

# **Analyzing the Impact of a Business Intelligence System with different models of Information System Success**

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## **Abstract**

During this research the results of three models were empirically compared: the DeLone and McLean model, the Seddon model and the Modified Seddon model, and were analyzed based on the impact of a Business Intelligence System (BIS) within companies in Peru. We worked with a sample of 104 users of the BIS, from companies in several important economic sectors, in a quasi-voluntary context, and with six constructs: Information Quality, System Quality, Service Quality, System Dependence, User Satisfaction and Perceived Usefulness. To interpret the results, we used structural equations. The idea was to look for the best fit and explanations for the outcomes. The main difference in these models is that the DeLone and McLean model considers System Dependence (Use of the System) as a part of Information System Success, but in the Seddon model, it is a consequence of it. The Seddon model seems to show the best fit and explanation for the outcomes.

**Keywords:** DeLone and McLean model, Seddon model, Impact of a Business Intelligence System

## **Introduction**

Business Intelligence, one of the most important components of Information Systems (IS), is playing a very relevant role in business in this time of high competition, high amounts of data and new technology. During these times, companies feel pressured to respond quickly to change and complicated conditions in the market, needing to make the correct tactical, operational and strategic decisions.

Business Intelligence (BI) is one of the most important drivers of the decade. Big companies of IS are creating special units specialized in BI, helping companies become more efficient and effective in daily operations. The field of BI is evolving at a fast speed, to become more innovative and obtaining knowledge of the data stream that was once never obtained. Today innovative programs of BI in all industries are being put to use (Chen, Chiang y Storey, 2012; Sharda, Delen and Turban, 2014).

A company that uses a Business Intelligence System can be more effective and efficient and can disseminate knowledge inside the company, with business partners, improving the decision making process and making the enterprise more competitive (Parzinger & Frolick, 2001).

Measuring the impact of Business Intelligence System is very important in order to get the best outcomes and increase the investment return rate. Several models have been used to measure the impact of Information Systems; one of them is the Delone and McLean (D&M) model from 1992, enhanced in 2003. Another important model is the Seddon model from 1997, a modification of the D&M model from 1992. Seddon

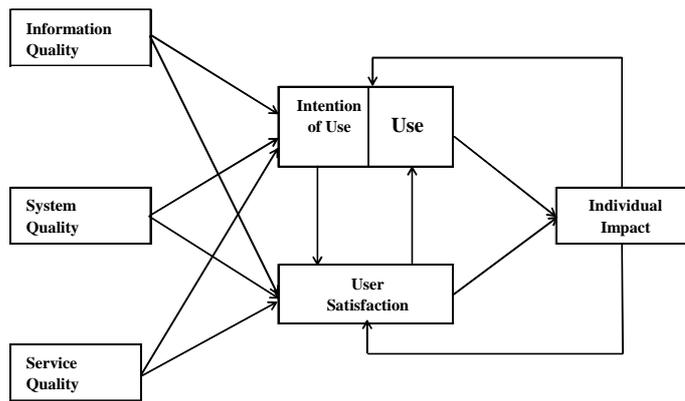
indicated that the D&M model is confusing and divided it into two parts, the IS Success model and the Partial behavioral model of IS use. Both models have been used by several researchers with various results.

In Peru, a developing country in South America, both models were compared for companies that use Business Intelligence Systems, using a sample of 104 users for the system in 13 enterprises, having a quasi-volitional IS use context. The proposal employed by Rai, Lang and Welker (2002) were used while analyzing the validity of IS Success models with an empirical and theoretical approach, in which they modified the Seddon model to be used as a third alternative.

## **Literature Review**

### **The Delone and McLean IS Success model**

Delone and McLean (1992) established a model that tried to measure the impact of the information system, taking six constructs into account. After ten years, DeLone and McLean (2003) reviewed the model, taking into consideration several studies that were used partially or completely on their model. They said that the model had fulfilled the main objective established: to obtain the information system success, through multidimensional and interdependent constructs. They modified the model considering the next constructs: Information Quality, System Quality, Service Quality, Use of the System or Intention to Use, User Satisfaction and Net Benefits. The model can be observed in Figure 1.



**Figure 1. DeLone and McLean's model from 2003**

One of the independent constructs is Information Quality, the variables related to it are: accuracy, precision, output timeliness, reliability, completeness, relevance, and currency. The second independent construct is System Quality, which recommends the consideration of variables such as performance of the system, trustworthiness of the computational system, on-time and on-line response, and the ease of use of terminals (Swanson, 1974).

