# Factors Affecting the Successful Implementation of Data Warehouse

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**Abstract**

Data warehouse (DW) is considered as the creation, maintenance, and utilization of a decision support infrastructure that offers a distinct opportunity to enhance the infrastructure of Information Technology (IT). The successful implementation rate of the data warehouse system is however low and the majority of firms fail to achieve their intended goals concerning the system. This paper provides a discussion of the results of the model, specifically the relationship between some of the quality factors and the net benefits of data warehouse. The selected independent variables were expected to measure system quality and information quality service while the dependent variable was expected to measure the net benefits of the data warehouse systems. This paper provides an overview of the background of data warehouse and successful data warehouse, and it also provides a description of the research model and hypotheses while concentrating on the affective factors. This study presents an in-depth examination into the data warehouse success factors using data warehouse success models that will eventually offer inferences for decision makers to apply in order to achieve successful data warehouse implementation.

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**Keywords:** Data warehouse, information technology, system quality, information quality and data warehouse success.

## 1. Introduction

Today many organizations possess Information Technology (IT) infrastructures that provide limited data management, integration, and access, these organizations would be better served by IT infrastructures that offer appropriate data and tools to support decision makers (Almabhouh, Saleh, and Azizah, 2011). A data warehouse refers to an information system (IS) that extracts knowledge from the operational data stores of businesses (Ali, 2014).

A data warehouse provides data integration solutions and it enhances timely, accurate and consistent access to data (Ang and Teo, 2000). In this regard, Meyer and Cannon (1998) contended that data warehouse furnishes its users with effective decision support tools through the integration of extensive corporate data into one repository form which can be utilized by users to run reports and conduct ad hoc analysis of data. In addition, data warehouse makes use of investments incorporated in legacy systems to provide business users with the potential to exploit informational assets (Counihan, Finnegan and Sammon, 2002).

Notwithstanding its many advantages and benefits, data warehouse, unlike other information systems faces factors that impact its successful implementation (Adelman, 1997; Haley, 1997; Wixom and Watson, 2001; Kanar and Oz, 2002; Shin, 2003; Chenoweth, Corral, and Demirkan, 2006; Hayen, Rutashobya and Vetter, 2007; Hwang and Xu, 2008; Abu Ali and Abu Addose, 2010). Specifically, Hwang and Xu (2008) and Mukherjee (2003) explained that the success factors of data warehouse implementation have their basis on four categories namely organization, technique, usage and system.

The concept of integrated data to support management is not a new one and management information systems and executive information systems have been have been around since the beginning of the 1970s (Shim, Warkentin, and Courtney, 2002). Nonetheless, the operational Information Technology (IT) environment in many major companies is characterized as heterogeneous because of the dynamic changing technologies (March, Hevener and Ram, 2000).

### 3. Data Warehouse Success

A structural data warehouse success model was proposed by Hwang and Xu (2008) as shown in Figure 1 Both critical success factors and data warehouse success dimensions were combined in the model, with data warehouse success depicted by four dimensions namely system quality, information quality, individual benefits and organizational benefits. On the other hand, critical success factors are depicted by four categories namely operational, technical, schedule and economic.

Similarly, the success of IS was also investigated by Hayen *et al* (2007) in various ways including the measurement of the users satisfaction, system quality and the perceived usefulness of certain applications. Researchers created a model for metrics that can be utilized to manage data warehouse implementation success.

