FACTOR ANALYSIS IN MEASURING INFORMATION SYSTEMS EFFECTIVENESS

Christian Bach
Technology Management
University of Bridgeport
cbach@bridgeport.edu

Salvatore Belardo
Management Science and Information Systems
University at Albany
belardo@albany.edu

Hassan Bajwa
Electrical Engineering
University of Bridgeport
hbajwa@bridgeport.edu

Pushpa Kantharaju
Technology Management
University of Bridgeport
pkanthar@bridgeport.edu

Praveen Prasanth
Technology Management
University of Bridgeport
pmanaval@bridgeport.edu

Abstract

In order to evaluate the value and usefulness of information systems that guide IS management actions and IS investments, DeLone and McLean established a universal definition of IS success that includes different perspectives of how information systems might be evaluated. The IS success taxonomy consists of six success categories (1) systems quality, (2) information quality, (3) service quality, (4) use, (5) user satisfaction, and (6) net benefit from which they created a multidimensional and interdependent measuring model that exemplifies the interdependencies between the different success categories to capture the complex nature of IS success. While the characteristics of information systems steadily increase in scope and complexity, it is imperious that academia and practice develop the means to evaluate the successfulness or effectiveness of a system and understand the factors and circumstances to build and maintain a successful system. The objective of conducting empirical research on systems success is to gain insight into the details of the complex systems processes and features which can be translated into prescriptive action plans for implementation. A focus of this article is to discuss how potential "user perceptions" influence on the information system effectiveness. The DeLone model is used as a base model for the systematic study of the features, factors and delivered benefits. The article employs the survey as an instrument to operationalize the model. The paper introduces the factor analysis technique to estimate the parameters of the proposed casual model. The factor analysis of the result reveals the underlying constructs that guide the decision making and planning processes for successful information systems implementations.

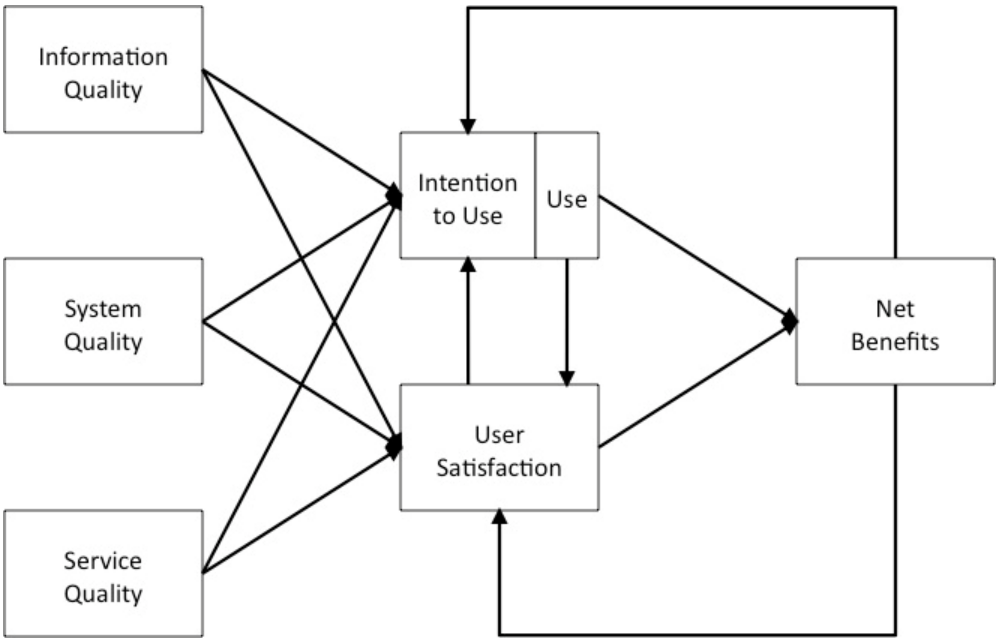
Introduction

Information Systems (IS) are the necessary backbone of our global economy, in which firms generate and collect more information than ever before. This information when properly managed can help improve operations and better fulfill customer needs. In other words, these systems are employed in the hope of helping firms achieve the two objectives common to all firms, namely, to improve operational efficiency and effectiveness. Not only must firms make the right decisions with regard to what products/services to offer and what markets to serve, but they must also ensure that their investments in the information systems and technologies ensure

that they are competitive in their industries. Put another way, investments in IS/IT must ultimately improve performance and deliver value to the firm. Improvements as such cannot be implemented without the intrinsic knowledge and understanding about the system's current status and equally about the changes that might ultimately be useful. However, as information technology (IT) has advanced with ever more promising and exciting new features and capabilities, there has been a move away from traditional data processing applications to more strategic information systems (IS) applications.