The third independent construct is Service Quality, which can be evaluated through technical competence of the IS staff, their attitude, their ability to complete the development of products and services on time, the span of time required to develop the systems and marketing measuring tools such as SERVQUAL, used to measure the dimensions of tangibles, responsiveness, assurance, reliability and empathy (Chen, Soliman, Mao and Frolick, 2000).

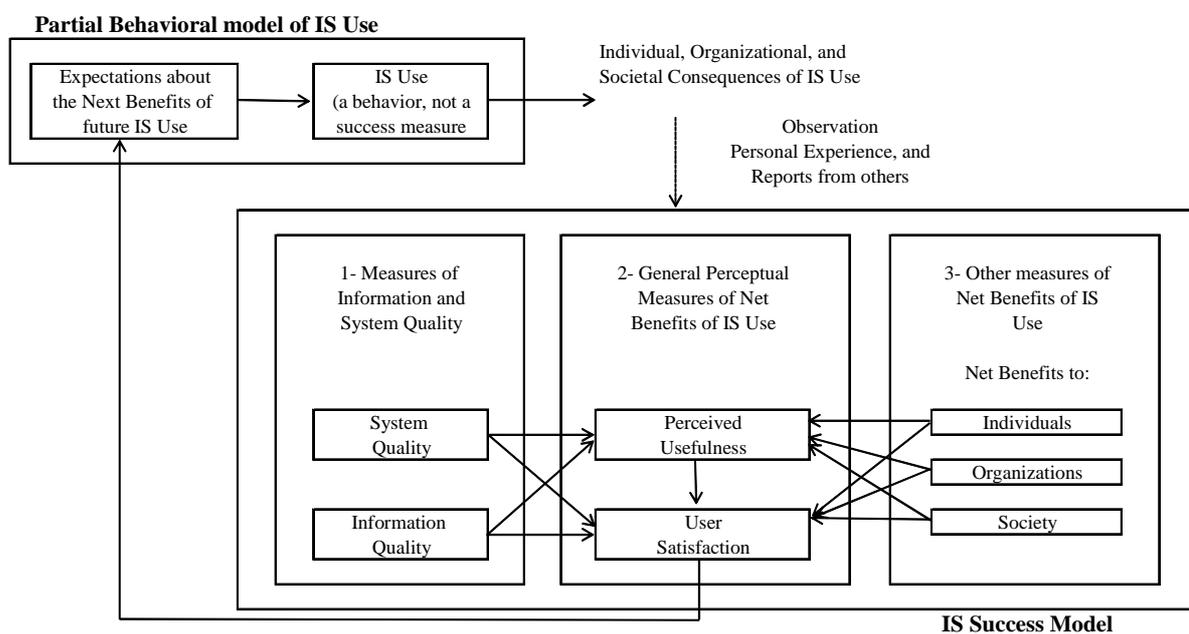
In past years, several evaluations of the DeLone and McLean model have been made during studies that have been used partially or completely (Petter, DeLone and McLean, 2008), corroborating most of the relations between constructs.

### **The IS Success Seddon model**

The Seddon model (1997) tries to improve the DeLone and McLean (D&M) model from 1992. According to Seddon, the model was derived from the combination of a process models with another of variance. This model maintains a great part of the D&M model, but is divided into two variance models, eliminating the process model. The first variance sub-model is the Partial Behavioral Model of IS Use. The second sub-model is the IS Success Model, a great part of the D&M model. Both models of variance are united, firstly from the Partial Behavioral model of IS Use, through the Individual, Organizational, and Societal Consequences of IS Use, after from the IS Success model through the Partial Behavioral model of IS Use, from the User Satisfaction construct to the Expectations about the net benefits of future IS Use.

The Partial Behavioral model of IS Use is composed by Expectations about the net benefits of future IS Use construct, that is directly related to the IS Use construct (behavior). The IS Success model is composed by three bodies. The first one is Measures of Information and System Quality, with System Quality and Information Quality constructs. The second body is General Perceptual Measures of Net Benefits of IS Use, with the Perceived Usefulness, and User Satisfaction constructs. The second body is Other Measures of Net Benefits of IS Use, with the net benefits for Individuals, Organizations, and Society. The constructs of the first and third body influence the

constructs of the second body. Besides that, the Perceived Usefulness of the second body is directly related to the User Satisfaction construct. Finally, the User Satisfaction Construct offers feedback with construct Expectations about benefits for future IS Use, of the Partial Behavioural model of IS Use. The Seddon model can be observed in Figure 2.