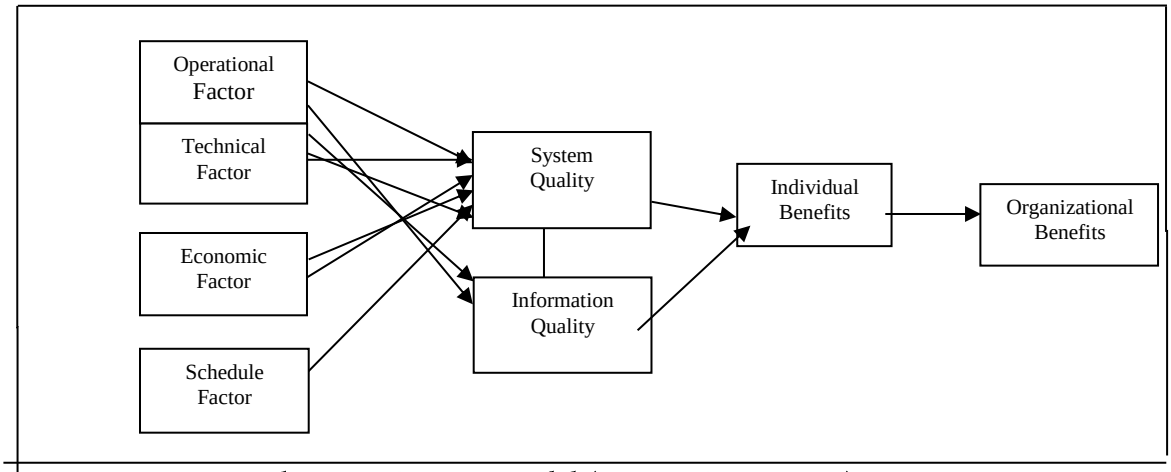


**Figure 1**: Data Warehousing Success Model (Hwang & Xu, 2008)

Prior studies have however confined their focus only on some aspects of the important issues and it is generally agreed that there is lack of comprehensive models that deals with data warehouse success. Majority of authors also stressed that a successful data warehouse can be realized through its benefits (Wixom and Watson, 2001; Shin, 2003; Mukherjee, 2003; Hwang and Xu, 2008). This study's research model and hypotheses are explained in the next sections.

Data warehousing success is an important issue for both researchers and practitioners; however, not many studies have empirically assessed data warehousing practices in general and critical success factors in particular. Although plenty of guidelines for implementation exist, few have been subjected to rigorous empirical testing (Xu, and Hwang 2007) .

### 4. Research Model and Hypotheses

The present study determines suitable variables and measures for a successful data warehouse implementation. This study's research model has three constructs as depicted in Figure 2. The model postulates that system quality and information quality are independent variables while the dependent variable is the net benefit.

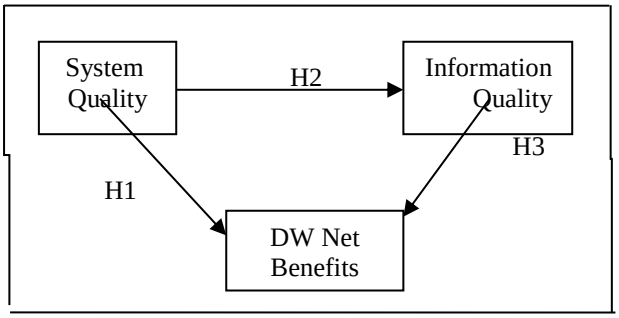


**Figure 2**: Hypotheses Research Model

A hypothesis refers to a defined logical conjecture of the relationship between two or more variables expressed in a testable statement. Conjectured relationships based on the association network are formulated for the research study. Hypothesis testing and confirming of the relationships is expected to provide the solution to the issue under study (Sekaran and Bougie, 2010). The entire study hypotheses are directional in stating the positive association between two variables or the comparison of two group terms.

Conceptualization of the data warehouse success model in this study involved three key activities: problem analysis, related dimensions identification, and construction of hypotheses. The analysis of the problem area was mainly established through a comprehensive literature review reported in chapter two. The main aspect of deriving a research model in this study is the identification of related dimensions. Review of literature revealed that existing data warehouse success models and their measures are insufficient and perhaps obsolete to assess the success of data warehouse (Chenoweth *et al.*, 2006; Hayen *et al.*, 2007). Hence, the following section discusses the hypotheses and variables of the research model in detail.

**4.1 System Quality**

Information system quality is reflected through the system quality and this covers tools and data components, and it is a measure of the level to which the system is technically dependable (Gorla, Somers, and Wong, 2010).

Gorla, Somers and Wong (2010) emphasized that an effectively designed and implemented system is required to obtain organizational benefits. These benefits are; increased revenues, reduced costs, and enhanced process efficiency (Bradley, Pridmore and Byrd, 2006). Contrastingly, an ill-designed system will likely run into system crashes which would adversely influence the outcome through increase product costs and business operations. An easily manageable system is characterized by a longer life that consequently results in the spread of software costs over a longer duration of time, which would eventually result in lower company cots (Swanson, 1997; Gorla et al., 2010).

