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An empirical study on data warehouse systems effectiveness: the case of Jordanian banks in the business intelligence era

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Abstract

Purpose – Despite the increasing role of the data warehouse as a supportive decision-making tool in today's business world, academic research for measuring its effectiveness has been lacking. This paucity of academic interest stimulated us to evaluate data warehousing effectiveness in the organizational context of Jordanian banks.

Design/methodology/approach – This paper develops a theoretical model specific to the data warehouse system domain that builds on the DeLone and McLean model. The model is empirically tested by means of structural equation modelling applying the partial least squares approach and using data collected in a survey questionnaire from 127 respondents at Jordanian banks.

Findings – Empirical data analysis supported that data quality, system quality, user satisfaction, individual benefits and organizational benefits have made strong contributions to data warehousing effectiveness in our organizational data context.

Practical implications – The results provide a better understanding of the data warehouse effectiveness and its importance in enabling the Jordanian banks to be competitive.

Originality/value – This study is indeed one of the first empirical attempts to measure data warehouse system effectiveness and the first of its kind in an emerging country such as Jordan.

Keywords Data warehouse system, DeLone and McLean model, Business intelligence, Structural equation modelling, Jordan

Paper type Research paper

1. Introduction

Data has become one of the worthiest assets in today's digital era for modern business organizations. However, data has little or no value without the tools by which deeper insights can be extracted from it for decision-making (Dubey *et al.*, 2020). The traditional methods of data analysis and interpretation for sound decision-making are not sufficient and effective with the enormous amount of organizational data being available in today's competitive environment (Niu *et al.*, 2021), resulting in an increasing number of requests for a new generation of technologies including data analytics and visualization tools to assist companies in voluminous data management, analysis and fed into the decision-making process (Chen and Lin, 2021). Since business data analytics is related to data warehouse systems, data warehouse has been considered as a key platform for the integrated management of decision support data in various industries and countries (Mehmood and Anees, 2019). One of the prominent

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consequences of the big data revolution is heavy investment in data warehouses to take advantage of the rich data sources for a variety of tasks such as planning, target marketing, decision-making, data analysis and customer services in unpredictable market fluctuations and competitive environments that put much pressure on businesses (Moscoso-Zea *et al.*, 2018). A data warehouse as a key component of business intelligence has been defined as a collection of subject-oriented data with information from a specific time period that assists the management decision-making process (Bimonte *et al.*, 2021). Data warehouse stores a high volume of cleansed data extracted from operational sources and transforms it into a format suitable for analysis, business intelligence therewith serves to present the transformed data to decision-makers (Eggert and Alberts, 2020; Halim *et al.*, 2020).

A data warehouse's main advantages compared to other forms of storage employed in data analysis, most notably data lakes, include the clean integrated schema optimized for analysis, which facilitates comparison of data from various sources (Schuetz *et al.*, 2018). As opposed to data stream management systems, a data warehouse preserves historical data for future analysis (Arora *et al.*, 2017). Through the introduction of analysis rules, an active data warehouse allows for fact-based management of business processes. Nonetheless, several business intelligence systems fail in the process of translating data into better informed organizational actions due to a lack of data warehouse effectiveness (Dahiya *et al.*, 2018; Atay and Garani, 2019; Hopfgartner *et al.*, 2017; Salaki, and Ratnam, 2018; Martins *et al.*, 2020; Jain and Sharma, 2018; Azgomi and Sohrabi, 2019). This is particularly important given that organizational decisions and actions are mainly made based on the data stored in a data warehouse as well as the insights generated following the analytics course of action (Liu *et al.*, 2020). Fast access to data from the data warehouse is a need for today's business intelligence (Torres and Sidorova, 2019). High system response time of analytical queries is also one of the most challenging issues of data warehouse effectiveness (Azgomi and Sohrabi, 2019). The lack of system and data quality from data warehouses poses enormous risks related to decision-making and business processes like monetary loss and operational inefficiencies (Liu *et al.*, 2021; Aftab and Siddiqui, 2018).

Furthermore, the global deregulation of the banking industry and the diversification of consumers' needs for financial services resulted in intense competition and consequently large investments in data warehouses to improve the quality of services offered to consumers and to enhance the decision-making capability of the bank (Nithya and Kiruthika, 2021). To succeed in today's highly competitive digital era, Jordanian banks have heavily invested in business intelligence and data warehouse to collect, store and analyse massive amounts of data coming from various sources that cannot be handled through traditional methods. Because these banks operate in a digital sphere and generate an increasing amount of data, it is a natural transition to find a better way to utilize that data. If all data are kept in a single system, such as a data warehouse system, it would be much faster and more accurate to gather and analyse data for the betterment of the bank. As these banks are transforming into data-driven organizations, they use data warehouses to plan their activities and decisions in order to meet the targeted business objectives. Nonetheless, their vision cannot be realized without an effective data warehouse, and the effectiveness of data warehouses in Jordanian banks is still unknown due to a lack of research attention, which limits our understanding of its organizational implications. In this situation, practitioners and researchers must better understand data warehousing in order to ensure the success and effectiveness of these promising, yet risky and costly, IT endeavours as well as to justify their initial investments and ongoing spending on data warehouse solutions' sustainability (Hassan *et al.*, 2022).

Despite the growing importance of data warehouse effectiveness or success (used interchangeably) in research communities, researchers have investigated data warehouse effectiveness in a variety of ways, including measuring user satisfaction (Nelson *et al.*, 2005; Dooley *et al.*, 2018), data quality (Subramanian and Wang, 2017), system use (Chen *et al.*, 2022), perceived usefulness (Wixom and Watson, 2001; Kefi and Koppel, 2011). To better understand the nature of data warehouse effectiveness, researchers should approach system success as a multifaceted construct, select several appropriate success measures based on the research objectives and phenomena under investigation, and consider possible relationships among the success dimensions when developing a research model (Ain *et al.*, 2019).

