), DW aimed at executive use (X16EXECS) and require careful treatment.

DISCUSSION

Most of the organizational variables included in this section of the current study were subject to investigate in other studies. Most of these studies have examined the effect of a single organizational variable on an IS's success [e.g., Schroeder & Banbasat, 1975; Pierce & Delbecq, 1977; Van de Ven & Ferry, 1980; DiMaggio & Powel, 1983; Premkumar et al., 1994, to name a few.] Few studies have endeavored to explain the relationships between organizational variables and IS success employing integrative models [e.g., Guimaraes, Igbaria, & Lu, 1992; DeLone, 1988; Fuerst & Cheney, 1982; Igbaria, 1986, Rivard & Huff, 1988; Kwon & Zmud, 1987; Cooper & Zmud, 1990; and Kimberly & Evanisko, 1981.]

Although other integrative models that endeavored to explain IS success [e.g., Kwon & Zmud, 1987; Cooper & Zmud, 1990; and Guimaraes et al., 1985] have not dealt with such system appropriation factors explicitly, the current study has found two of these factors significant in their association with the DW success: shared understanding & meanings of the DW project, and clarity of organizational procedures for capturing and processing data.

Shared Understanding & Meanings of the DW Project

Multivariate tests, in the current study, reveal the significance of the system aiming at executive use (X16EXECS) on the DW overall success. This result substantiated Treacy [1985] and Fuerst & Cheney [1982] findings and Ward & Griffiths [1996] expectations.

Analysis of estimated parameters reveals that although the DW being aimed at executive use (X16EXECS) has positive influence on the DW success at the initiation & adoption (YINIT), adaptation (YADAPT), and acceptance & routinization (YACCEPT) phases, it has negative influence on the DW success at the infusion (YINFUSE) phase. As the most advanced phase of the DW development, if the system is felt as being aimed only at executive use, other users will not consider it a success.

Clarity of Routines & Processes

Multivariate tests reveal that clarity of organizational processes of capturing, organizing, processing, and reporting data from the DW has significant influence on the DW overall success. Therefore, management should make every effort to clarify these procedures and organizational processes to all the system users. This finding agreed with Quinn [1973], Umstot et al. [1976], Zmud [1979], Iiavari [1987], and Ives et al. [1983.]

Analysis of estimated parameters shows that clarity of procedures (X17PROCS) is positively associated with the DW success at both the adaptation (YADAPT) and the infusion (YINFUSE) phases. However, it is negatively associated with the DW success at the initiation & adoption phase (YINIT). One would expect a positive association of using clarity of procedures on DW success at all phases of development, in general. Success at initiation & adoption phase, in the current study, composes of finding a match between DW solutions and its applications, making the decision to invest in the DW at the right time, having the overall IT architecture of the DW in the long-term business plans, and employing the DW in organizational work. While clarifying organizational procedures of capturing and processing data can be related to finding a match between DW solutions and its applications, the sample subjects might not find it easy to be related to employing the DW in organizational work at this early phase of DW development or having the overall IT architecture of the system in the long-term business plans. They might think that it does not worth it to clarify organizational procedures of capturing and processing data during this phase when the system is

not yet ready and its users are not in a position to use the system. Thus, the impression would be that clarity of procedures might not be instrumental in employing the DW in organizational work or including the overall IT architecture of the system in the long-term business plans.

Moreover, clarity of procedures does not have significant effect on DW success at the "acceptance & routinization" (YACCEPT) phase. The construct clarity of procedures is about clarity of organizational procedures of capturing and processing data. While DW technical developers understand that capturing and processing data are continuing functions throughout all the DW phases of development, most users think that these two functions are only important at the early phases of developing the system. This disagreement is suspected to be the reason behind this insignificant relationship between clarity of procedures and successful "acceptance & routinization".

STUDY IMPLICATIONS

Analysis in the current study demonstrated that the substantial differences in DW success among the UAE firms might be due to organizational factors, system appropriation factors, and the DW stage of development. This implies that these firms need to be extremely cautious when adopting a DW system.

Implications for Research

While many of the previous studies have examined the effect of a single organizational variable on an IS's success, the current study employed an integrative model to its analysis.

Despite some explicit appreciation of organization-related variables' effect on IS success, very few of the integrative studies have examined the effect of innovation related variables on IS success. The current study model included a specific construct on innovation characteristics to test their impact on DW success within the study integrative model.

None of the reviewed integrative studies have included any culture-related variables. The current study model encompassed a distinct construct on corporate culture & organizational climate to test their influence on DW success within the study model. Although, the current study relates more to the literature of IS implementation on which it mainly builds its model, it also builds on the organizational behavior, corporate culture and innovation literatures.

The implication here is that, the current study model is an endeavor to contribute to a contingency theory that to help the implementation efforts with respect to data warehousing. Other researchers may use the current study as a model to achieve contributions with respect to other information systems toward the development of a contingency theory.

Implications for Practice

The fact that there is significant effect of DW development phase on UAE firms' data warehousing success as evaluated by their top management, end-users, and IS developers highlights the demanding organizational activity of dealing with relevant implementation-process-related and organizational-behavior-related aspects of DW implementation.

On one side, "physical support characteristics", "implementation characteristics", "surrounding external environment conditions", and "corporate culture & organizational climate" aspects should be on the top of the implementation-process-related list. On the other side, "shared understanding & meanings" and "clarity of organizational routines & processes" should also be on the top of organizational-behavior-related list.

Since individuals assuming different job positions in the UAE firms seem to have important effect on the DW success at different phases of development, it is necessary to invite these parties to increase their involvement in adopting and managing the system. Their expectations should carefully be investigated and their participation should be encouraged.

CONCLUSION

The current study has built a multivariate model that treats the DW success at the different phases of development as a Y vector associated with the same set of PHASE and JOB factors and X DW system implementation covariates. The model has proven that all its factors and independent covariates have significant influence on the DW overall success.

Focusing on the system appropriation related variables, DW success at the initiation phase is positively affected by six characteristics one of them is DW aimed at executive use. Clarity of procedures requires careful attention at this phase because of its unexpected negative impact . At the adaptation phase, DW success is positively influenced by seven characteristics two of which are DW aimed at executive use, and clarity of procedures. However, success at the acceptance & routinization phase is positively affected by five characteristics one of which id DW aimed at executive use. Still, while success of the DW at the infusion phase is positively influenced by six characteristics one of which is clarity of procedures, it is negatively influenced by DW aimed at executive use.

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