Prior studies such as Seddon (1997), DeLone and McLean (2003) viewed system quality as the non-existence of system error, ease of use, user interface consistency, program code quality and documentation quality. In the context of information systems, system quality is a significant success factor (Petter, DeLone and McLean, 2008), as it is deemed to be the higher information systems quality that should be easy to use and that have greater success levels (Seddon, 1997; Nelson, Todd and Wixom, 2005). On the other hand, Nelson et al. (2005) considered the construct of system quality as one that produces information output in terms of flexibility, accessibility, integration, reliability, and response time and these are indicators of system success. Other researchers investigated the influence of data warehouse on decision performance and revealed that quality data warehouse systems support decision performance via system use (Seddon, 1997; Park, 2006).

The system quality-net benefits relationship is strongly reinforced in literature particularly in terms of measuring the success of information systems in various environments. A significant relationship is generally established between perceived ease of use as a measure of system quality, and perceived usefulness (Yang and Yoo, 2004; Wixom and Todd, 2005; Hsieh and Wang, 2007). Additionally, a study of e-commerce systems revealed that the system quality, gauged through ease of use, flexibility, reliability, and access convenience are all significantly associated with decision-making satisfaction (Bharati and Chaudhury, 2006). Seddon and Kiew (1996), and Shih (2004) reported a significant relationship between system quality and perceived usefulness as proxied by productivity and quality of decision-making. Therefore, the researcher proposes the following hypothesis;

***Hypothesis 1* (*H1*): *System quality is positively associated with data warehouse net benefits.***

System quality can be utilized to reflect information quality where lower system quality leads to high costs owing to the inability of the software to serve its intended purpose, its erroneous design, the errors within it, its limited safety measures and its lack of robustness (Gorla et al., 2010). Therefore, low-quality system leads to low quality of information (with regards to information content) owing to irrelevant and incomplete information. Moreover, a data warehouse system is flexible in updating in a short time and it thus satisfies changed user information needs and results in relevant and up-to-date information user outputs. These indicate high information quality. Consequently, flexibility of the system (maintainability, invaluable system features) results in high accuracy and completeness of information (Hwang and Xu, 2008).

Despite its importance, studies dedicated to the relationship between system quality and information quality is still few and far between. Among them, Gorla et al. (2010) investigated the system quality-information quality relationship on IS success model. They showed that system quality is significantly associated with information quality, measured in terms of content and format. In another study, Hwang and Xu (2008) concluded that system quality positively relates to information quality as proxied by better quality information and enhanced productivity. Hence, the following hypothesis is proposed;

***Hypothesis 2* (*H2*): *System quality is positively associated with information quality*.**

**4.2 Information Quality**

DeLone and McLean (2003) contended that information quality is considered as the output quality generated by the information system that can take the form of either reports or online screens. Various attributes have been used by researchers for information quality and among them Nelson *et al* (2005) who made use of constructs such as completeness, accuracy, currency and format to gauge information quality. Similarly, Huh, Keller, Redman and Watkin's (1990) study, defined four information quality dimensions including completeness, accuracy, currency and consistency. More importantly, majority of authors (Haley, 1997; Thomann and Wells, 1999; Rudra and Yeo, 2000; Wixom and Watson, 2001; Shin, 2003; Nelson et al., 2005; Hwang and Xu, 2008, among several others) are

of the consensus that information quality is an important aspect that influences data warehouse success.

However, in data warehouse systems, data quality is generally poor and several setbacks are expected – for instance economic failure and ineffective planning of strategies (Rudra and Yeo, 2000). The development of the warehouse systems and the direct information access from several sources by management and users of information contributes to the need for superior information quality within organizations (Lee, Strong, Kahn and Wang, 2002). In addition, the system is expected to allow the generation of high quality information and novel information for the purpose of innovation. For example, Sakaguchi and Frolick (1997) explained that one of the benefits of the data warehouse system is its provision of quantitative values that enable an organization to match their performance in order to gauge their development.

