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Hospital information systems: Measuring end user computing satisfaction (EUCS)

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ABSTRACT

Over the past decade, hospitals in Greece have made significant investments in adopting and implementing new hospital information systems (HISs). Whether these investments will prove beneficial for these organizations depends on the support that will be provided to ensure the effective use of the information systems implemented and also on the satisfaction of its users, which is one of the most important determinants of the success of these systems. Measuring end-user computing satisfaction has a long history within the IS discipline. A number of attempts have been made to evaluate the overall post hoc impact of HIS, focusing on the end-users and more specifically on their satisfaction and the parameters that determine it. The purpose of this paper is to build further upon the existing body of the relevant knowledge by testing past models and suggesting new conceptual perspectives on how end-user computing satisfaction (EUCS) is formed among hospital information system users.

All models are empirically tested using data from hospital information system (HIS) users (283). Correlation, explanatory and confirmation factor analysis was performed to test the reliability and validity of the measurement models. The structural equation modeling technique was also used to evaluate the causal models.

The empirical results of the study provide support for the EUCS model (incorporating new factors) and enhance the generalizability of the EUCS instrument and its robustness as a valid measure of computing satisfaction and a surrogate for system success in a variety of cultural and linguistic settings.

Although the psychometric properties of EUCS appear to be robust across studies and user groups, it should not be considered as the final chapter in the validation and refinement of these scales. Continuing efforts should be made to validate and extend the instrument.

1. Introduction

The use of Information Technology (IT) is spreading more and more in public hospitals and, generally, in the health care sector in Greece. It is widely accepted that the use of IT in hospitals offers huge development prospects and opportunities, mainly in improvements to the quality of patient care, increased staff efficiency and effectiveness, and a significant decrease in their operational expenditure [6]. Whereas the cost of introducing and spreading the use of IT in hospitals is constantly increasing, the results of these investments have not been thoroughly examined [75]. Although individual studies have suggested a positive relationship between the level of IS/IT investment and the productivity of health care services [49], the overall results of IT investment profitability studies have been inconclusive [50]. On the other hand, IT investment productivity does not guarantee the productivity of a single hospital information system. Therefore, a rigorous evaluation of the systems implemented in hospitals is recommended and the results of this could be of great importance for both the current decision makers and the future users of information systems [30,60].

Many different approaches have been developed for the evaluation of information systems, each one having its own unique characteristics. However, no one approach is considered as complete and generally applied for the evaluation of HIS [2,30]; as is characteristically observed by Bokhari [9], "*the evaluation of an informational system in terms of success, is a complicated phenomenon by its nature*" (p. 211).

The main purpose of this research is to (a) determine whether an IS instrument that is commonly used as a surrogate measure for success, the end-user computing satisfaction model, can be applied in hospital information systems and (b) extend the generalizability of the end-user computing satisfaction (EUCS) instrument by assessing the psychometric properties of a Greek translation of the EUCS survey.

2. Theoretical background

End-user computing satisfaction can be described as the IS end-user's overall affective and cognitive evaluation of the pleasurable

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level of consumption-related fulfillment experienced with the IS [23,14]. Cyert and March [19], who were the first to propose the concept of user information satisfaction (UIS) as a surrogate of system success, suggested that an IS that meets the needs of the users reinforces their satisfaction with the system. User information satisfaction is often used as an indicator of user perception of the effectiveness of an IS [4,23], and is related to other important constructs concerning systems analysis and design.

End-user computing satisfaction is probably the most widely used measure of IS success. Not only does satisfaction have a high degree of face validity due to reliable instruments having been developed by past researchers but also most other measures are either conceptually weak or empirically difficult to validate [24,21].

The most frequently used EUCS instrument was developed by Bailey and Pearson [4], who identified 39 factors that can be used to measure the EUCS of IS. This model was first assessed and refined by Ives et al. [35] in 1983 and, later, by Baroudi and Orlikowski [5] in 1988. As a result, a new shortened model was developed comprising 13 factors, which can be broadly grouped into three main dimensions: (a) information quality, (b) EDP Staff and Services, and (c) User Knowledge or Involvement. Typical measures of *Information Quality* include accuracy, relevance, completeness, currency, timeliness, format, security, documentation and reliability. Measures of *EDP Staff and Services* mainly comprise staff attitude, relationships, level of support, training, ease of access and communication. Finally, measures of *Knowledge or Involvement* mainly include user training, user understanding and participation. Other dimensions such as *Top Management Support*, *Organization Support*, or user support structures of any kind, are also suggested as influencing IS user satisfaction [45,26]. Additionally, two other IS dimensions, namely *System Quality* and *Interface Quality*, are also proposed by other researchers from the IS attributes lists [72,45,26]. Most measures in the former dimension are aspects of engineering-oriented technical performance, such as speed, features, robustness and upgrade flexibility. The latter category refers to the interaction between the end-user and the computer system, which consists of hardware devices, software and other telecommunications facilities. These two groups include variables which assign the efficiency of an information system, which has an important impact on the satisfaction of the end-users.

3. Research models

The research models developed and empirically tested in this research (Figs. 1–3) are mainly based on the end-user's computing satisfaction model of Doll and Torkzadeh [23], Bailey and Pearson's model [4], the suggestions of DeLone and McLean [22], and the findings of other related researches [45,72,36,35,69].

The first model (Fig. 1) is mainly based on the end-user's computing satisfaction model of Doll and Torkzadeh [23]. It was modified to include more items for measuring each factor, based on the suggestions of the structured equation modeling theory which requires at least three items for each construct included in the model.

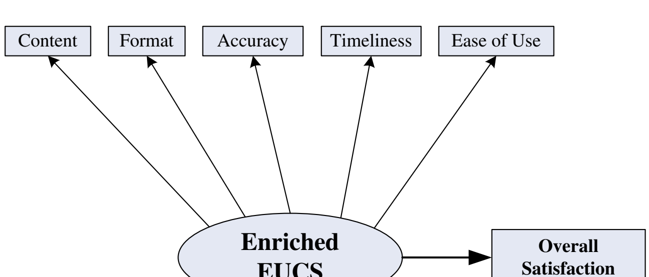


Fig. 1. The enriched end user computing satisfaction model.

Doll and Torkzadeh's [23] EUCS model is based on five independent constructs which are used to estimate the dependent variable (satisfaction). These constructs are: (a) content, (b) accuracy, (c) format, (d) ease of use, and (e) timeliness. Since then, the model has been empirically tested and end-user's satisfaction is accepted as a reliable determinant of information system success. The model has been extensively tested by many researchers and the instrument validity (content validity, construct validity, and reliability) as well as internal validity, external validity, test retest reliability and statistical validity have been demonstrated [23,70,24,25,47,46,78,69].