**Figure 2. The Seddon model**

Seddon indicates that Use must be after impacts and benefits because it does not cause them. It is affirmed by Seddon that IS Use is a behavior that expresses a belief of goodness from using an information system. The Seddon model labels IS Use as a behavior caused by IS success. IS Use is a consequence of the IS success.

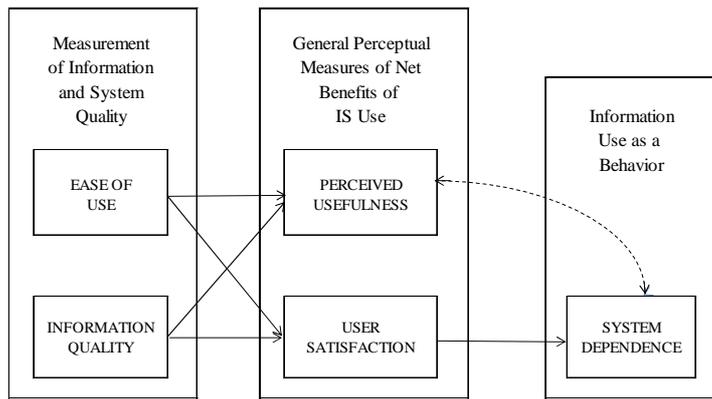
In relation to the construct Use of the System, this model was developed for volitional and non-volitional usage, in contrast to the DeLone and McLean model that solely assumes volitional use (Rai, Lang and Welker, 2002).

Several recent studies have used the Seddon model, because it explains adequately the impact of an Information System (Brown & Jayakody, 2009; Kulkarni, Ravindran & Freeze, 2006; and Sabherwal, Jeyaraj, and Chowa, 2006).

### **The Modified Seddon Model**

Rai, et al. (2002) used the DeLone and McLean model (1992) and the Seddon model (1997) in order to estimate the validity of both. It was founded that both models exhibited reasonable fit. They considered a third alternative, modifying the Seddon model. It was estimated that the perceived usefulness was related to individual impacts, considering that DeLone and McLean (1992) connected several constructs to individual impacts.

In this way, Rai et al. (2002) established a model of five constructs: system quality, information quality, perceived usefulness, user satisfaction and system use. Besides that, they represent system use in terms of system dependence. The Seddon model was modified, including a correlational path between system use (system dependence) and perceived usefulness, so best fit and variance explanation would be obtained. The model can be observed in Figure 3.



**Figure 3. The modified Seddon model, by Rai et al.**

## Method

The model used is a quantitative one, in which the individual User of the Business Intelligence System (BIS), in a company that employs the system, is the unit of analysis. A Pilot Test is employed to test the tools, the questionnaire and the model. Structural Equations are used for the analysis. The model is analysed with the DeLone and McLean model, the Seddon model, and the Modified Seddon model.

The study sample includes the most important companies in the Peruvian economy from different economic sectors: banking, food industry, consumer marketing products, pension funds, government, beauty products, market research, and credit cards. The Use of Business Intelligence Systems (BIS) in those companies is not mandatory and users have other channels providing the information, but in general it is more cumbersome and perhaps not as precise in the data for the analysis, so the BIS is assumed as quasi-volitional or quasi-mandatory.

## **Quantitative Analysis**

We compare the DeLone and McLean model with the Seddon model in a sample of companies that use Business Intelligence Systems. In selecting the size of the sample, the guidelines of Hair, Black, Babin, Anderson and Tatham (2006) were followed. The initial sample was of 110 surveys, but after eliminating some outliers, the final sample consisted of 104. The measurement of the constructs was made using a seven-point scale (semantic differential, Likert, ordinal and ratio: Iivari, 2005; Hong *et al.*, 2006; Chen *et al.*, 2000; McKinney, Yoong and Zahedi, 2002). The questionnaire has 29 statements for the six constructs.

The validity of the constructs was verified through face validity, convergent validity, discriminant validity and nomological validity. All construct validity statistics were considered satisfactory. The general reliability coefficients in the CFA and Structural model were satisfactory: Cronbach's alpha of 0.954, and Rho of 0.974. A pilot test was conducted with 68 observations to verify the questionnaire and apply the Exploratory Factor Analysis through Principal Components and Varimax rotation to verify that each item pertained to only one construct.