In this context, many studies investigated the information quality-net benefits of the success models relationship. For instance, Gatian (1994) claimed that information quality is linked to the efficiency of decision making. In the present study, information quality is deemed to be significantly related to work quality and time savings (Shih, 2004), as well as decision-making support (Bharati and Chaudhury, 2006). In addition, information quality is related with net benefits in a positive way as consistent with the claims of Seddon and Kiew (1996), Rai, Lang and Welker (2002), Shih (2004) and Wu and Wang (2006). The effect of information quality on net benefits in e-government environment was also studied by Prybutok et al. (2008) and they revealed significant outcome. Hwang and Xu (2008) claimed that information quality in the context of data warehouse systems is directly associated with individual benefits while Wixom and Watson (2001) contended that in successful data warehouse system, the importance of information retrieved is significantly related with perceived net benefits.

The outcome of the information quality-net benefits relationship at the organizational level is positive, where information quality is directly linked with organizational image, organizational efficiency and sales (Farhoom and and Drury, 1999) and superior perceptions of the workplace environment (e.g. interesting work, morale of employees, job content) (Teo and Wong, 1998). In addition to the above, data quality is found to be significantly linked to perceived decrease in both effort and time in terms

of decision making (Wixom and Watson, 2001). Despite the many reported findings, Petter et al. (2008) stressed on the need for further research to examine the information quality-net benefits relationship.

The above explanation and discussion of prior studies lead to the following hypothesis;

***Hypothesis 3 (H3): Information quality is positively associated with data warehouse net benefits.***

**5. Research Method and Population**

A population was defined by Sekaran and Bougie (2010) as an entire group of people, things or events that the researcher is interested to investigate (p.262). Similarly, Hair, Money, Samouel and Page (2007) defined it as a complete group that categorizes the set of common elements that is significant to the study. The population under study is also known as the target population and the research project is designed in a way that it gathers data from the population under focus. According to Hair et al. (2007), the target population is a crucial step in designing a research project.

The measures adopted in the present study are comparable to those of previous studies. Some items are presented in some form in the data quality instrument proposed by Haley (1997), Wixom and Watson (2001), Shin (2003), Dijcks (2004), Nelson et al. (2005), Ganczarski (2006), Watson and Ariyachandra (2006), Gorla et al. (2010), and Wixom and Watson (2001). Pre-testing evaluates the survey instrument prior to its employment on the target population. The pre-test stage involved three academic staff, three PhD students and three data warehouse experts, who are all experienced in data warehousing, research methodology and systems analysis. The participants were provided a copy of the survey instrument for their perusal and examination of it.

**6. Sample and Data Collection**

The researcher designed a web-based questionnaire divided over eight pages to clarify the questions, to minimize potential data loss and to keep track of each participant's progress. Moreover, welcome and thank you pages were added to introduce the questionnaire and to thank the respondents for participating. The switching between pages was facilitated through "Next Page" and "Previous Page" buttons with the answers saved per session. This data collection method provided a simple process of collecting responses from the participants, minimized manual data entry

errors and offered an efficient method for raw data analysis and its exportation to SPSS, version 17.

Specifically, the survey instrument comprises of three sections. First, Section 1 is dedicated to the respondent's personal details including their location, position of organization, experience in data warehouse projects, status of data warehouse projects and organizational details. The remaining sections dealt with data warehouse systems. In particular, Section 2 requested respondent's response to the statements that relate to information quality of data warehouse systems while Section 3 requested respondents to provide their opinions concerning the statements about system quality of data warehouse systems. In the final section, Section 4, the statements addressed the net benefits of data warehouse systems and respondents were asked to provide their perceptions on them.

According to researchers, simple random sampling involves the least bias and provides an extensive generalizability, with each element having a similar and equal chance for selection as a population subject.

The researcher selected 2,500 members of the TDWI randomly from the three groups with a combined total of 20,800 members. The members were chosen according to their frequent login to the TDWI website, their participation in events, and their published articles and papers. The reason for selecting 2,500 members lies in the fact that the researcher accepted the cheaper offer of that number of members for $1,300.