However, there is an alarming lack of effort in validating instruments [11] and a relative paucity of replication in HIS, which needs to be ameliorated [8]. Responding to the call for "*reinstating replication as a critical component of research*" [8], we believe EUCS, as developed by Doll and Torkzadeh [23], should be reinvestigated, in the light of emerging technologies, with new data to demonstrate the robustness of the measurement model.

Taking into consideration all the above-mentioned findings of previous studies, it was decided that this research should also test an enhanced (expanded) version of Doll and Torkzadeh's [23] model (Fig. 2).

Some constructs, concerning the system quality and service quality, were also added. More specifically, these new constructs deal with: (a) the system processing speed, (b) user interface, (c) user documentation, (d) user training, (e) the support provided by the information department, and (f) the support provided by the maintenance company.

3.1. System processing speed

Problems in the processing speed or in communications appear even today and directly influence both user satisfaction and efficiency [67]. Previous research has proved that there is a statistically significant relation between the system processing speed and the user efficiency and, as a result, user satisfaction with the system [43]. In fact, Rushinek and Rushinek [62] suggest that a system's processing speed is the most important factor for determining user satisfaction. Chin et al. [15] also note that the system's processing speed, along with the system's accuracy, are the two most important factors for determining the user's attitude concerning acceptance and system usage.

3.2. User interface

A number of researchers have suggested that user satisfaction is one of the key factors leading to IS success [1] and the usability of interfaces can be seen as one of the factors that influence end-user satisfaction [56]. According to Benbunan-Fich [7], the subjective user perceptions towards an interface can directly mediate perceptions of system usability. Indeed, research has shown that user perceptions towards a system's interface are strongly related to apparent usability and may significantly affect overall system acceptability [29,64,53].

3.3. User training

Training has been identified as one of the key factors responsible for ensuring successful IT usage [20]. Research has shown that training increases system usage and helps users to feel comfortable with its usage and thus indirectly increases its acceptance [17]. It has also been empirically shown that training is strongly correlated with: (a) the system usage and the improvement of decision-making [52], (b) users' efficiency and effectiveness [58], and (c) users'

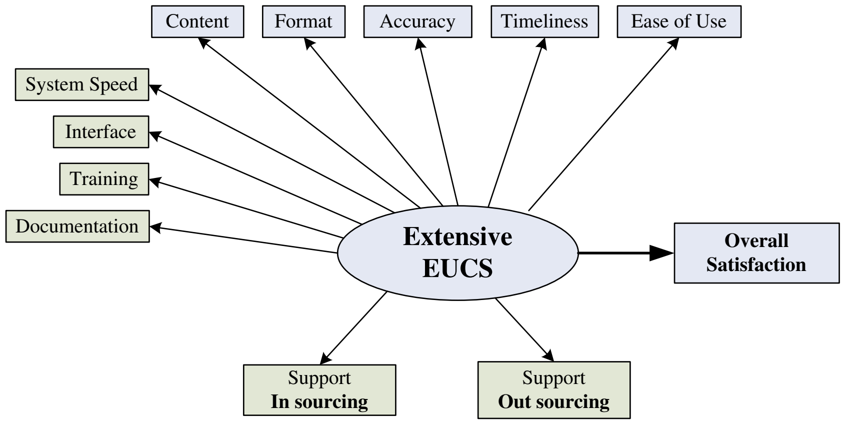


Fig. 2. The extensive end user computing satisfaction model.

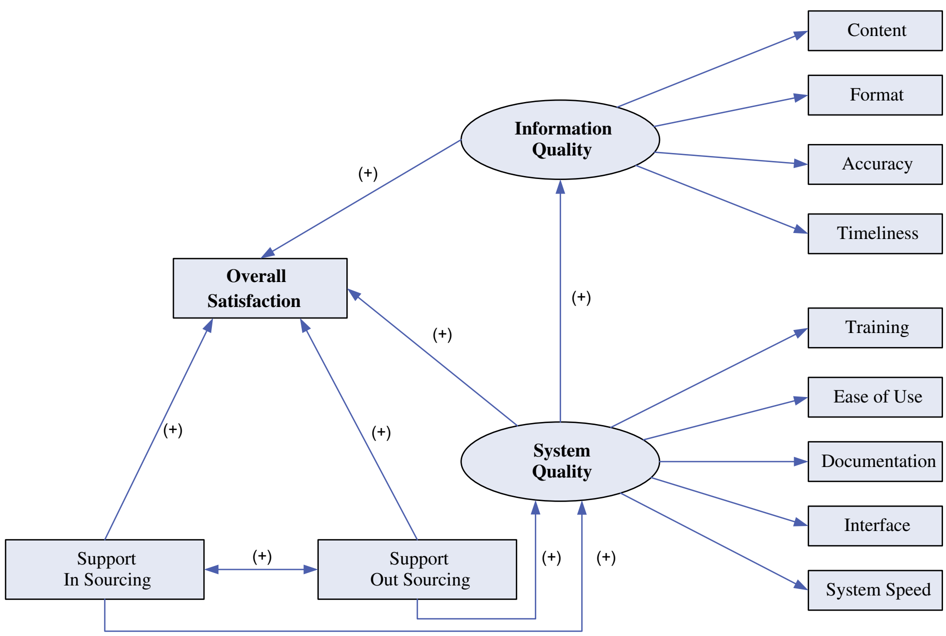


Fig. 3. A new proposed model of EUCS.

satisfaction [13]). Consequently, users' continuous training is a key determinant of the long-term viability of IS in a given organization [79,61,68]. Unfortunately, training costs and tight implementation budgets can result in limited training prior to actual usage [65].

3.4. User documentation

User documentation is a written or electronic explanation of what application software does and how to use it. Schaeffer [63] suggests that user documentation is important for generating a satisfying user image of the systems department, making work more efficient and pleasant, reducing costs and confusion, eliminating frustration, and improving management control and employee morale. However, despite the growing interest in user-related concepts, little is known about the role of user documentation in maintaining user satisfaction. The research has shown that user documentation: (a) increases the handiness of the system [51], (b) improves users' efficiency and effectiveness and decreases the processing cost, (c) reduces user dependencies on the EDP department, (d) facilitates installation, operation, use, evaluation, and maintenance of a system, (e) increases the acceptance and system usage, and (f) increases end-users' satisfaction [32,62,26,55,7].

3.5. User support (service quality)

Taking into consideration the first end-user satisfaction model [4], as well as the suggestions of many other researchers [35,57,76,34,21,22], it is accepted that user support related factors play an important role in the determination of the end-user's satisfaction. Pitt et al. [57] observed that "*commonly used measures of IS effectiveness focus on the products rather than the services of the IS function. Thus, there is a danger that IS researchers will mismeasure IS effectiveness if they do not include in their assessment package a measure of IS service quality*" (p. 173). This is also accepted by many other researchers [41,77,44,21]. The research has empirically shown that the quality of support directly influences the success of the system [21], the total quality of the system [71,40,38,39] and end-user satisfaction [66,73]. In this research, the quality of the support provided to the users is represented by the support offered by the information systems department of the organization (insourcing) as well as the external maintenance company (outsourcing).