## **Sample Analysis**

Standard procedure was followed, commencing with the Confirmatory Factor Analysis (CFA), and thereafter the Measurement model was established. The estimated method used in structural equations was Maximum Likelihood Estimation, with the complementary method of Robust from the EQS program.

The CFA was initially established using all the observable variables. The fit of the model was modified, working with  $X^2$ , CFI, RMSEA, multivariate normal distribution adjustment, and the average variance extracted (AVE) (Byrne, 2006). Thereafter, the final Confirmatory Factor Analysis (CFA) was obtained with 22 items derived from 104 observations. The software used for the statistical analysis was Minitab, while the structural equations used EQS version 6.1. See Table 1 for statistics from the Confirmatory Factor Analysis.

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Statistics - Confirmatory Factor Analysis

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Number of observations	104
Multivariate Kurtois	2,86
<u>Method ML</u>	
Chi-squared	290
CFI	0,956
RMSEA	0,070
<u>Method Robust</u>	
Chi-squared	281
CFI	0,946
RMSEA	0,067
<u>Average Variance Extracted</u>	
Information Quality	39,99%
System Quality	54,41%
Service Quality	53,36%
System Dependence	51,97%
User Satisfaction	70,74%
Perceived Usefulness	61,86%

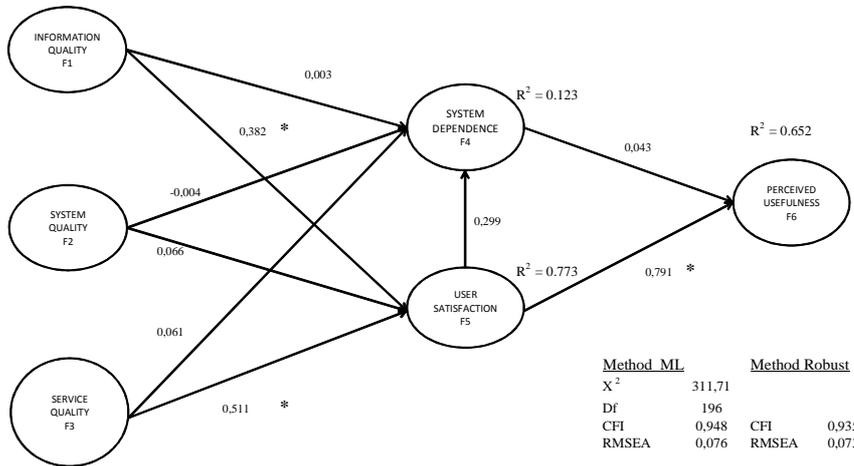
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**Table 1. Main Statistics of the Confirmatory Factor Analysis**

## Results

After completing the Confirmatory Factor Analysis, the Structural Model was established. Figure 4 presents the structural model found with the DeLone and McLean

model, including the relations between constructs and the variance explained for each dependent construct through  $R^2$ .

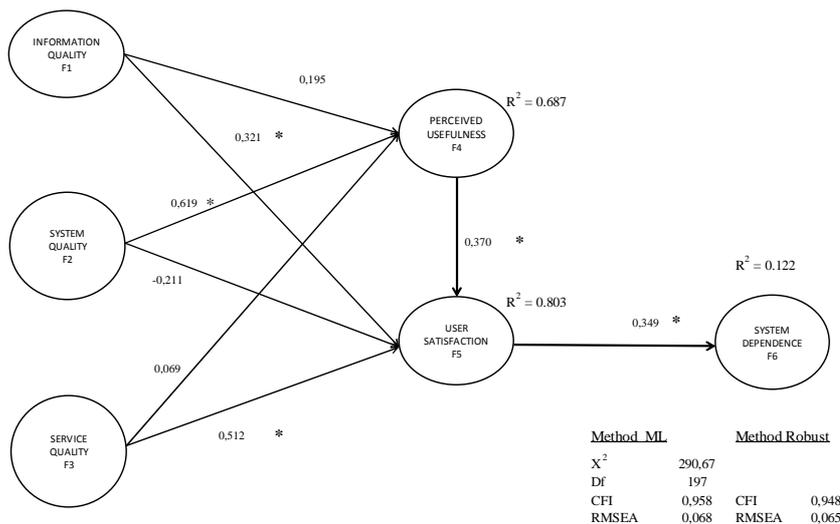


**Figure 4. DeLone and McLean structural model**

In this case a variance explanation of 65,2% for Perceived Usefulness, 77,3% for User Satisfaction and 12,3% for System Dependence was obtained, and three significant relations were found (alpha 0,05). The independent constructs Information Quality and Service Quality have significant relations with the mediator construct User Satisfaction. Likewise, User Satisfaction has a significant relation to the dependent construct, Perceived Usefulness. In contrast, the independent construct System Quality does not have any significant relation to the mediator constructs. The System Dependence construct shows no significant relation to the independent constructs or dependent construct. The dependent construct, Perceived Usefulness, is explained in 65,2% ( $R^2$ ).