The motivation for this research stems from some gaps in the literature in this field. Indeed, there is a lack of scientific evidence for the business value of data warehouses in Jordanian banks. Further, most research in this area of data warehouse effectiveness focuses on the individual benefits rather than the organizational value and impact. To supplement previous research, we propose a theoretical model based on the DeLone and McLean IS success framework to assess the effectiveness of data warehousing at the organizational level in Jordanian banks. This research builds upon the DeLone and McLean model (which is discussed in detail later) to evaluate data warehouse effectiveness for several reasons. First, the model suggests temporary and casual interrelationships between the specified factors (Al-Okaily and Al-Okaily, 2022). Second, their success model can be applied at multiple levels of analysis depending on the research purpose (Mehta *et al.*, 2021). Third, it allows evaluating complex systems such as data warehouse (Soto and Aponcio, 2008). Fourth, this model is a holistic taxonomy that proposes that IS success is determined by the positive value and effect it has on a whole organization (Al-Okaily *et al.*, 2022). Fifth, the literature stresses that success factors that focus on a technical orientation are more likely to achieve better results in effectiveness measurement (Gavidia *et al.*, 2021). Drawing on the work of DeLone and McLean, five dimensions of system success were selected as being the most appropriate for this study: data quality, system quality, user satisfaction, individual and organizational impact or benefits. In this spirit, this paper seeks to address the following research question: To what extent is the DeLone and McLean model applicable to measure data warehouse system effectiveness in the organizational context of Jordanian banks?

This present research effort contributes to the literature by investigating data warehouse effectiveness at the organizational level in the context of Jordanian banks. To the best of our knowledge, this present effort is the first of its kind that examined interrelationships among data warehouse effectiveness dimensions beyond the implementation stage and the individual level in Jordanian banks. Furthermore, given the scarcity of research on data warehouse effectiveness at the organizational level, our study adds to our understanding of effectiveness measurement in that context. This study also applied the DeLone and McLean model to data warehouse effectiveness in the organizational context, which adds to the model's validation. On the practical side, the empirical findings provide a better understanding of the factors of data warehouse effectiveness and their relative importance in enabling Jordanian banks to be competitive and improve their performance.

The remainder of this paper is outlined as follows: Section 2 provides the theoretical research background. The hypotheses along with the methods used to test them are presented in section 3 and section 4, respectively. In section 5, the study findings are presented. A discussion, implications, limitations and future works are highlighted in section 6 and section 7, respectively.

2. Literature review

The business environment today is dynamic and necessitates high-quality decisions from strategic, operational and tactical perspectives for economic sustainability (Bag *et al.*, 2021). Technological breakthroughs such as artificial intelligence and blockchain have ushered in a new era for business organizations over the last decade (Hujran *et al.*, 2021). The key to an organization strategic position and competitive advantage is to analyse a large amount of data from various origins and derive from it, some vital actionable insights (Bogojevic, 2020;

Di Vaio *et al.*, 2022). Organizations are developing a higher dependence on the processed data to attain the development of products and services that will not only help them evolve but also help them be better than their competitors (Secinaro *et al.*, 2021). A data warehouse solution is usually employed as a critical foundation for many analytical applications such as business intelligence and analytics as well as artificial intelligence (Harrison *et al.*, 2015). For instance, it has been argued the processing of data combined with artificial intelligence can enhance operational performance and sustainability (Dilling, 2020). The evolution of artificial intelligence has resulted in the expansion of the boundary of business process and practice, inducing the adoption of business intelligence that has promoted the transformation of information techniques to optimize business decisions and operation (Niu *et al.*, 2021). Business intelligence can be described as an intensive yet extensive process of turning large amount of scattered and different data into functional information and then into knowledge for organizational needs, customer needs and satisfaction, competition and environment in the industry (Petrini and Pozzebon, 2009). The abstract idea of business intelligence became excessively used now the association of these terms is widely used in different fields ranging from data technology to business modelling to support sustainable business practices in contemporary firms (Al-Eisawi *et al.*, 2020).

In a data warehouse environment where data mining techniques can be used to discover untapped patterns of data that enable the creation of new information, by extension then, the use of technologies such as data warehousing, data mining and other artificial intelligence technologies can enhance the knowledge creation, storage, dissemination and management processes (Makhija and Chacko, 2021). The primary focus behind data warehouse was to support the data processing on static data or data streaming at a very low rate (Costa *et al.*, 2019). But this does not mean supporting real-time transactional data analysis and supporting its alternatives (Aftab and Siddiqui, 2018). In response to the above, real-time business intelligence is supported by real-time data warehouses. With changing environments, the researchers have perceived that there will be no further need for data warehouses and relational databases to support big data (Silva *et al.*, 2021). To respond to a turbulent business environment, an organization should have agile access to its data storage warehouse to deliver relevant, fast and accurate data insights thus improving business performance. The data warehouse can improve business performance in various ways, including better decision-making, improved customer relationship management and greater operational efficiency. It can also result in the reengineering of business processes. For instance, its integrated, subject-oriented, time-variant and non-volatile environment offers a stable and reliable information source for advanced organizational computing, thereby substantially freeing up managers' time and effort for other tasks (Rahman, 2017). Furthermore, enterprises can exploit insights gained from their data warehouse using sophisticated online analytical processing (OLAP) and data mining tools to increase sales, reduce costs and offer better services.