Generally, **outsourcing** is the act of one company contracting with another company to provide services that might otherwise be performed by in-house employees (support from external vendors). As far as IT is concerned, the term outsourcing support refers to the supply system of services, functions or procedures from an external provider/partner, who is usually the one who has supplied the software or/and hardware as well. Furthermore, the term outsourcing expands the way these services are offered, since it includes specific terms and processes for securing the quality of the services provided.

Insourcing, on the other hand, is the case when companies look at their pool of employees to find those who may be the most appropriate to perform certain needed jobs. A different form of insourcing does not utilize current employees but instead temporarily hires specialists to work onsite at a company, and occasionally help train other employees. Even though the temporary employee comes from outside the company, the fact that he or she is "brought in" means he can be considered insourced.

DeLone and McLean [21] note that models measuring end-user satisfaction must incorporate variables from all the three main dimensions which define the general success of an informational system (quality of information, system, and support). This opinion is also supported by many other researchers (e.g. [59]) who highlight the existence of a significant statistical relation between the quality of the system and user satisfaction. Pitt et al. [57] also stress the danger of misestimating the effectiveness of a system if some factors that measure the quality of the support provided are not included in the model. In order to investigate the causal relations between the latent variables of system and information quality, insourcing and outsourcing support and the dependent variable (end-user satisfaction), the hypothetical model (Fig. 2) has been transformed. Firstly, the independent variables of content, accuracy, format and timeliness are grouped together in one higher-level variable, namely information quality. Secondly, the variables of ease of use, user documentation, system-processing speed, user training, and user interface are grouped in another higher-level variable, namely system quality. The model that is derived from this transformation process is presented in Fig. 3.

Thus, based on the new hypothetical research model of satisfaction, the following hypotheses will be tested:

H1. Information quality positively affects end-user computing satisfaction.

H2. System quality positively affects end-user computing satisfaction.

H3. System quality has a direct and positive effect on information quality.

H4. Support (insourcing) and support (outsourcing) are positively related.

H5. Support (insourcing) has a direct and positive effect on system quality.

H6. Support (insourcing) positively affects end-user computing satisfaction.

H7. Support (outsourcing) has a direct and positive effect on system quality.

H8. Support (outsourcing) positively affects end-user computing satisfaction.

4. Research method

4.1. Data collection

Initially, based on the literature, items for each construct were developed to test the hypothetical models. All items were measured using a five-point Likert scale. These items were incorporated into a preliminary structured questionnaire which was sent out for review to 30 HIS users and three experts who had practical and academic experience with IS research. This phase was used to refine the items and constructs incorporated in the research and also to clarify the wording, content, and general layout of the survey instrument. The main survey was carried out via personal interviews, involving 341 HIS users from all the main public hospitals in the region of East Macedonia and Thrace. They were identified by the personnel department of each hospital. A structured questionnaire was delivered to all individuals and an appointment was fixed for the interview.

Adopting Turunena and Talmon's [74] taxonomy, this research focuses on the actual users, including (in the sample) members of the medical, nursing and administrative personnel, who interact with HIS on a daily basis in order to insert data or retrieve information. The response rate achieved was rather high (83%), with a total of 283 respondents. The demographic characteristics of the non-respondents were similar to those who participated in this study. Multivariate outliers were found and removed using Mahalanobis distance (see Table 1).

As Table 2 shows, the sample consists of 10.6% medical, 16.6% nursing and 72.8% administrative personnel. This distribution makes the sample a good representation of the population, since IS penetration in the Greek hospitals is mainly with systems that are intended for use by the administration department (personnel). The sample consists mainly of female, middle-aged, moderately educated participants who are well experienced as far as their knowledge of the specific organization and the numbers of years using a computer are concerned. Surprisingly, though, they consider themselves rather as being moderately experienced with using computers, despite the fact that most of them have been using computers for more than 6 years.

4.2. Data analysis method

Data screening was performed to identify data entry errors and to examine whether data met all statistical assumptions. Then a preliminary descriptive analysis was performed in order to extract specific statistics (central tendency and dispersion) for the items included in the questionnaire. Correlation, exploratory and confirmatory factor analysis was also used to check the reliability and validity of the measurement model. Then a two-step data analysis approach using the structural equation modeling was followed, as suggested by Anderson and Gerbing [3], to evaluate the goodness-of-fit of the structural models. SPSS was used to perform descriptive, correlation and factor analysis, while structural equation modeling techniques with Amos 7.0 were used to examine the models and all paths within the models.

4.2.1. Testing the reliability and validity of the measurement model

Content validity ensures that construct questions (items) are representative and drawn from a universal pool [18]. In this research, definitions for all the constructs came from the existing literature, where they had been shown to exhibit strong content validity. However, the items in the research instruments are

Table 1
Definitions and literature support.

Term	Definition	Supporting literature
System speed	The system speed is the time that elapses from the time an activity starts until the results are displayed on the screen or on the printer [67]	Chin and Lee [14]; Chin et al. [15]; Kuhmann [86]; Shneiderman [67]; Rushinek and Rushinek [62]; Shneiderman [93]
Interface	The working environment which is offered to the user for the importing, processing and exporting of the information (Ribiere et al. [90])	Ribiere et al. [90]; Benbunan-Fich [7]; Hassenzahl and Wessler [82]; Chin et al. [15]; Mullins and Treu [89]; Davis and Bostrom [20]; Seddon [92]; Bailey and Pearson [4]; Suh et al. [72]; Mathieson and Keil [88]
Documentation	User documentation consists of written or visual explanations (e.g., manuals, procedures, films, tutorials, online help instructions, operating instructions, etc.) concerning what the application software does, how it works, and how to use it (Torkzadeh and Doll [95]).	Bailey and Pearson [4]; Rushinek and Rushinek [62]; Kekre et al. [84]; Etezadi-Amoli and Farhoomand [26]; Palvia and Palvia [55]; Gemoets and Mahmood [32]; Rushinek and Rushinek [91]; Torkzadeh and Doll [95]; Torkzadeh [96].
Training	User's notion concerning the training provided before and during system's usage	Ang and Soh [80]; Bailey and Pearson [4]; Davis and Davis [81]; Davis and Bostrom [20]; Igbaria and Nachman [83]; Khalil and Elkordy [85]; Lee et al. [87]; Simon et al. [94]
Insourcing support	The quality of the support provided to the end-user concerning the system usage from the staff of the IS department of the organization	Chen et al. [13]; Etezadi and Farhoomand [26]; Venkatesh et al. [97]; Bailey and Pearson [4]; Kettinger and Lee [41]
Outsourcing support	The quality of the support provided to the end-user concerning the system usage from the staff of the external vendor	Etezadi and Farhoomand [26]; Venkatesh et al. [97]; Bailey and Pearson [4]; Palvia and Palvia [55]; Grover et al. [34]; Jiang et al. [37]; Kekre et al. [84]

translated and used for the first time in Greece; thus, they may not have the desired psychometric properties. This, in turn, may affect the validity and reliability of the scales adversely. Therefore, the scales need to be refined and inappropriate items need to be removed [16]. Firstly, the criterion-related validity is assessed using the correlation (spearman) between the item scores and the corrected mean of the construct the items belong to, and the mean of the two global items (items were retained if the significance level of correlation was greater than 0.05).