The selected members were then emailed the questionnaires through MERIT DIRECT. The total response was 288 questionnaires, constituting around 12% of the rate of response. From the 310 participating members, 22 were eliminated because of incomplete answers. Members were encouraged to participate through an offered draw for a $110 Amazon gift card and a copy of the completed research after it gets published. Due to the fact that the survey is unsolicited, fairly complex, quite long and because of limited resources, the researcher anticipated a low rate of response. This rate of response was explained by Dillman, Phelps, and Tortora (2009) who stated that the rate across various survey modes varied from low (13% for web), to moderate (28% for interactive voice response, IVR) and high (44% for telephone and 75% for mail).

**7. Analysis of the Data**

According to the first hypothesis (H1), the system quality is positively related to new benefits of data warehouse system. The system quality-net

benefits relationship was found to be significant and thus H1 is supported at the level of significance of 0.000. From Table 1, it is noted that the standardized correlation coefficient is 0.658 indicating that the factors are like easy to use, easy to learn, easy to manage, flexible, accessible and have quick response time of system for a successful data warehouse system.

**Table 1:** Hypothesis (H1) Correlations

| | | Net Benefits |
|---|---|---|
| System Quality | Pearson Correlation | **0.658**** |
| | Sig. (2-tailed) | **0.000** |
| ** Correlation is significant at the 0.01 level (2-tailed). | | |

The second hypothesis (H2) states that the system quality is positively associated with information quality. Based on the results, the system quality-information quality relationship was found to be significant and hence supports H2 at the 0.000 significance level. In this regard, the standardized correlation coefficient was found to be 0.663 as listed in Table 2. This finding is consistent with the notion that poor system quality is expected to result in poor information quality.

**Table 2:** Hypothesis (H2) Correlations

| | | Information Quality |
|---|---|---|
| System Quality | Pearson Correlation | **0.663**** |
| | Sig. (2-tailed) | **0.000** |
| ** Correlation is significant at the 0.01 level (2-tailed). | | |

Moving on to the third hypothesis – it stated that information quality is positively associated with the net benefits of data warehouse. The results support this hypothesis at the level of 0.000 significance. From Table 3, the correlation coefficient is 0.578 indicating that providing good quality of information would contribute to the success of data warehouse system through the enhancement of its decision making capabilities and the minimization of time and effort during the process. In this context, it is clear that accuracy, usefulness, relevancy, format, timeliness and sufficiency

of information could assist in the success of executing data warehouse system.

**Table 3:** Hypothesis (H3) Correlations

| | | Net Benefits |
|---|---|---|
| Information Quality | Pearson Correlation | **0.578**** |
| | Sig. (2-tailed) | **0.000** |
| ** Correlation is significant at the 0.01 level (2-tailed). | | |

The researcher performed multiple regression analysis to examine the combined effects of quality factors on the data warehouse net benefits. The analysis was also used to determine the effect of system quality on information quality. Table 4 lists the adjusted coefficient of determination ($R^2$), which indicates that 0.468% of the variation in the dependent variable is explained by that of the independent variable. Stated differently, 46.8% of the ($R^2$) in information quality is explained by the DW Net Benefits significantly.

**Table 4**: Multiple Regression Results of System Quality and Information Quality with DW Net Benefits

| **Variables** | **Unstandardized Coefficients** | | **Standardized Coefficients** | | |
|---|---|---|---|---|---|
| | **B** | **Std. Error** | **Beta** | **t** | **Sig.** |
| (Constant) | 1.730 | 0.421 | | 6.392 | 0.000 |
| System Quality | 0.771 | 0.069 | 0.678 | 12.559 | 0.000 |
| Information Quality | 0.669 | 0.073 | 0.732 | 11.663 | 0.000 |
| Dependent Variable: DW Net Benefits, R=0.688 [a], $R^2$=0.468, Std. Error of the Estimate =0.73938<br>a. Predictors: (Constant), system quality and information quality. | | | | | |

The regards to the impact on information quality, results of the analysis listed in Table 5 shows that the adjusted coefficient of determination ($R^2$) reveals that 0.687% of the variation in the dependent variable is explained

by that of the independent variable. In other words, 68.7% of the variance ($R^2$) in the information quality is explained significantly by system quality.