A data warehouse is a complex technological infrastructure that is the source or origin of the data used by decision support systems (DSS) and executive information systems (EIS) (Eggert and Alberts, 2020). It related a collection of data that is subject-oriented, integrated, non-volatile and has time variance to support management decision-making (Schuetz *et al.*, 2018). The data warehouse (in various forms) represents a central database for the entire company to store and access historical data and its existence is separate from the operational system (Ngo *et al.*, 2019). Rahman (2017) stated that a data warehouse is a concept and a combination of technology that facilitates the organization to manage and maintain historical data obtained from operational systems or applications. From the above definitions, it can be concluded that the data warehouse is a centralized and mutually exclusive database that reacts to manage and maintain historical data that is subject-oriented, integrated, non-volatile and has time variance to support decision-making. Given that data comes to the data warehouse from external sources, data latency occurs. A successful data warehouse tries to minimize data latency as much as possible (Harrison *et al.*, 2015). Here, the goal should be to ensure the timeliness of data availability in the data warehouse so that business executives can make decisions at the right time (Schuetz *et al.*, 2018). The development of data warehouses and business intelligence applications has improved considerably in developed economies. However, in less-developed regions, such as Jordan, the development of data warehouses and business intelligence is less advanced and has yet to gain unique insights into its expected benefits. Figure 1 presents the data warehouse architecture to better understand the nature of the system.

2.1 Data warehouse system effectiveness

As a data warehouse system is one of the major components in the organizational information system environment, the theoretical notion of IS effectiveness or success became the foundation of this research. Indeed, numerous success measures have been proposed to evaluate IS success, but these measures do not give a holistic picture of IS adoption success owing to its complex, interdependent and multi-dimensional nature. To explore potential IS success factors, DeLone and McLean (1992) conducted an extensive literature review of around 200 related works to develop a multidimensional framework that synthesized individual measures of IS success into a single coherent model. In their original influential model, they pointed out that information and system quality, satisfaction, use, and individual and organizational impact were key determinants of IS success (DeLone and McLean, 1992). This model is a holistic taxonomy that proposes that IS success is determined by the positive value and effect it has on a whole organization. Despite its popularity, the original model has received a lot of criticism and theoretical considerations, which resulted in an amendment to the model in 2003. The modified version of the success

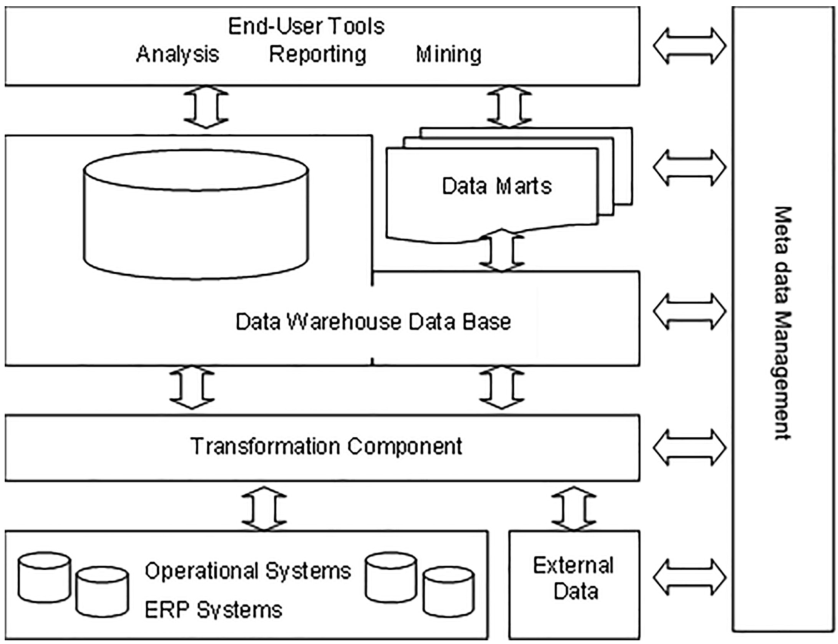

Figure 1.
Data warehouse system architecture

model was comprised of six success factors, which are service quality, information quality, system quality, user satisfaction, system usage and net benefits, i.e. individual and organizational (DeLone and McLean, 2003).

This model is a suitable theoretical basis for conceptual and empirical data warehouse success studies (Ain *et al.*, 2019). Nevertheless, past studies seldom used this model in the data warehouse context. For example, Wixom and Watson (2001) demonstrated the impact of system quality and data quality on perceived individual benefits from data warehouse success implementation. An exploratory investigation by Shin (2003) showed the particular importance of information quality, system quality, data quality and user satisfaction in data warehouse success. In their empirical study, Hwang and Xu (2008) found system quality positively influences information quality, which in turn positively affects net benefits from the data warehouse (i.e. individual benefits and organizational benefits). In another study, Soto and Aponcio (2008) used the updated DeLone and McLean model to measure the effect of quality dimensions (information-system-service) on system use, satisfaction and net individual benefits of data warehouse system in 127 Spanish financial institutions. Generally, their model has a good predictive value to assess data warehouse success from users' viewpoint. Similarly, Kefi and Koppel (2011) in their study to examine the factors that affect data warehouse success used the original DeLone and McLean model at the individual level of analysis in large European financial firms. However, their findings reported no impact of system quality on system usage.

In a later publication, Gonzales *et al.* (2015) applied the updated DeLone and McLean model to test the effect of information, system and service quality on system use, satisfaction and individual benefits as determinants of data warehouse success in the context of Peru. Their findings revealed the interrelationships between system use and other dimensions of the model to be extremely low. As evidenced by earlier work, no empirical study has yet used DeLone and McLean model to measure data warehouse success at the organizational level. Overall, the DeLone and McLean model has a lack of validation at the organizational level compared with the individual level of analysis (Mehta *et al.*, 2021). This is a gap that has been recognized in calls for theoretically grounded research on data warehouse success from an organizational perspective (Gonzales and Wareham, 2019; Gaardboe *et al.*, 2017). Meanwhile, no one has assessed data warehouse success in Jordan. The paucity of work and inconsistent results on this aspect of research motivated us to measure data warehouse success in a new context, namely Jordan. To bridge this void, this paper seeks to investigate whether the traditional success model can be applied to measure data warehouse success in the organizational context of Jordanian banks.