Secondly, construct validity was assessed by performing a principle components factor analysis (PCA), as recommended by Straub [70]. A construct is considered to exhibit satisfactory validity when items load highly on their related factor and have low loadings on unrelated factors. As a rule of thumb, a measurement item loads highly if its loading coefficient is above 0.6 and does not load highly if the coefficient is below 0.4 [28]. Next, confirmatory factor analysis was performed on each used construct, taking into consideration that items that include the factor loadings and covariance amongst the errors are added sequentially, based on the Modification Index, to maximize model fit [10].

Construct reliability was assessed using Cronbach's α-value. In order to test the convergent validity of the measurement models, the methodology suggested by Fornell and Larcker [27], which includes the estimation of the items squared factor loadings (those greater than 0.5 are considered very significant), the composite reliability for each construct (has to exceed the threshold of 0.70), and the extracted variance for all constructs (greater than 0.50), has been followed.

Table 2
Respondents' demographic characteristics.

		Frequency (persons)	Frequency (%)
Gender	Male	97	34.3
	Female	186	65.7
Age	20–30	18	6.4
	31–35	40	14.1
	36–40	70	24.7
	41–50	129	45.6
	>50	26	9.2
Educational background	High school or below	158	55.8
	University graduates	108	38.2
	Post graduate degrees	17	6.0
Personnel	Medical	30	10.6
	Nurses	47	16.6
	Administrative	206	72.8
Years of employment	<15 (new employees)	115	40.6
	⩾15 (experienced employees)	168	59.4
Experience with computers	More than 6 years	127	44.9
	Between 4 and 6	71	25.1
	Between 1 and 3	85	30.0
Perceived experience	Low	55	19.4
	Mediocre	138	48.8
	High	90	31.8

Finally, discriminant validity was tested performing confirmatory factor analysis runs on pairs of scales (examining the relationship, covariance, between the constructs). Fornell and Larcker [27] advocate that the correlations between items in any two constructs should be lower than the square root of the average variance shared by items within a construct.

4.2.2. Model fitness

When the requirements of reliability and validity in the measurement model are met, the next step is to evaluate the goodness-of-fit of the structural model. In the analysis, multiple items were summed together for each construct. These sums were then divided by the number of the items included (i.e., the mean score of items comprising the corresponding construct), and an index number was created. According to Grapentine [33], summated scales have the following two benefits: "First, they help manage multicollinearity's effects on the estimation of regression coefficients and second, they help focus attention on more fundamental dimensions, of which the individual attributes are indicators" [33].

Six common model-fit measures were used to assess the model's overall goodness-of-fit: the ratio of x^2 to degrees-of-freedom (d.f.), the comparative fit index (CFI), the goodness-of-fit index (GFI), the normalized fit index (NFI), the root mean square residual (RMR), and the root mean square error of approximation (RMSEA). Generally, fit is obtained when x^2/d.f. is lower than 3, the CFI, GFI and NFI are higher than 0.90, RMR is lower than 0.05 and the RMSEA is lower than 0.006 [28].

5. Results

5.1. Measurement analysis

Following the criteria set by the adopted methodology (correlation, explanatory and confirmatory factor analysis), 19 items were dropped from the original 68 items from various constructs of the models. All constructs successfully passed the construct validity test. More specifically, it is found that all factor loadings exceed the 0.6 threshold on their own constructs and, at the same time, have low loadings (<0.30) on unrelated factors (Appendix A). Furthermore, the criterion-related validity is also verified since all correlations between the item scores and the corrected mean of the construct the items belong to and the mean of the two global items are significant.

Moreover, Cronbach's α values range from 0.87 (for outsourcing support) to 0.94 (for Interface). Nunnally and Bernstein [54] recommend that the Cronbach's α should be greater than 0.7 for items to be used together as a construct. Furthermore, convergent validity of the model is also confirmed since SFLs exceed the 0.50 threshold for all constructs, while composite reliability (CR) and average variance extracted (AVE) for all constructs exceed the 0.70 and 0.50 threshold, respectively (Appendix B).

Discriminant validity is also confirmed by the findings since the correlation between factors is not so high (e.g., >0.85) as to lead to the conclusion that any combination of two factors overlap conceptually. Furthermore, the square root of the variance shared between a construct and its items is greater than the correlations between the construct and any other construct in the model, satisfying Fornell and Larcker's [27] criteria for discriminant validity (Appendix C). The above results therefore confirm that our measurement models encompass satisfactory content, construct, convergent and discriminant validity as well as construct reliability.

Finally, the results of descriptive statistics (Table 3) show that all constructs have mean scores higher than 3, showing that participants have a positive perception toward these constructs. But the low constructs means indicate that end-users considered their information system as marginally accurate. Training, outsourcing support, documentation, system speed and insourcing support received the lowest ratings by the end-users in our sample, which was not surprising, given that hospital information systems are profoundly complex pieces of software that require large investments of money, time, and expertise.

Table 3
Descriptive statistics of the constructs.

Construct	Mean	Std. dev.	Correlation with overall satisfaction
Ease of use	3.815	0.797	0.687
Training	3.047	0.765	0.698
Content	3.561	0.667	0.741
Accuracy	3.781	0.725	0.768
Format	3.662	0.623	0.756
Timeliness	3.707	0.746	0.798
Speed	3.540	0.789	0.717
Documentation	3.211	0.599	0.625
Interface	3.736	0.786	0.765
Insourcing support	3.511	0.649	0.783
Outsourcing support	3.111	0.621	0.715

5.2. Structural equation model and hypothesis testing

Table 4 shows the results of the three measurement models. The chi-square value for all models is significant, which could indicate poor model fit. This is because a significant chi-square value indicates that the observed covariance matrix and the estimated covariance matrix given by the model differ significantly. Therefore, a non-significant chi-square value would indicate that our model predicts the observed covariance matrix of the data very well and thus it has good fit. However, this statistic is very sensitive to sample size and it is often significant even for models with good fit [42]. The other fit indices for all three measurement models exceed the recommended threshold levels: X^2/Df < 3, GFI, NFI, CFI > 0.90; RMR < 0.05 [48,42,31].