As such the focus of the work reported on in this paper is directed towards the systematic study of IS success factors and the delivered benefits to users and organizations as defined by Delone and McLean [1, 2]. In their model, the success or effectiveness construct of information systems consists of multi-dimensional factors that interact with users, interactions that can be measured and translated into practical action. In order to operationalize the Delone McLean model it was necessary to either develop or employ an already developed and validated instrument. In this case the instrument employed is a survey previously employed by Miller and Doyle (1987). In their excellent article in MIS Quarterly [3], the authors presented the survey instrument and discussed the results of a survey of 276 executives from various financial services firms in South Africa. Their survey instrument, a seventy six (76) question survey which was validated from other studies, was modified to reflect changes that have taken place since their study was conducted over 20 plus years ago.

Figure 1: Updated DeLone model [2]



In the Miller and Doyle study, the authors focused on 21 South African financial service industry firms. Their study consisted of 276 executive users [3]. In this study we report on a survey of 276 individuals as well, but from a number of different industries primarily from Europe (Germany, Switzerland, Austria, France, Italy and Argentina).

Here we examine the results of the answers provided by the main sample consisting of all 276 individuals for performance and compared to the performance results of the Miller article. We are able to compare the changes in attitudes that have taken place over the last 20 plus years concerning what managers believe are the important factors that determine IS success.

Result: ISE Factor Analysis

The objective of the study is to discern the factor structure of a variety of a sample of 276 responses. A series of principal component analyses using varimax rotation were run for 34 questions in the questionnaire (the "performance" responses). The sample consisted of all 276 individuals in the population. Rotated component matrices were conducted. A set of components were found for the set of responses. The factors were defined based on the specific questions that were part of each factor. These defined factors were then compared to the actual intended factors or subscales on the assessment to determine whether the factors that were found are similar to the factors that were intended in the original survey.

A series of analyses was run to understand the internal factor structure within the data set. The primary analysis was a factor analysis, which essentially shows which sets of variables are highly correlated with each other. These correlations, called "factor loadings", measure how close each individual question on a survey correlates to each factor. A factor loading of greater than or equal to .5 is considered strong, so only factor loadings of greater than or equal to .5 were shown in the tables. In each case, several factors resulted from a certain subset of questions on the assessment. These factors were defined based on the specific questions that were part of each factor. These defined factors were then compared to the actual intended factors or subscales on the assessment to determine whether the factors that were found are similar to the factors that were intended in the original survey. Separate tables (importance table not included) resulted from both the importance and performance responses for each of the four principal data sets. The importance score for question 1 was used to determine the x and y coordinates of each point on the scatterplot. Additionally, at the start of the analysis, values for Cronbach's alpha were calculated to assess the reliability of the questionnaires; the scale had values greater than .8 on the entire set.

Analyses of Survey

Table 1 displays the reliability statistics for both the importance and performance scales for the 276-person sample, which consists of all people in the sample. The performance data is more reliable than the importance data, with a Cronbach's alpha of .953, compared to .872 for importance. However, both scales are clearly reliable at measuring these constructs, as any Cronbach's alpha value above .8 is very good.

Table 1: Reliability Statistics for Importance and Performance

Scale	Cronbach's Alpha	Number of Items
Importance	.872	38
Performance	.953	38

Here we report on the more reliable performance results.

Principal Components Analysis with Varimax Rotation (Questions 39-72)

According to Table 2, which displays a principal components analysis with varimax rotation of the performance responses, eight factors resulted from the second principal components analysis.

The eight (8) components were defined as follows:

Component 1 – Development of new systems
Component 2 – Operations, IS, and applications
Component 3 – Development, use, and knowledge of IS
Component 4 – IS staff who respond quickly to user requests
Component 5 – CEO involvement in developing IS
Component 6 – Ability to adapt new systems to a changing environment
Component 7 – Sharing user experience in application design
Component 8 – Use of external consultants for planning and implementation

With regard to the complete 276-person sample, several factors appear in both the importance and performance sample, which indicate they accurately reflect the factor structure for the entire sample. These include the development of new systems, the CEO's personal involvement in developing new IS systems, use of internal and external co-worker s to implement IS, and user participation in application design. Several other factors are similar to each other as well. Using these factors, one can construct a new version of this survey with distinct subsamples. Several factors on the other hand did not have such clear counterparts between the importance and performance surveys, such as Components 2, 3, 4, 6, 7, 9, and 11 on the importance survey, and Components 2, 3, 4, and 6 on the performance survey. Clearly, although the factor structure differs on the two surveys, with the performance section having a smaller number of factors, there is much crossover in the results.