3. Research framework and hypotheses

To develop the research framework, business intelligence, data warehousing and IS success literature was reviewed to identify factors that potentially affect data warehousing success. In order to be able to research how a data warehouse system can be successful, we must define what we mean by effectiveness or success. This research defines data warehouse effectiveness as the positive value and benefits an organization receives from its investment. The ultimate touchstone of data warehouse success is the organizational benefits the system generates for the organization such as time savings, cost savings, increased productivity and expanded markets (Hwang and Xu, 2008). It is therefore important to understand what can help companies gain benefits from the investments in data warehouse systems. This study used the subjective measure of organizational benefits, rather than the objective measure, because of the difficulty of obtaining financial data. Previous research emphasized the use of perpetual belief and senior managers' perceptions of organizational benefits. Our research framework as shown in Figure 1 included five data warehouse success factors that feature seven research hypotheses. These factors are system quality, data quality, user satisfaction, individual benefits and organizational benefits.

The links in the research model are justified based on the assumptions proved in the literature of data warehouse success as described below. Additional success dimensions of the DeLone and McLean model such as system use service quality were not included because they were considered less appropriate for this study than the selected constructs. For example, several researchers maintained that usage is an antecedence of success rather than a critical success factor (Al-Okaily *et al.*, 2021a, b). Others argued that system usage does not play a role in system success; rather, translating use into organizational benefits is a success measure (Al-Okaily *et al.*, 2020a, b). Service quality has similar limitations because it is directly influenced by performance but is not a determinant of system success (Park *et al.*, 2011; Lin, 2010). In addition, information quality measures system output, mainly in the form of reports. Data quality is typically related to technical features of data, while information quality concerns non-technical aspects (Côrte-Real *et al.*, 2020). In our case, we do not distinguish between data quality and information quality, preferring to use the term data quality over information quality to represent both technical and non-technical attributes of data. Therefore, we omitted the system use and service quality dimensions from our research framework and replaced information quality with data quality.

3.1 Data quality

The fundamental purpose of building a warehouse is to provide high-quality data to decision-makers. Data quality refers to the data characteristics in terms of accuracy, consistency, correctness, completeness, reliability, timeliness and relevance that are available from the data warehouse (Subramanian and Wang, 2017). High data quality concerning both format (i.e. appearance, outputs consistency and understanding) and content (i.e. accuracy, completeness and relevance to decision-making) can drive a high level of organizational decision-making (Işık *et al.*, 2013). In the data warehouse domain, Soto and Aponcio (2008) in their empirical study found that data quality attributes such as reliability, flexibility is positively related to user satisfaction and individual benefits. Another study carried out by Wieder *et al.* (2012) reported that high data quality that met users' needs increased the level of satisfaction and improved decision-making. From another angle, Wieder and Ossimitz (2015) found a high data quality in terms of appearance, consistency, understanding, accuracy, completeness and relevance is related to individual decision-making. Likewise, Masa'Deh *et al.* (2018) in their study reported that data quality is positively related to perceived individual benefit through ease of use of business intelligence. A similar finding found by Rejikumar *et al.* (2020) showed that there is a significant relationship between data quality and perceived individual benefit. Thus, we hypothesize:

H1. Data quality is positively related to user satisfaction.

H2. Data quality is positively related to individual benefits.

3.2 System quality

High response time of analytical queries is also one of the most challenging issues of data warehouses effectiveness. The effectiveness of a data warehouse is dependent on the system quality because a warehouse provides the infrastructure that integrates data from various systems and sources (Subramanian and Wang, 2017). System quality is concerned with system performance attributes through ease of use, functionality, accessibility, reliability, response time, flexibility, integration and other metrics (DeLone and McLean, 2016). A data warehouse quality that integrates data from multiple sources can improve organizational decision-making and flexibility allows decision-makers to easily modify applications as their information needs change (Schuetz *et al.*, 2018). The seminal and modified work of DeLone and McLean claimed that system quality in terms of reliability, flexibility, ease of use, ease of learning impact user satisfaction and individual performance. With regard to the data warehouse field, Gonzales *et al.* (2015) found that system performance attributes such as reliability, flexibility and ease of use improved user tasks and productivity, thereby having a positive effect on user satisfaction and performance. In a similar vein, Kefi and Koppel (2011) in their study showed that user satisfaction and individual benefits are positively influenced by a high quality of the data warehouse. Evidence in the IS effectiveness literature also found a positive effect from system quality on both user satisfaction and individual benefits (e.g. Al-Hattami and Kabra, 2022; Al-Adwan *et al.*, 2021; Al-Okaily *et al.*, 2021c; Al-Debei *et al.*, 2013; Almazán *et al.*, 2017). Thus, we hypothesize:

H3. System quality is positively related to user satisfaction.

H4. System quality is positively related to individual benefits.

3.3 User satisfaction

One key factor that influences data warehouse success is user satisfaction. End-user satisfaction is often a subjective or perceptual measure of system success which reflects users perceive that a system meets their needs (DeLone and McLean, 2016). In fact, user satisfaction is a substantial factor that comprises one of the core considerations upon which managers can take corrective actions to increase data warehouse acceptance by end-users (Kefi and Koppel, 2011). The first and revised form of the DeLone and McLean model states that user satisfaction is an antecedent success factor of individual and organizational benefits. The assumption between satisfaction and individual benefits has been positively determined by a series of related studies such as (Cidral *et al.*, 2018; Aparicio *et al.*, 2017; Hsu *et al.*, 2015; Tam and Oliveira, 2016). Other scholars found a positive effect from user satisfaction on organizational benefits (Harr *et al.*, 2019; Dezdar and Ainin, 2011; Chou and Hong, 2013; Almazán *et al.*, 2017). From the above, it can be concluded that a high level of user satisfaction with data warehouse not only impacts individual benefits but also leads to organizational benefits. Nevertheless, no prior study has been investigating the relationship between user satisfaction and organizational benefits in data warehouse success literature. Therefore, we posit:

H5. User satisfaction is positively related to individual benefits.

H6. User satisfaction is positively related to organizational benefits.