The only exception is the root mean square of approximation (RMSEA) for the first model, which should be lower than 0.08 for good fit [12]. Since the rest of the indices are well above their threshold levels and the RMSEA is at its threshold level, we find the models to have a reasonably good fit.

Table 4
Overall model fit indices of the research models.

Models	X^2	Df	*P*-value	X^2/Df	CFI	GFI	NFI	RMR	RMSEA
Recommended values	N/A	N/A	>0.05	<3	>0.90	>0.90	>0.90	<0.05	<0.08
EUCS	185.81	50	0.000	3.72	0.981	0.929	0.940	0.035	0.096
Enriched EUCS	22.32	9	0.000	2.45	0.986	0.965	0.977	0.012	0.085
Extensive EUCS	109.67	54	0.000	2.03	0.973	0.915	0.948	0.016	0.071
New proposed model	89.15	49	0.000	1.82	0.980	0.928	0.958	0.015	0.064

Table 5
Standardized parameter estimates and *t*-values (indicates a parameter fixed at 1.0 in original solution and *t*-values for item factor loadings are indicated in parentheses).

Items	Doll et al. EUCS		Enriched EUCS		Extensive EUCS	
	Standard structure coefficient	*R* square reliability (%)	Standard structure coefficient	*R* square reliability (%)	Standard structure coefficient	*R* square reliability (%)
Content	0.912 (17.67)	68	0.808 (13.76)	65	0.794 (13.53)	63
Accuracy	0.822 (16.04)	73	0.819 (14.03)	67	0.797 (13.62)	64
Format	0.993 (18.19)	53	0.789 (13.33)	62	0.792 (13.50)	63
Timelines	0.719 (13.09)	68	0.840 (14.64)	71	0.821 (14.25)	67
Ease of use	0.883 (13.78)	76	0.743 (12.22)	55	0.744 (12.33)	55
Speed					0.774 (13.03)	60
Documentation					0.726 (11.93)	53
Interface					0.808 (13.90)	65
Training					0.765 (12.84)	59
Insourcing support					0.825 (14.36)	68
Outsourcing support					0.757 (12.65)	57

5.3. Hypothesis testing

The enriched and the extensive EUCS are able to account for 91% and 94% respectively of the variance of the overall end-user computing satisfaction (Appendices D and E). The standard structural coefficients indicate the validity of the latent constructs with values ranging from 0.743 to 0.840 for the enriched EUCS, and from 0.726 to 0.825 for the extensive EUCS. Additionally, the *t*-values are all significant and the *R*-square values range from 55% to 71% for enriched EUCS, and from 53% to 68% for extensive EUCS, indicating acceptable reliability for all factors (Table 5).

In the third model, all the independent variables cumulatively explained 93% of the variance of the dependent variable *Overall End-user Satisfaction* (Fig. 4). The two derived factors, *System Quality* and *Information Quality*, are statistically significant and have a positive relationship with the *Overall End-user Satisfaction*. However, in contrast to the initial hypothesis, *Insourcing* and *Outsourcing Support* do not have a significant direct effect on the end-user computing satisfaction. On the other hand, it is found that both of them significantly affect (positively) *System Quality*, with path coefficients of 0.57 and 0.44 and *p*-values less than 0.001 respectively. This result indicates that, for the IS support department, building a good relationship with end-users is the most important determinant in achieving high system quality and, consequently, high end-user computing satisfaction. At the same time, system quality has a significant direct effect on information quality.

Additionally, standard structural coefficients indicate the validity of the latent constructs, with values ranging from 0.80 to 0.84 for *Information Quality*, and from 0.74 to 0.81 for *System Quality*. Additionally, the *t*-values are all significant and the *R*-square values range from 63% to 70% for information quality, and from 54% to 66% for system quality, indicating acceptable reliability for all factors (Fig. 4).

Concluding, the results of Table 6 (overall model fit) are consistent with the results of other similar researches and support the view that EUCS models are both valid and reliable in measuring end-user satisfaction from using IT systems. Content, accuracy, format and timeliness are found to play a significant role not only in determining end-user satisfaction [23–25,46,47,69,70,78] but also in the quality of the information provided. User interface, system processing speed, training and documentation are also some more significant factors for determining end-user satisfaction and system quality, as has also been found by other researchers [13,15,26,32,43,53,55,62–64].

As far as the users' support factors are concerned (insourcing, outsourcing), they are found to be statistically significant for the formulation of end-user satisfaction, as is also suggested by other researchers [21,22,34,35,57,76]. However, the results from the