Table 2: Rotated Component Matrix for Questions 39-76, "Performance" Responses, 276-person sample

	Component							
	1	2	3	4	5	6	7	8
Question 75: Development of more Inquiry Systems.	.814							
Question 76: Development of more Analysis Systems.	.808							
Question 74: Development of more Exception Systems.	.805							
Question 73: Development of more Monitor Systems.	.708							
Question 39: Availability, timeliness, accuracy, completeness, relevance, and flexibility of information output (reports, documents, etc.)	.445							
Question 65: Up-to-date information of operational processes.		.659						
Question 51: User participation in planning of operations, IS and applications.		.637						
Question 58: IS is used to increase organizational performance.		.566						
Question 64: User applications that make work easier.		.559						
Question 48: User understanding of systems.		.527						
Question 66: User friendly computer applications.		.527						
Question 52: Detailed knowledge of operational processes.		.457						
Question 56: Establishment and use of effective IS performance measures.			.797					
Question 54: Frequent redesign of user applications.			.613					
Question 47: Preparation of a strategic plan for developing IS.			.583					
Question 57: Management and users become knowledgeable about IS opportunities and capability of technology.			.533					
Question 71: Continuous improvement of IS.			.469					
Question 55: Alignment of IS to new strategy, processes and applications.			.468					
Question 42: Efficient running of current systems (costs, ease of use, documentation, maintenance).				.686				
Question 40: IS staff who know user operations, have positive attitude and can communication to users.				.609				
Question 41: Prompt processing of user requests for changes in system.				.544				
Question 67: Short time for new systems developments.				.503				
Question 46: High degree of interpersonal collaborative competence of IS staff.				.480				
Question 49: Upper management and CEO involvement in defining and monitoring IS strategy and policies.					.858			
Question 72: The CEO plays an important role in the corporate IS steering committee.					.763			
Question 43: Use of steering committee for developing and monitoring IS.					.525			
Question 61: Attention and commitment to action by upper management and CEO.					.507			
Question 50: Strategic program in place to identify, collect and analyze information for developing and redesigning strategy, operations and user applications.					.474			
Question 45: The improvement of new systems development (with respect to user requests, updates, time, cost, quality, alignment).						.715		
Question 44: User's preparation of proposals of new systems is supported by IS staff.						.698		
Question 53: Frequent reassessment and redesign of strategy and operational processes to adapt to a changing environment.						.503		
Question 62: Users participate in computer application design.							.732	
Question 59: Promoting informal networks such as communities of practice to share user experience.							.691	
Question 63: Users can request applications and services.							.486	
Question 60: Frequent evaluation whether users receive the right information in the right form at the right time.							.439	
Question 68: Use of external consultants for planning and implementation.								.795
Question 69: Use of internal teams for planning and implementation.								.495

Table 3: Comparison of Surveys

Miller Performance Factors (M1-7)	New Performance Factors (U1-8)
M1: Characteristics of conventional systems	N1: Development of new systems
M2: Strategic management issues	N2: Operations, IS, and applications
M3: User involvement	N3: Development, use, and knowledge of IS
M4: Responsiveness to new systems needs	N4: IS staff who respond quickly to user requests
M5: End user computing	N5: CEO involvement in developing IS
M6: IS staff quality	N6: Ability to adapt new systems to a changing environment
M7: Reliability of service	N7: Sharing user experience in application design
	N8: Use of external consultants for planning and implementation

With regard to the two surveys (consult the Miller 1987 survey), several factors appear in both, which indicate they accurately reflect changes of the factor structure over time. Similarities of factors can be seen in following pairs: (1) M2: Strategic management issues / N5: CEO involvement in developing IS, (2) M3: User involvement / N7: Sharing user experience in application design, (3) M4: Responsiveness to new systems needs, and (4) M6: IS staff quality / N4: IS staff who respond quickly to user requests. Even though similarities exist there is a significant shift in meaning and application of all of the components over time, which indicates that user perception changes in a critical way to which systems needs to be constantly adapted. The significance of M7: Reliability of service diminished probably because systems today are perceived as reliable to which less attention is drawn.

Notably there are the two new components N7: Sharing user experience in application design and N8: Use of external consultants for planning and implementation, which seems to be necessary construct to fulfill N6: Ability to adapt new systems to a changing environment and M4: Responsiveness to new systems needs.

Table 4: Factors influencing Dependent Variables in the DeLone model:

DeLone Dependent Variables (DV)	Factors Influencing DV
System Quality • Adaptability • Availability • Reliability • Response time • Usability	M 1,3,4,5,6,7 N 1,2,4,6,7,8
Information Quality • Completeness • Ease of understanding • Personalization	M2,3,5 N 2,3,4,5,6

• Relevance • Security	
Service Quality • Assurance • Empathy • Responsiveness	M 3,4,5, N 1,2,4,6,7,8
Intend to Use • Nature of use • Navigation patterns • Number of site visits • Number of transactions executed	M 2,5 N 2,3,5,7
Use • Repeat purchases • Repeat visits • User surveys	M 2,5 N2,3,5,7
Net Benefits • Cost savings • Expanded markets • Incremental additional sales • Reduced search costs • Time savings	M 2,5 N 2,3,5,7

Table 4 displays significant overlap to the DeLone construct. This indicates the need as DeLone has mentioned to move from taxonomy to a multidimensional and interdependent measuring model.