3.4 Individual benefit

The evaluation of individual benefits is necessary since it not only justifies the investments of the system but also provides insights into how to better manage users' behaviour (Hsu *et al.*, 2015; Tam and Oliveira, 2016). Individual benefits refer to the effect brought about by the data warehouse system on individual users such as changes in productivity, decision-making and decision mode (Hwang and Xu, 2008). It is noteworthy that the nomological order in the initial taxonomy developed by DeLone and McLean (1992) generally posits that IS organizational impacts and results come after users and individuals have benefited from IS qualities. In the data warehouse vein, Hwang and Xu (2008) generally agreed that individual benefits in terms of improving productivity and making better decisions lead to high organizational benefits such as improved business processes and increased competitive position. The same result was also achieved by IS effectiveness studies conducted by García-Fernández *et al.* (2020), Ifinedo (2011), Petter and Fruhling (2011), Ifinedo *et al.* (2010), Park *et al.* (2011) and Urbach *et al.* (2010) who have empirically proven a positive correlation of individual benefits and net organizational benefits. To conclude, user performance at a high level could save time and effort in the decision-making process and thus be a source of organizational benefits from data warehouse investment. As a result, our final hypothesis is (see Figure 2):

H7. Individual benefit is positively related to organizational benefits.

4. Methodology

4.1 Instrument development

This exploratory study used quantitative analysis and collecting primary data through questionnaire surveys and analysing the data with the help of PLS software. The survey questionnaire was developed and included three parts which include a cover letter, demographic features and questionnaire measures. A comprehensive set of measures was derived from prior studies to guarantee validity and reliability. For example, system quality was gauged with five scales, which are accessibility, reliability, response time, flexibility and integration adapted from Nelson *et al.* (2005). Data quality was evaluated through five indicators, which are accurate, comprehensive, correct, consistent and reliable adapted from Côrte-Real *et al.* (2020) and Torres and Sidorova (2019). User satisfaction was assessed using five measures taken from Harr *et al.* (2019) study. Individual benefits were assessed through five indicators such as task accomplishment, productivity, creativity, saving time and decision-making, acquired from Hwang and Xu (2008) and Ifinedo *et al.* (2010). Six subjective measures in terms of improving business processes, decision-making, competitive advantage, organizational data use, productivity and cost-saving were used to assess the organizational benefits taken from Ifinedo (2011) and (Hwang and Xu, 2008). The researchers slightly tailored and adjusted some measures to suit the research context. Respondents were asked to assess each item based on a five-point Likert scale, where 1 meant "strongly disagree" and 5 meant "strongly agree".

4.2 Data collection

The Jordanian banks use data warehouses to accumulate data from multiple sources for data analysis. The more data the more difficult it is to manage and turn into knowledge, so data warehouse manages centralized data storage from a variety of operational data and is presented in a representation format that suits the needs of business data analysis. The Jordanian banks invested in data warehouses to face competitive pressures and support increasing the effectiveness and efficiency of business performance through extracting information from large amounts of data such as customer data, operations, products, services,

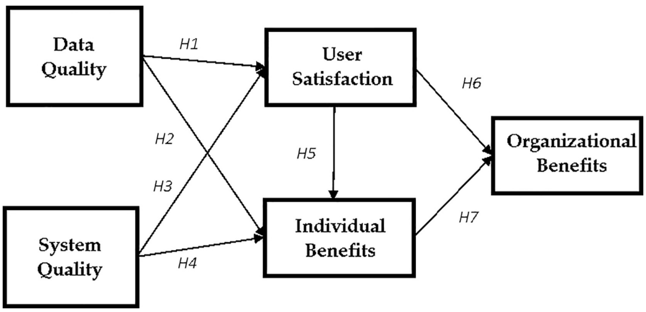

Figure 2.
Research framework

suppliers and all related transactions to generate knowledge. On that basis, all 16 Jordanian banks were used as a study sample due to their leading in business intelligence applications implementation such as data warehouses and have high contributions to the national economy. To assess data warehouse effectiveness, the researchers must ensure that the assessing responder is in a position to fill out the questionnaire with accurate information. Therefore, we used purposive non-probability sampling to choose senior executives and mid-level managers, including IT professionals and business sponsors who use data warehouses and business intelligence for strategic, tactical and operational decision-making. These groups of respondents are among the most knowledgeable regarding data warehouse effectiveness as some of them are essentially responsible for data warehouse system management pursuits and others are among the end-user groups of data warehouse in their works (Işık *et al.*, 2013).

A multiple-informant strategy from one bank was preferred due to it allows to minimize common source bias, increases the response rate and enhances results accuracy through the collection of rich data. To decide the sample size, *a priori* power analysis in G*Power 3.0 (effect size = 0.15, α = 0.05, power = 0.95) was computed. After calculation, the required sample size was 107. To increase the response rate, we set out to collect data greater than the required sample size. A total of 250 questionnaires were distributed to respondents at the bank headquarters in the capital city, i.e. Amman. However, the self-administered questionnaire yielded a data set of 141 before incomplete and invalid questionnaires were eliminated. The final tested sample consisted of 127 (a valid response rate of 50.8%). The study descriptive analysis of the banks' profile shows that out of 16 banks, there are 13 commercial and 3 Islamic. Related to the bank size using the number of employees show that 6 of the sampled banks have 500–1,000 employees, whereas 8 banks have annual revenue from $300 million to $600 million. Results related to respondents' profiles reveal that 97 were male and 30 females, as well as the age of 63 respondents was between 41 and 50 years. Most of the managers, 72, have a BSc education and 55 have experience from 5 to 10 years. Lastly, the most managers, 95, were working in business functions while 31 were in IT functions. The researchers used the Harmon one-factor test to assess if such biases were a problem in our sample (Podsakoff *et al.*, 2003). The test results showed that several factors with eigenvalues greater than one are present in our data. As well, the most covariance explained by one factor in our data is 34.7% which is below the recommended value of 50%. This confirms that targeting multiple respondents from each organization in this work enhanced the legitimacy of the perceptual data and bias-free information.