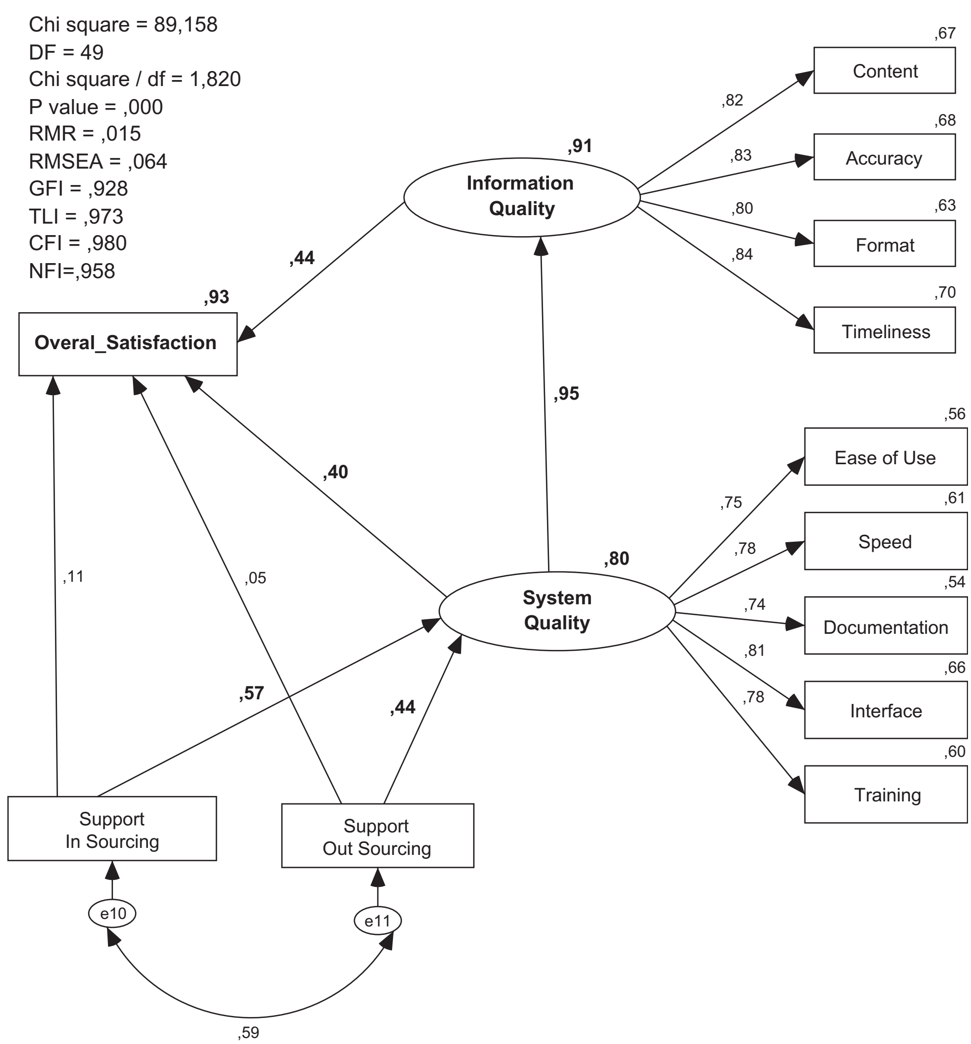


Fig. 4. Confirmatory factor analysis of a new EUCS model.

Table 6
Direct, indirect and total effect of factors.

		Information quality	System quality	Overall satisfaction
Insourcing support	D		0.584	
	I	0.553		0.561
	T	0.553	0.584	0.561
Outsourcing support	D		0.432	
	I	0.409		0.415
	T	0.409	0.432	0.415
Information quality	D		0.947	0.358
	I			
	T		0.947	0.358
System quality	D			0.622
	I			0.339
	T			0.961

new suggested model indicate that they do not directly affect end-user satisfaction, in contrast to the suggestions of Shaw et al. and Susarla et al. [66,73]. Their effect is indirect, through their statistically significant relationship with system quality, something that is also supported by previous findings [38–40,71]. Supporting DeLone and McLean's [21,22] general model, it emerges that system quality is the most important factor for explaining and, thus, predicting the variance of end-user satisfaction. Actually, it has both the highest direct and total impact on satisfaction. Additionally, system quality significantly and positively affects, to a large extent, the variance of the quality of the information provided from the system to its users.

Further, according to path coefficients and their statistical significance, shown in Table 7, all the proposed hypotheses are supported except H6 and H8 about the direct effect of insourcing and outsourcing support on the end-user computing satisfaction. However, it must be stressed that H6 is marginally rejected, since the *p* value is .061.

Table 7
Path coefficients and their statistical significance.

Constructs		Constructs	Loadings	*t*-Value	*p*-Value
Ease of use	←	System quality	0.749	11.032	0.000
System speed	←	System quality	0.774	11.47	0.000
Documentation	←	System quality	0.735	10.996	0.000
Interface	←	System quality	0.813	12.319	0.000
Training	←	System quality	0.777	11.703	0.000
Content	←	Information quality	0.817	5.844	0.000
Accuracy	←	Information quality	0.825	5.818	0.000
Format	←	Information quality	0.795	6.011	0.000
Timeliness	←	Information quality	0.836	5.956	0.000
System quality	←	Insourcing support	0.560	10.413	0.000
System quality	←	Outsourcing support	0.448	8.498	0.000
Information quality	←	System quality	0.952	5.027	0.000
Overall satisfaction	←	Information quality	0.378	2.035	0.042
Overall satisfaction	←	System quality	0.523	4.423	0.000
Overall satisfaction	←	Insourcing support	0.091	1.872	0.061
Overall satisfaction	←	Outsourcing support	0.051	1.09	0.276

6. Conclusions

This study was conducted to empirically investigate issues that might be related to the key determinants of EUCS, to extend the generalizability of the EUCS instrument by assessing the psychometric properties of a Greek translation of the EUCS survey and, finally, to provide additional insights into end-user satisfaction by considering additional factors that may be determinants of EUCS.

An assessment of the survey instrument's reliability using coefficient alpha, composite reliability and variance extracted supports the conclusion that the second-order EUCS construct and each of its first-order sub-factors are reliable. An assessment of t-tests on indicant loadings supports the conclusion that EUCS sub-factors exhibit convergent validity and construct reliability. An assessment of chi-square difference tests among construct sub-factors supports the conclusion that the EUCS sub-factors exhibit discriminant validity. An assessment of the fit indices supports the conclusion that the proposed EUCS models provide a good fit to the Greek data. And, finally, the significant loadings of the sub-factors on the EUCS variable provide support for a model with second-order model construct (EUCS).

The findings indicate that the new EUCS model proposed is a valid and reliable instrument that can be used confidently by researchers in Greece and elsewhere. These results enable the generalizability of the EUCS instrument and enhance its robustness as a valid measure of computing satisfaction and a surrogate for system success in a variety of cultural and linguistic settings.

6.1. Discussion

A better understanding of the factors that can influence user satisfaction needs to be developed in order for HIS applications to be used effectively. This study advances previous research by using three variations of the EUCS instrument to evaluate end-user satisfaction with HIS and examine validation issues related to the instruments. It represents the first comprehensive examination of EUCS instruments in Greece using multiple informant responses from end-users of various HIS applications. Consistent with findings from several previous studies, the EUCS has been shown to be a valid predictor of user satisfaction with information systems. Although the psychometric properties of EUCS appear to be robust across studies, continuing efforts should be made to validate and extend the instrument.

6.2. Implications

Researchers have suggested that the EUCS instrument (and others) must be tested prior to application in new areas. Our study shows that the EUCS instrument may be used to evaluate hospital information systems. The instrument provides not only an overall assessment of end-user satisfaction but also the capability to identify the most problematic aspects of HIS implementation efforts. The magnitude of path coefficients provides useful insights into the relative importance of each subscale of the EUCS models and, thus, the major areas of satisfaction or dissatisfaction with the use of a given hospital information system. Managers could focus on these factors as significant contributors to overall satisfaction to improve HIS system effectiveness. Similar to other studies, in the first model examined (enriched EUCS), timeliness, accuracy and format have the highest loadings, indicating that these three factors play a critical role in EUCS. The lowest loadings in this model were for ease of use. In the second model under examination (extensive EUCS), timeliness, insourcing support, interface, accuracy content and format have the highest loadings, indicating that these five play a critical role in EUCS. The lowest loadings in this model were for documentation, ease of use, and outsourcing support. Finally, in the third model, system quality directly and indirectly contributes significantly to the observed explanatory power of end-user computing satisfaction (H2), thus implying that an increase in the quality of the system leads to an increase in EUCS. System quality incorporates system ease of use, speed, documentation, user interface and training. Thus, a net positive effect from these factors will result in a positive effect on EUCS. Further, information quality directly and positively affects EUCS (H1), thus indicating that an increase in the quality of the information leads to an increase in decision-making satisfaction. Content, accuracy, format and timeliness are used as measures of the information quality construct. Thus, a net positive effect from these factors will result in a positive effect on EUCS.