**Table 5**: Regression Results of System Quality with Information Quality

| Variables | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| (Constant) | 1.625 | 0.340 | | 4.712 | 0.000 |
| System Quality | 0.567 | 0.071 | 0.663 | 8.891 | 0.000 |
| Dependent Variable: information quality.<br>R=0.663 [a], $R^2$=0.687, Std. Error of the Estimate =0.84988<br>a. Predictors: (Constant), system quality. | | | | | |

**8. Discussion of Results:**

The study findings indicate that the system quality factor positively and significantly impacted the net benefits at the level of 0.000 confidence with 0.658 correlation coefficient. This indicates that ease of use, ease of learning, ease of management, flexibility, accessibility a timely response of the data warehouse system are critical for its success.

The findings are consistent with that of Prybutok et al. (2008) who revealed a significant association between system quality and net benefits in an e-government context. Similarly, Bharati and Chaudhuri (2006) also revealed that system quality significantly and positively relate to decision making satisfaction in the context of e-commerce. Along the same line of revelation, Seddon and Kiew (1996) and Shih (2004) highlighted a significant relationship between system quality and perceived usefulness as proxies by productivity and quality of decision making. More importantly, in the context of data warehouse, Wixom and Watson (2001) showed that system quality significantly and positively influenced perceived net benefits. Hayen et al.'s (2007) case study also showed that system quality positively and significantly related to perceived net benefits of data warehouse systems.

This positive impact of system quality indicates the following; first, the data warehouse systems that are easy to use and learn will likely urge business users to conduct ad-hoc data analysis and reports that could be invaluable for decision-makers to make timely and accurate decisions and thus, eventually obtaining competitive advantages. Second, a data warehouse system that is easy to manage and maintain can be kept for a longer period could therefore mean lower costs to the organization. Third, data warehouse systems that are highly flexible and accessible and possess various useful features may lead to great benefits in light of competitive advantage and enhanced decision making capabilities. Fourth, an effectively designed and implemented data warehouse system is required for the derivation of likely benefits such as increased revenues, cost reduction, and enhanced process of decision making. Finally, an ineffectively designed warehouse system will likely result in system breakdown and this would adversely impact business processes and would lead to increased software and hardware costs to the organization.

It is evident from the findings that information quality positively and significantly impacted the net benefits at the level of 0.000 confidence with 0.578 as correlation coefficient. Information quality was also revealed to partially mediate the system quality-net benefits relationship indicating that good quality information would facilitate data warehouse systems success. The above findings and prior studies support the research model.

Specifically, prior studies such as study by Prybutok et al. (2008) found a positive relationship between information quality and net benefits in the context of e-government. Similarly, Bharati and Chaudhury (2006) also stated that information quality significantly and positively affected decision making in the context of e-commerce. In the study conducted by Kositanurit, Ngwenyama and Osei-Bryson (2006), they also found information quality to positively impact ERP system performance. More specifically, in terms of data warehouse systems, Hwang and Xu (2008) revealed that information quality significantly related to individual benefits and Wixom and Watson's (2001) and Hayen et al. (2007) supported the hypothesis that data quality significant and positively impact perceived net benefits. In a broader context, data quality was found to positively and significantly impact the successful adoption of data warehouse by Bhansali (2007).

Moreover, the study findings indicated that system quality positively and significantly affected information quality at the level of 0.000 confidence with 0.663 correlation coefficient. The findings also reported that system quality factor reported 68.7% of the information quality variance ($R^2$) indicating that poor system quality could lead to poor information quality. This finding and those in literature also support the research model.

**9. Conclusion and Future Research:**

Based on the current trend of IS/DW success studies, quality factors could be gaining increasing interest and hence, more studies are stressing for greater focus on them in subsequent studies. The present research managed to highlight several practical and theoretical issues for the success of data warehouse systems. Several reasons can be enumerated to pursue this line of study and among them, data warehouse systems would likely cost more than expected but although it is riddled with risks, it offers great rewards for decision makers.

Data warehouse systems success seems promising with encouraging initial results. Studies can consider data warehouse systems success in light of new findings and their implications to dialogue and decisions. As knowledge is power, then new information provided by this research should serve warehouse managers, researchers and practitioners in making highly intelligent and informed decisions during the process of implementation.

The present study's replication in various IS contexts like web-based information systems, e-commerce, enterprise resource planning (ERP), customer relationship management (CRM) or outsourcing is highly recommended as these contexts may offer additional insight into the topic.

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