5. Empirical analysis

A partial least squares-structural equation modelling (PLS-SEM) software was run to the research model estimation. This software is better than others for analysing complex models with small sample sizes, and it is widely accepted in IS studies such as this one (Hair, 2020). This research followed a two-stage analytical path for data analysis, which are the measurement model and the structural model. First, the PLS measurement model was assessed to check reliability and validity. Tables 1–3 show the measurement model findings.

Construct	CR	CA	AVE
Data quality	0.935	0.912	0.744
System quality	0.868	0.812	0.569
User satisfaction	0.938	0.916	0.751
Individual benefit	0.964	0.953	0.843
Organizational benefits	0.916	0.889	0.644

Table 1. Reliability and convergent validity findings

The value for Cronbach's alpha (CA) and composite reliability (CR) were higher than the minimum required score of 0.70 (Hair *et al.*, 2017), indicating that the model has good internal consistency. The Factor Loading (FL) reliability was assessed based on the criterion that the loadings should be 0.70 or more (Hair *et al.*, 2017). The average variance extracted (AVE) was used to evaluate convergent validity. The scores of AVE's should be greater than 0.50 so that the latent constructs explain more than half of the variance of their items (Hair *et al.*, 2017). As illustrated in Table 1, AVE for all latent variables is above the required threshold of 0.5, indicating good and consistent findings and ensuring convergence. These values ensure the validity and reliability of the constructs and measures in our research model. Next, discriminant validity was conducted as it is one of the most important measurement model tests (Hair *et al.*, 2017). It was conducted using a common method, which was the square root of AVE given in Fornell and Larcker (1981), according to which cross-correlations within the variable itself should be more than its correlation with other variables. The results in Table 3

Construct	1	3	4	5
1. Data quality	*0.863*			
2. Individual benefit	0.789			
3. Organizational benefits	0.415	*0.803*		
4. System quality	0.672	0.345	*0.754*	
5. User satisfaction	0.808	0.428	0.612	*0.867*

Note(s): Diagonal value represents the square root of AVE and represented in italic

Table 2. Discriminant validity findings

Items	DQ	IB	OB	SQ	US
DQ1	*0.870*	0.693	0.389	0.618	0.765
DQ2	*0.911*	0.721	0.424	0.609	0.708
DQ3	*0.739*	0.591	0.304	0.490	0.631
DQ4	*0.913*	0.734	0.350	0.611	0.726
DQ5	*0.870*	0.651	0.312	0.558	0.644
IB1	0.677	*0.909*	0.518	0.513	0.686
IB2	0.725	*0.942*	0.539	0.566	0.735
IB3	0.720	*0.900*	0.467	0.584	0.704
IB4	0.758	*0.920*	0.505	0.621	0.737
IB5	0.738	*0.919*	0.486	0.609	0.737
OB1	0.324	0.445	*0.820*	0.276	0.336
OB2	0.334	0.470	*0.865*	0.282	0.358
OB3	0.302	0.378	*0.731*	0.255	0.319
OB4	0.314	0.419	*0.789*	0.290	0.304
OB5	0.363	0.449	*0.783*	0.285	0.348
OB6	0.357	0.469	*0.822*	0.274	0.392
SQ1	0.597	0.516	0.284	*0.809*	0.517
SQ2	0.523	0.533	0.324	*0.766*	0.512
SQ3	0.535	0.496	0.201	*0.783*	0.513
SQ4	0.455	0.406	0.252	*0.732*	0.381
SQ5	0.395	0.403	0.234	*0.705*	0.349
US1	0.671	0.659	0.341	0.490	*0.850*
US2	0.721	0.687	0.394	0.515	*0.900*
US3	0.779	0.762	0.427	0.590	*0.937*
US4	0.734	0.684	0.397	0.550	*0.855*
US5	0.577	0.594	0.280	0.503	*0.784*

Table 3. Factor loading findings

achieved the required criteria, suggesting that discriminant validity was acceptable. The measurement or outer model findings confirm that our research model has good internal consistency and validity. Therefore, it can be concluded that all model constructs are statistically distinct and suitable for further structural model measurement.

As a second step, the structural or inner model was assessed to test the research hypotheses (Hair *et al.*, 2017). As recommended by Hair *et al.* (2017), we used a Bootstrapping method with 5,000 subsamples to calculate Path Coefficients (β). The β values indicated that H1, H2, H3, H4, H5 and H7 were supported, whereas H6 was not supported. The test of Effect Size (F^2) allows evaluating an exogenous variable contribution to an endogenous variable (Hair *et al.*, 2017). Guidelines for measuring F^2 suggested values of 0.02 (small), 0.15 (medium), and 0.35 (large), and values less than 0.02 indicate that there is no effect (Cohen, 2013). As depicted in Table 4, H1 was supported with a large effect size, H5 and H7 were supported with a medium effect, H2, H3, H4 were supported with a small effect while H6 has no effect. Another important scale is the Determination Coefficient (R^2), which reflects the extent of variance between endogenous and exogenous latent variables (Chin, 2010). Chin (1998) assumed that R^2 values of 0.19, 0.33 and 0.67 can be considered weak, moderate and substantial, respectively. As seen in Figure 3, our model accounts for 66.2% of the variance in user satisfaction; 69.4% of the variance in individual benefits; and 30% in the variance in organizational benefits. The evaluation test Predictive Relevance (Q^2) represents a proposed

Hypothesis	β- value	t-value	p-value	F^2-value	Remark
H1: DQ→US	0.723	19.148	0.000	*0.848*	Accepted
H2: DQ→IB	0.378	5.671	0.000	0.138	Accepted
H3: SQ→US	0.126	2.978	0.001	0.026	Accepted
H4: SQ→IB	0.134	2.751	0.003	0.031	Accepted
H5: US→IB	0.397	6.395	0.000	*0.175*	Accepted
H6: US→OB	0.004	0.055	*0.478*	0.000	Rejected
H7: IB→ OB	0.551	6.975	0.000	*0.167*	Accepted