To learn how to use a fully integrated HIS system is not an easy task, and ease-of-use problems are gaining greater attention as more vendors broaden their reach to occasional users. Our results imply the need for HIS vendors to reduce the complexity of their software and make their outsourcing support and user interfaces easier to customize. The results also underline the need to design highly effective user documentation and provide additional and continuing training to end-users. Creating a supportive environment responsive to end-user concerns and needs, and working collaboratively with end-users in utilizing new software applications, can yield long-term benefits and increase the system's use and effectiveness. Technical difficulties, such as bugs in the software, problems interfacing with existing systems, system speed and hardware difficulties, can lead to increased user frustration and lower user satisfaction. End-user computing satisfaction may be used to signal to management such mismatches and difficulties.

Finally, this study has several limitations. Firstly, its sample size is rather small, since only a particular subject group, the hospital personnel of East Macedonia and Thrace who interact directly with the information system, was targeted. Secondly, the main emphasis was on the information system used by hospital administration personnel. Thirdly, the proportion of administrative and medical personnel in this sample was atypical, reflecting the actual degree of information system penetration to different sections (departments) of Greek hospitals. Thus, caution needs to be taken when generalizing the findings to other technologies and professional groups.

Despite the limitations, the major contribution of this study lies in the area of measurement by rigorously validating three different end-user computing satisfaction models and thus enabling researchers to use the EUCS instruments with increased confidence. With a validated instrument, further research can be conducted into relationships among the antecedents and consequences of end-user satisfaction, particularly in the area of HIS and other technological innovation.

Appendix A

Content validity (PCA with varimax rotation on the remaining 49 items. Factor loadings should exceeded 0.6 on their own constructs and have low loadings (<0.35) on unrelated factors: Hair et al. [28]).

KMO	Bartlett's test of sphericity					Total variance explained					
0.957	9110.74 (Sig. 0.000)					78.87%					
Items	Constructs										
	1	2	3	4	5	6	7	8	9	10	11
a.1.2 Content											0.599
a.1.3 Content											0.735
a.1.4 Content											0.639
a.1.5 Content											0.601
a.2.2 Accuracy							0.656				
a.2.3 Accuracy							0.715				
a.2.4 Accuracy							0.695				
a.2.5 Accuracy							0.703				
a.3.1 Format										0.660	
a.3.2 Format										0.618	
a.3.3 Format										0.774	
a.3.5 Format										0.658	
a.4.2 Timeliness									0.614		
a.4.3 Timeliness									0.641		
a.4.4 Timeliness									0.676		
a.4.6 Timeliness									0.739		
b.1.1 Ease of use		0.626									
b.1.2 Ease of use		0.840									
b.1.4 Ease of use		0.673									
b.1.5 Ease of use		0.758									
b.1.6 Ease of use		0.760									
b.2.1 Speed						0.751					
b.2.2 Speed						0.805					
b.2.3 Speed						0.694					

Appendix A (*continued*)

KMO 0.957 Items	Bartlett's test of sphericity 9110.74 (Sig. 0.000) Constructs					Total variance explained 78.87%					
	1	2	3	4	5	6	7	8	9	10	11
b.2.4 Speed						0.624					
b.3.1 Documentation			0.676								
b.3.3 Documentation			0.699								
b.3.4 Documentation			0.736								
b.3.5 Documentation			0.717								
b.3.6 Documentation			0.682								
b.4.1 Interface	0.737										
b.4.2 Interface	0.761										
b.4.4 Interface	0.728										
b.4.6 Interface	0.738										
b.4.7 Interface	0.664										
g.1.1 Insourcing support				0.662							
g.1.2 Insourcing support				0.676							
g.1.3 Insourcing support				0.694							
g.1.4 Insourcing support				0.688							
g.1.6 Insourcing support				0.691							
g.2.1 Outsourcing support					0.617						
g.2.3 Outsourcing support					0.750						
g.2.4 Outsourcing support					0.655						
g.2.5 Outsourcing support					0.687						
g.2.6 Outsourcing support					0.664						
g.4.1 Training								0.632			
g.4.3 Training								0.764			
g.4.4 Training								0.767			
g.4.5 Training								0.729			

Appendix B

Convergent validity – construct reliability (squared factor loadings (SFL's) for each construct, composite reliability (CR), average variance extracted (AVE), and Cronbach's *a*-value of each construct should be greater than 0.5, 0.7, 0.5 and 0.7 respectively: Fornell and Larcker [27]; Nunnally and Bernstein [54]).

Items	Constructs	Enriched EUCS				Extensive EUCS				New EUCS			
		SFL's	CR	AVW (%)	Cronbach's a	SFL's	CR	AVW (%)	Cronbach's a	SFL's	CR	AVW (%)	Cronbach's a
A.1.2	Content	0.62	0.88	65	0.88	0.61	0.88	65	0.88	0.61	0.88	65	0.88
A.1.3		0.61				0.63				0.63			
A.1.4		0.66				0.66				0.65			
A.1.5		0.70				0.69				0.69			
A.2.2	Accuracy	0.78	0.92	74	0.91	0.78	0.92	74	0.91	0.78	0.92	74	0.91
A.2.3		0.81				0.81				0.81			
A.2.4		0.69				0.69				0.69			
A.2.5		0.68				0.68				0.68			
A.3.1	Format	0.56	0.90	69	0.89	0.55	0.90	69	0.89	0.56	0.90	69	0.89
A.3.2		0.70				0.70				0.70			
A.3.3		0.81				0.80				0.80			
A.3.5		0.69				0.69				0.69			
A.4.2	Timeliness	0.75	0.92	73	0.91	0.76	0.92	73	0.91	0.76	0.92	73	0.91
A.4.3		0.71				0.71				0.72			
A4.4		0.80				0.79				0.79			

(*continued on next page*)

Appendix B (*continued*)