This model does not find any significant relation between the System Dependence and other constructs of the model, and it is worth considering that, as an indicator of the success of the system, it makes sense if it is voluntary or discretionary, and not when the system has captive users, who do not have an alternative system to process information (Lucas, 1978).

For the Seddon model, the next results, including the relations between constructs and the variance explained for each dependent construct through  $R^2$  that can be observed in Figure 5, were found.

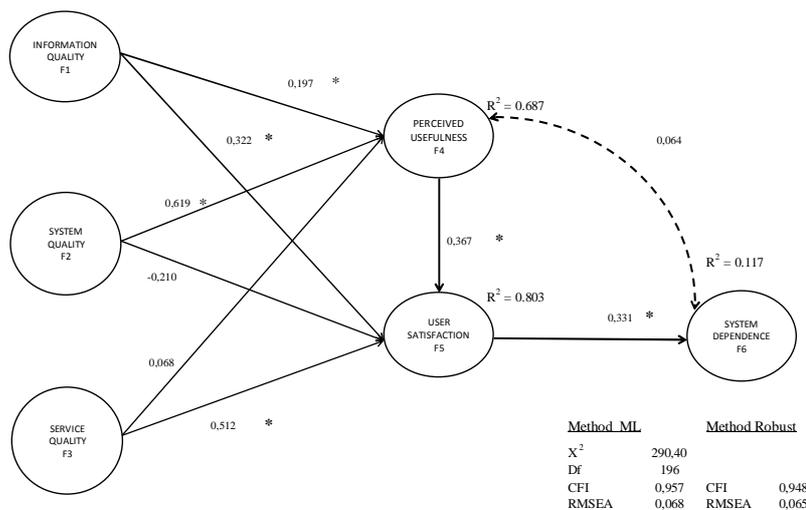


**Figure 5. Seddon structural model**

In this second model, a variance explanation of 12,2% for System Dependence, 80,3% for User Satisfaction and 68,7% for Perceived Usefulness, and find five significant relations (alpha 0,05) are presented. The independent constructs Information Quality and Service Quality have significant relations with the mediator construct User

Satisfaction. Likewise, User Satisfaction has a significant relation with the dependent construct, System Dependence. The independent construct System Quality has a significant relation with the mediator construct Perceived Usefulness and the Perceived Usefulness has a significant relation with the User Satisfaction construct. The dependent construct, System Dependence, is explained in 12,2% ( $R^2$ ).

For the modified Seddon model, the next results, including the relations between constructs, and the variance explained for each dependent construct through  $R^2$  that can be observed in Figure 6, were found.



**Figure 6. Modified Seddon structural model**

In this third model, a variance explanation of 11,7% for System Dependence, 80,3% for User Satisfaction and 68,7% for Perceived Usefulness, and six significant relations are presented (alpha 0,05). The independent constructs Information Quality and Service

Quality have significant relations with the mediator construct User Satisfaction. Likewise, User Satisfaction has a significant relation with the dependent construct, System Dependence. The independent constructs Information Quality and System Quality have a significant relation with the mediator construct Perceived Usefulness and the Perceived Usefulness has a significant relation with the User Satisfaction construct. The dependent construct, System Dependence, is explained 11,7% ( $R^2$ ).

We can compare the three models in the next Table 2. The best model is the Seddon model, the second best model is the Modified Seddon model, which is pretty similar to the first model and thirdly the DeLone and McLean model. The Seddon model has the best for CFI (0,958 against 0,957 and 0,948), RMSEA (0,068 against 0,068 and 0,076),  $R^2$  of Perceived Usefulness (0,687 against 0,687 and 0,652),  $R^2$  of User Satisfaction (0,803 against 0,803 and 0,791). The Seddon model explains the significance of the System Dependence construct in relation to other constructs of the model (like the Modified Seddon model), but the DeLone and McLean does not. The DeLone and McLean better explain System Dependence ( $R^2$  of 0,123, against 0,122 and 0,117 for the other models). And in total significant relations between constructs, the Modified Seddon model explained 6 relations, against 5 for the Seddon model and 3 for the DeLone and McLean model.