Note(s): Path- β: $^{**}p < 0.05$; $^{***}p < 0.01$

Table 4.
Hypotheses testing results

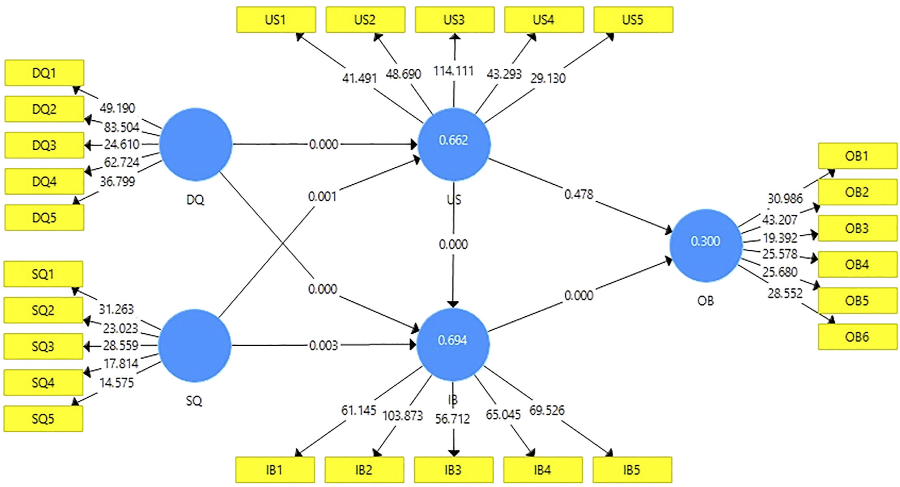

Figure 3.
PLS structural model

model's predictive power (Hair *et al.*, 2017). The proposed model can be considered to have enough predictive relevance when endogenous variable values are more than *Zero* as a score of *Zero* and below reflects a lack of model predictive relevance (Hair *et al.*, 2017). As indicated in Table 5, the score for Q^2 was 0.489 for user satisfaction, 0.580 for individual benefits and 0.191 for organizational benefits, which means that the proposed model had predictive relevance. The Goodness of Fit (GoF) was gauged using average AVE and average R^2 mean (GoF = ($\sqrt{}$ (AVE × R^2)) (Tenenhaus *et al.*, 2005). The *GOF* value was found to be 74.2%, which represents a large model fit based on the criteria given by Wetzels *et al.* (2009).

6. Discussion and implications

This study investigated the success factors of data warehousing by using a multidimensions research model. The DeLone and McLean model has been used as a backbone to construct an evaluation model for data warehousing effectiveness. The empirical findings found that the DeLone and McLean model at the organizational level has adequate predictive power in measuring data warehouse system effectiveness. As hypothesized, empirical research data confirmed the positive proposition impact of data quality on both user satisfaction and individual benefits, thus H1 (β = 0.723; p = 0.000) and H2 (β = 0.378; p = 0.000) gained empirical support. The H1 finding is in line with prior data warehousing studies results (Soto and Aponcio, 2008) and for H2 findings (Wixom and Watson, 2001). Data quality is deemed an essential construct to measure the effectiveness of data warehouse systems. In that sense, it is important that users perceive that the data contained in the warehouse system are accurate, reliable, consistent, complete and relevant to decision-making and analysis purposes so that users' confidence increases in the data warehouse system and improves their performance and tasks effectiveness. Likewise, system quality also was positively associated with both user satisfaction and individual benefits which indicates that H3 (β = 0.126; p = 0.001) and H4 (β = 0.134; p = 0.003) were accepted. This indicates that a high-quality data warehouse in terms of accessibility, reliability, response time, flexibility and integration with other systems increase overall satisfaction with the system, increasing user productivity, decision-making, and saving time and effort to achieve their tasks. These findings are akin to observations elsewhere in the data warehousing literature for H3 (Gaardboe *et al.*, 2017) and H4 (Hwang and Xu, 2008).

We also found user satisfaction with the data warehouse to be a significant predictor of individual benefits which indicates that H5 (*β = 0.397; p = 0.000*) was accepted. This finding was consistent with Soto and Aponcio (2008) and Kefi and Koppel (2011) findings. In line with the data warehousing literature, the high degree of user satisfaction positively affects individual benefits in terms of work productivity, task effectiveness, decision-making, and saving time and effort. Interestingly, the user satisfaction construct showed insignificant relations with organizational benefits, hence H6 (β = 0.004; p = 0.478) was rejected. One possible theoretical reason for the lack of H6 support is user satisfaction construct has indirectly linked to organizational benefits through individual benefits rather than directly impacting organizational benefits as in the initial model developed by DeLone and McLean (1992). Another reason is that it is unlikely that organizations would invest heavily in data

Endogenous variable	Q^2	R^2
User satisfaction	0.489	0.662
Individual benefit	0.580	0.694
Organizational benefit	0.191	0.300

Table 5. Predictive relevance and determination coefficient results

warehousing systems to make their users satisfied (Hwang and Xu, 2008). The last hypothesis was empirically supported (β = 0.551; p = 0.000) which proposed a positive relationship between individual benefits and organizational benefits. It can be concluded that no organization-level benefits such as improving business processes, decision-making, competitive advantage and overall productivity ought to be expected until system users have reaped the benefits individually from the data warehouse usage. This result is almost consistent with the past studies (Harr *et al.*, 2019; Al-Okaily, 2021). From a broader organizational perspective, a successful data warehouse provides Jordanian banks with business value creation, cost avoidance, innovation, productivity, internal operations efficiency and decision-making.