Items	Constructs	Enriched EUCS				Extensive EUCS				New EUCS			
		SFL's	CR	AVW (%)	Cronbach's a	SFL's	CR	AVW (%)	Cronbach's a	SFL's	CR	AVW (%)	Cronbach's a
A.4.6		0.67				0.67				0.66			
B.1.1	Ease of use	0.69	0.92	69	0.91	0.70	0.92	69	0.91	0.70	0.92	69	0.91
B.1.2		0.70				0.69				0.69			
B.1.4		0.74				0.74				0.74			
B.1.5		0.68				0.68				0.68			
B.1.6		0.66				0.66				0.66			
B.2.1	Speed					0.84	0.94	78	0.93	0.84	0.93	78	0.93
B.2.2						0.81				0.81			
B.2.3						0.75				0.75			
B.2.4						0.72				0.72			
B.3.1	Documentation					0.61	0.90	63	0.89	0.61	0.90	63	0.89
B.3.3						0.65				0.64			
B.3.4						0.66				0.66			
B.3.5						0.67				0.68			
B.3.6						0.57				0.57			
B.4.1	Interface					0.79	0.95	79	0.94	0.79	0.95	79	0.94
B.4.2						0.82				0.83			
B.4.4						0.85				0.84			
B.4.6						0.74				0.74			
B.4.7						0.73				0.74			
G.3.1	Training					0.74	0.93	77	0.93	0.74	0.93	77	0.93
G.3.3						0.83				0.83			
G.3.4						0.74				0.74			
G.3.5						0.80				0.80			
G.1.1	Insourcing support					0.60	0.88	60	0.91	0.61	0.88	60	0.91
G.1.2						0.56				0.57			
G.1.3						0.57				0.56			
G.1.4						0.66				0.66			
G.1.6						0.57				0.57			
G.2.1	Outsourcing support					0.72	0.92	60	0.87	0.72	0.92	60	0.87
G.2.3						0.73				0.72			
G.2.4						0.67				0.67			
G.2.5						0.69				0.69			
G.2.6						0.62				0.63			

Appendix C

Discriminant validity (diagonal elements in bold (the square root of AVE) should exceed the inter-construct correlations below and across them for adequate discriminant validity: Fornell and Larcker [27]).

Enriched EUCS

	Ease of use	Timeliness	Format	Accuracy	Content
Ease of use	**0.831**				
Timeliness	0.654	**0.854**			
Format	0.589	0.683	**0.830**		
Accuracy	0.664	0.771	0.694	**0.860**	
Content	0.666	0.772	0.695	0.785	**0.806**

Extensive EUCS

Appendix C (*continued*)

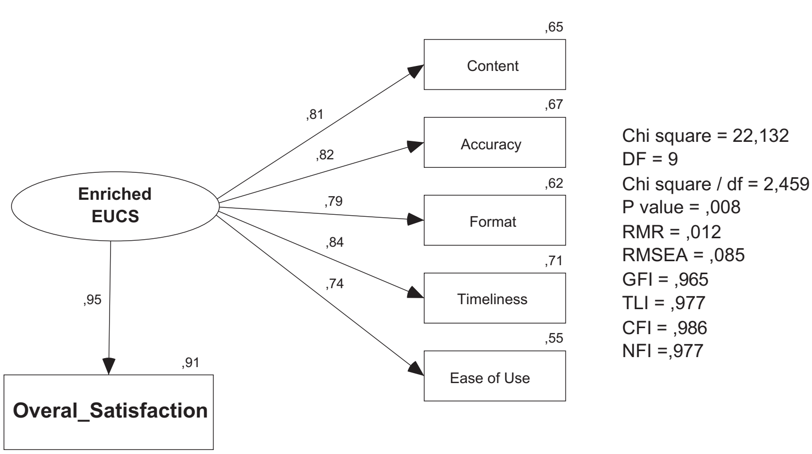
	Training	Support out sourcing	Support in sourcing	Interface	Documentation	Ease of use	Speed	Timeliness	Format	Accuracy	Content
Training	**0.877**										
Outsourcing support	0.658	**0.775**									
Insourcing support	0.629	0.677	**0.775**								
Interface	0.645	0.694	0.663	**0.888**							
Document.	0.611	0.657	0.628	0.644	**0.793**						
Ease of use	0.612	0.658	0.629	0.645	0.611	**0.830**					
Speed	0.625	0.672	0.643	0.659	0.624	0.625	**0.883**				
Timeliness	0.666	0.717	0.685	0.702	0.665	0.666	0.681	**0.854**			
Format	0.641	0.690	0.659	0.676	0.640	0.641	0.655	0.698	**0.830**		
Accuracy	0.657	0.707	0.675	0.692	0.656	0.657	0.671	0.715	0.689	**0.860**	
Content	0.670	0.721	0.689	0.706	0.669	0.670	0.685	0.730	0.702	0.720	**0.806**

New EUCS

	Support out sourcing	Support in sourcing	Training	Interface	Documentation	Ease of use	Speed	Timeliness	Format	Accuracy	Content
Outsourcing support	**0.774**										
Insourcing support	0.699	**0.774**									
Training	0.519	0.420	**0.877**								
Interface	0.547	0.442	0.587	**0.888**							
Documentation	0.502	0.406	0.539	0.567	**0.794**						
Ease of use	0.512	0.414	0.549	0.578	0.531	**0.830**					
Speed	0.512	0.414	0.550	0.579	0.531	0.542	**0.883**				
Timeliness	0.548	0.443	0.588	0.619	0.568	0.579	0.580	**0.854**			
Format	0.503	0.407	0.540	0.569	0.522	0.532	0.533	0.653	**0.830**		
Accuracy	0.534	0.431	0.573	0.603	0.554	0.565	0.565	0.693	0.637	**0.860**	
Content	0.543	0.439	0.583	0.614	0.563	0.575	0.575	0.705	0.648	0.687	**0.806**

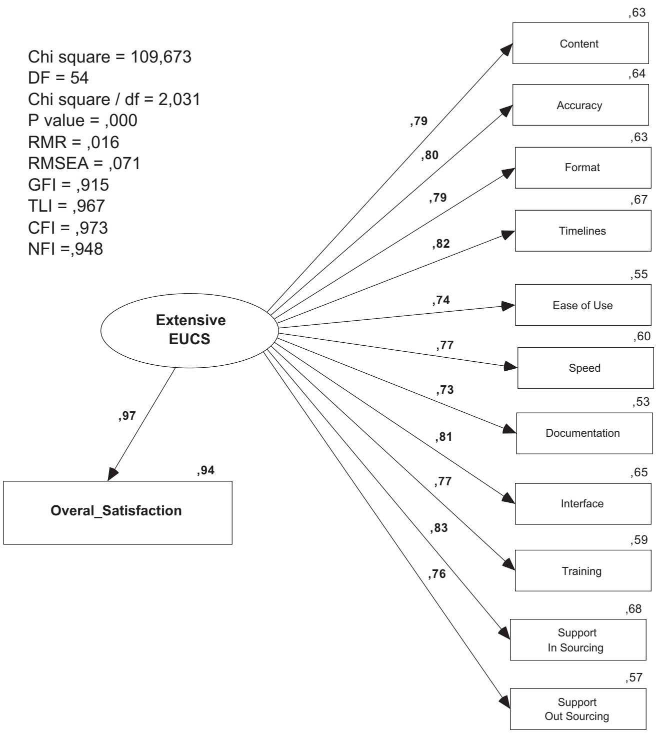
Appendix D

Confirmatory factor analysis of the enriched EUCS model.



Appendix E

Confirmatory factor analysis of the extensive EUCS model.



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