Table 5: Factors indicating new Dependent Variables for an updated DeLone model:

New Dependent Variables (DV)	Factors New DV
User Feedback • Needs • Usefulness • Satisfaction over time • Response time to change	M 2,3,4,5,6,7 N 2,4,6,7,8
Technology Partner • Expertise • Speed • New technologies • State-of-the Art • State-of-the	 N 1-5 N 6,7,8

Two new constructs can be deduced from factors N6,7,8 as well as M3,4,5 indicate the need of feedback loops to keep the system state-of-the-art. The “Technology Partner” construct indicates fast moving development of new and emerging technology cannot be efficiently handled internally. It probably also indicates the need of several Technology Partners (infrastructure, security, etc.) to cover the very different technologies of which a system composes of.

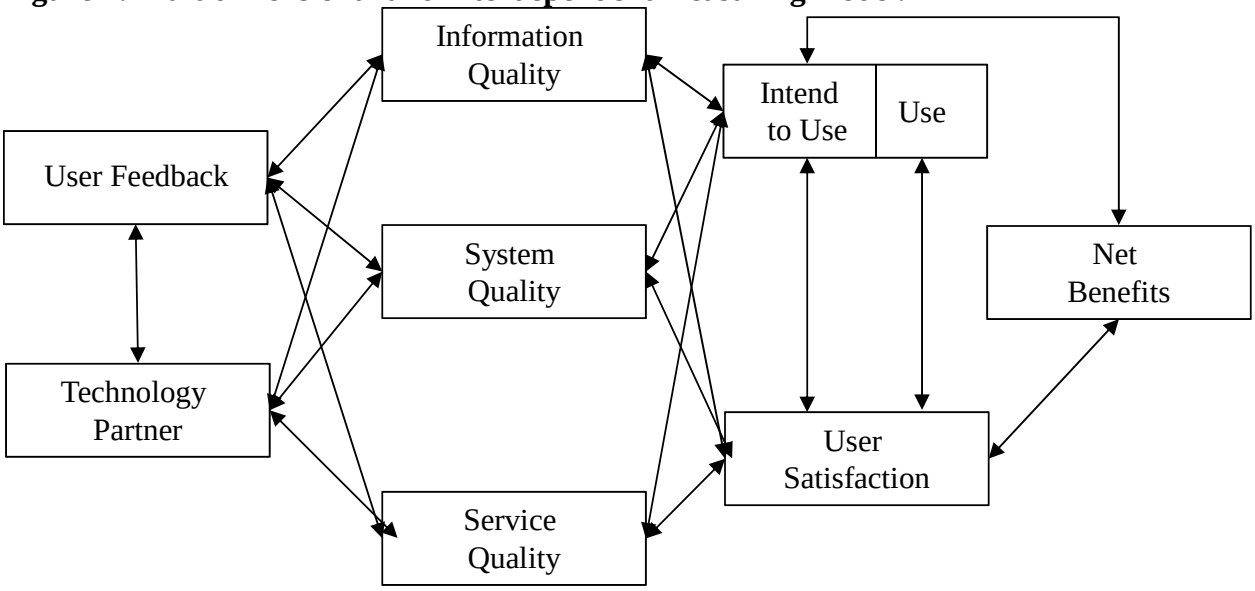
Table 6: Factors indicating new Dependent Variables for an updated DeLone model:

Missing Dependent Variables (DV)	Factors New DV
Internal Teams • Coordination • Training • Analysis • Continuation	

Based on case study research one construct is missing. To analyze the current status, analyze user feedback, and coordinate actions internally, the "Technology Partner" is a vital construct to manage continuous IS success. It also promoted the idea of triangulating and validating research finding from several perspectives and motivation, instead of using a single research approach.

From the empirical data so fare the DeLone model can be extended as shown in Figure 2.

Figure 2: Multidimensional and interdependent measuring model.



Conclusion

As our findings show, conducting empirical system research that is able to reveal factors which in turn can be translated into understandable practical construct is vital to maintain IS success over time to enhance quality of work, encourages decentralization of authority by monitoring the performance, analyze complex problems and facilitates co-ordination of all departments.

References

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[3] J. Miller and B. A. Doyle, "Measuring the Effectiveness of Computer-Based Information Systems in the Financial Services Sector," *MIS Quarterly,* vol. 11, pp. 106-124, 1987.