This research effort has theoretical implications for information systems and, in particular, data warehouse effectiveness. Despite the fact that the DeLone and McLean model has been widely studied in the literature, few have used its schema to assess the effectiveness of data warehouses in the banking industry. Keeping this in mind, our findings have expanded the existing body of research knowledge of data warehousing benefits based on the DeLone and McLean model in the context of Jordanian banks and at the organizational level. Our findings provide empirical support, demonstrating that a data warehouse will be effective for Jordanian banks if the system and data quality are perceived to be high. Because the aforementioned quality aspects have a direct impact on user satisfaction and performance, the entire bank's business will benefit in the long run. In this regard, we provided additional empirical support for the findings reported in the literature regarding the nature of relationships among the dimensions of data warehouse effectiveness (as discussed above), and our findings emphasized that IS effectiveness measurement is an inter-related and multidimensional rather than an individual measure (DeLone and McLean, 2016).

Other researchers, such as Kefi and Koppel (2011) and Soto and Aponcio (2008), have already evaluated the effectiveness of data warehouses in the post-implementation stages using the same model. Nonetheless, their studies focused on individual benefits rather than organizational benefits, leaving us with a poor understanding of its organizational implications. We extended the DeLone and McLean model and added to the literature by testing the interrelationships among its dimensions in data warehouses at the organizational level of analysis in this study. We have, to some extent, responded to the calls made by Gonzales and Wareham (2019) and Gaardboe *et al.* (2017) for research testing the relationships among constructs used to examine the effectiveness of IS from an organizational standpoint. Our study also emphasizes the importance of satisfaction as a data warehouse effectiveness metric. Satisfaction may result in user benefits, as dissatisfied users are more likely to obstruct, delay and sabotage its use. This particular finding is not aligned with the findings of Hwang and Xu (2008), who concluded that organizations are unlikely to spend millions of dollars on data warehousing to satisfy their users. The research outcomes also can be used as a beneficial tool by the Jordanian banks to measure data warehousing effectiveness, given that the findings implied an adequate predictive power for our research model. It is evident that Jordanian banks need to place high attention on the quality of data so as to maximize the effectiveness of the data warehouse solutions in terms of individual and organizational benefits. This in fact can be accomplished by increasing the accuracy, correctness, consistency and reliability of data. To do so, Jordanian banks may consider the utilization of AI-based operational solutions such as robotics process automation to reduce the volume of manual data entry which is prone to human errors. Jordanian banks can also consider the employment of Master Data Management (MDM) technology-enabled solutions that aid in ensuring higher levels of data consistency, governance and reliability. To significantly improve the data quality of a data warehouse solution, Jordanian banks need also to improve the comprehensiveness of data by increasing the number of operational data sources that are integrated into the data warehouse solution. In the same vein, Jordanian banks need to place a great deal of effort to enhance the quality of the data warehouse system so as to ensure higher levels of effectiveness and success. Therefore, Jordanian banks need to make sure that the data warehouse solution is appropriately and conveniently accessible, available and functioning well when needed by considering aspects related to clustering, redundancy, scalability, security and disaster recovery.

Further, to reap the maximum benefits of a data warehouse solution, Jordanian banks need to consider performance seriously. Hence, they need to ensure that the system is responding to queries and tasks efficiently and effectively and with no significant delay. This is a challenge given that the size of the data warehouse solution increases daily due to the data loaded into it coming from operational data stores. Therefore, scalability should be taken into consideration starting from the design phase in order to make sure that the system is scalable and flexible enough to accommodate more data and to integrate additional new data sources while performing effectively. We believe that cloud technology may significantly help Jordanian banks in achieving this by employing cloud-based data warehouse solutions given that scalability and flexibility are two major promises of cloud computing. Finally, we believe that adopting intuitive and user-friendly ETL (Extract, Transform, Load) tools by Jordanian banks may help in enhancing both data and system quality in comparison to the traditional and manual code-based way of extracting data from data sources, transforming it, and then loading the data into the data warehouse repository. This is significant as improving the quality of data and system would result in enhancing user satisfaction and in increasing the benefits that individuals gain which would subsequently positively affect organizational benefits.

7. Conclusions and future research

The measurement of data warehouse system success or effectiveness is critical for both practitioners and researchers to understand its individual and organizational implications in the business intelligence age. Yet, few empirical studies have assessed its effectiveness in general and on the organizational level in particular. Furthermore, prior research has used various success factors, which leads to difficulties in integrating and comparing these studies' findings. This research has proposed and tested a model to measure data warehouse effectiveness to consolidate insights about critical success factors that affect its effectiveness in the organizational context. This study contributes to the understanding of data warehouse effectiveness by showing interlinks between a set of success factors including system quality, data quality, user satisfaction and net system benefits, i.e. individual and organizational.

Although our current study has theoretical and practical implications, it is not without limitations. One such limitation is represented by the generalization of the results. This research focused on the context of Jordanian banks; thus, our findings may not be generalizable to other sectors and vice versa. Future work should focus on other developing countries and sectors including the service and manufacturing sectors. Another notable limitation is using a cross-sectional research design in our study. It would be interesting, therefore, for future studies to evaluate data warehouse effectiveness over time using longitudinal methods as the technology and business conditions are best described as fast-moving. The research employed the PLS-SEM method for data analysis, a Bayesian neural network approach can also be used in future studies to explore hidden structures within models, unstipulated model paths and nonlinear relations between model variables (Batra, 2018). As part of future work, it is interesting to investigate how big data could bring new insights and business benefits to an organization, and how big data can be transformed and integrated with existing data sitting within a data warehouse to support strategic, operational and tactical decisions. Future work might use bibliometric analysis that is based on the literature data to allow a scientific investigation of the entire field of interest and from a global standpoint. Given the paucity of research that used the DeLone and McLean model at the organizational level of analysis in the context of the data warehouse system and business intelligence, more research is needed to confirm its validity in the organizational context and extend the model with more success factors such as training quality. This is because a lack of effective training programs is a constraint in achieving the full expected benefits of business intelligence applications.

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