Statistics	Models		
	DeLone and McLean	Seddon	Modified Seddon
$\chi^2$	311,71	290,67	290,40
Degrees of Freedom	196	197	196
Comparative Fit Index (CFI)	0,948	0,958	0,957
RMSEA	0,076	0,068	0,068
$R^2$ Perceived Usefulness	0,652	0,687	0,687
$R^2$ User Satisfaction	0,791	0,803	0,803
$R^2$ System Dependence	0,123	0,122	0,117
$R^2$ Average explained	0,522	0,537	0,536
Significant relation of the System Dependence construct with other constructs	No	Yes	Yes
Total significant relations between constructs	3	5	6

**Table 2. Comparison of the three models**

## Discussion

In the last years, the DeLone and McLean have been evaluated through several studies that have used partially or completely. Most of the relations between constructs have been confirmed (Petter, DeLone and McLean, 2008). The construct Use of the System, as previously mentioned, could be a good indicator of a successful system when it is voluntary or discretionary, and not when the system has captive users, who do not have an alternative system to process information (Lucas, 1978). Besides that, Petter and McLean (2009) performed a meta-analysis on the DeLone and McLean Success of IS model, considering 52 studies. They concluded that the User construct needed to be improved. Given that there no more consistent or confident measures exist, it would be difficult to find relations between this construct and the others of the model.

Weider, Ossimitz and Chamoni (2012) performed a research about the impact of Business Intelligence (BI) tools on Performance working with the DeLone and McLean

model of IS Success. They did not find a significant relation between User Satisfaction and BI Use, but found a weak relation between BI Use and Performance Indicators. They indicated that it is possible to find several particularities in Business Intelligence Systems (BIS): firstly, the most advanced users of the system use the system more, in its full capacity, find errors, create difficult questions about the system, become less satisfied with the system and possibly use it less. On the other hand, the less experimented users look for the simple ways of using the system, find everything they need, are happy with the system, and would use it more.

Secondly, the BIS are configured to elaborate reports for easy usage in a full automated way. Users who want to get the most from the system need to have advanced technical skills and need to know a little more about the basic configuration of the system. This is related with the frustration of the user, indicating lack of friendliness and adequate technical characteristics of the system. Finally, there would be an inadequate Use of the system because of a shortage of mental and culture awareness of Business Intelligence and the BIS would lack performance.

Because of those reasons, the construction of the System Dependence (Use of the System, according to Rai et al., 2002), is not working well in the DeLone and McLean model, it is not a good fit, nor does it have a good level of explanation.

The Modified Seddon model considers an additional restriction compared with the Seddon model. It indicates that there is a correlation between the Perceived Usefulness and the System Dependence constructs. In this way, a better explanation and fit will exist. The supposition here is that the users of the Information System only have one

viable choice for getting and analysing information, increasing the perceived benefit of the Perceived Usefulness, so there is a correlation between Perceived Usefulness and System Dependence (Use of the system), with no causal relation between them.

The results received from this research indicates that the Seddon model performs and explains better what is happening with the Business Intelligence System, compared to the DeLone and McLean model and with the Modified Seddon model. The fit is better than the DeLone and McLean model (CFI of 0,958 vs 0,948; RMSEA 0,068 vs 0,076), the same goes for  $R^2$  Average explained (0,537 vs. 0,522). The Seddon model has a significant relation between the System Dependence and the other constructs, whereas the DeLone and McLean do not. The Seddon model has five significant relations between the constructs, while the DeLone and McLean has only three. The Modified Seddon model obtains almost as good result as the Seddon model, with the only advantage that explains one more significant relation between constructs (with six in total).

## **Limitations and Recommendations for Future Studies**

It is estimated that the sample includes more than 15% of all the companies that use a Business Intelligence Systems in Peru, so the size of the sample is adequate, but it is not entirely random and therefore limits the generalizability of the results of the study. Besides that, a sample size that is bigger could be better for the sake of making a more detailed analysis, permitting the use of some items with less power, or the use of another statistical procedure for structural equations such as the Asymptotical Distribution Free, permitting a more detailed analysis (Hair et al., 2006).

For future studies it could be better to use the Seddon model, considering more alternatives for “other measures of the Net Benefits of IS Use” (as a part of the IS Success Model). Trying to become more rigorous would be equally better, allowing the utilization of some objective measures, not only perceptual measures for several of the constructs. A good idea for future studies would be to estimate how the results vary according to the volitional or non-volitional context in which de BIS is working.

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