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From the Editor

Dear readers,

Journal of Information and Organizational Sciences again brings high-quality scientific papers from the wide scope of topics of information sciences and management, whose authors are from different countries around the world.

This issue brings fourteen papers – twelve original scientific papers, one preliminary communication, and one survey paper. Authors come from Africa, Asia, and Europe.

All this diversity makes, in my opinion, the issue interesting to a wide scope of readers, too. Therefore, I hope that our readers will find interesting ideas and scientific results, and help them in their own research.

Alen Lovrenčić

Editor

Early Cocoa Blackpod Pathogen Prediction with Machine Learning Ensemble Algorithm based on Climatic Parameters

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Abstract

Machine learning has been useful for prediction in the various sectors of the economy. The research work proposed an ensemble SA-CCT machine learning algorithm that gives early and accurate prediction of blackpod disease to farmers and agricultural extension officers in South-West, Nigeria. Since data mining put into consideration the types of pattern in a given dataset, the study considered the pattern in climatic dataset retrieved from Nigeria Meteorological agency (NIMET). The proposed model uses climatic parameters (Rainfall and Temperature) to predict the outbreak of blackpod disease. The ensemble SA-CCT model was formulated by hybridizing a linear algorithm Seasonal Auto Regressive Integrated Moving Average (SARIMA) and a nonlinear algorithm Compact Classification Tree (CCT), the implementation was done with python programming. The proposed SA-CCT model gives the following results after evaluation. Precision: 0.9429, Recall 0.9167, Mean Square Error: 0.2357, Accuracy: 0.9444

Keywords: Blackpod Disease, Machine Learning, Data Mining, SA-CCT Model; SARIMA; CCT

1. Introduction

Data mining is a technique which makes use of patterns and knowledge in a given dataset. The information that is extracted from the dataset helps to improve existing research, and thus leading to productivity. Various fields such as education, health-care, engineering, agriculture and market analysis has found the application of data mining relevant [1]. Virtually, all sectors in Nigeria rely on information and communication technologies for an optimum productivity; this is because complex problem can be tackled with the aid of a computer. [2] pinpoints that the greatest problem of farmers across the globe is infestation of crops with disease and pest and how to protect their crop that is not far-fetched because of lack of specialized tools that will help in predicting when the conditions for the outbreak of the diseases is near. [3] stated in their work that there are two major requirements that must be fulfill during prediction of plant diseases, and these requirement includes accuracy and fastness. Cocoa has been a major economic crop and served as a major source of income for Nigeria over the decades and has drastically reduced because of low production that is caused by the incidence of diseases on the crop and farmers not

willing to produce cocoa because of the outbreak of blackpod disease. Blackpod is the deadliest and destructive disease of cocoa globally, this disease affects every aspect of cocoa plant. And all the parts that are affected includes the pods, stems and roots, leaves and flower cushion. A great number of cocoa pods have been lost to diseases across the globe due to the unavailability of timely reports of outbreaks, epidemics in developing regions like West Africa is still a serious challenge [4]. Also, in the time past, number of algorithms have been developed and implemented to extract information and knowledge patterns which are used for prediction of diseases from a time series dataset but they are unable to accurately make the prediction correctly [5]. Therefore, there is a need to improve on the prediction model and also develop an ensemble system that gives timely report. Maina [6] proposed a vision-based model that was developed to classify plant diseases, the use of such models is applicable in situations where the crop has fully matured and its phenotypic characteristics are visible; hence such models may not be feasible for early detection and accurate determination of crop diseases. This is because a disease at advanced stage would have spread more than such models could capture. Therefore, there is indeed the need to utilize information technology in providing a model for early and accurate detection of crop diseases. It has been proven using both theoretical and empirical findings that when models are combined, there is an improvement in the performance of the hybridized model compared to the individual model(s). The performance of the hybridized model increases when the ensemble model are of different types. Decision support system for farmers will reduce the incidence of disease and improve food production [7], [8]. [9] presented C4.5 algorithm in machine learning for prediction of crop yield in Indian, the authors used climatic parameters in the proposed research work. [10] gave a new perspective on plant disease by using deep learning. This research work proposed an ensemble model that decompose a time series data into its respective linear and non-linear component. Research has it that Seasonal Auto Regressive Integrated Moving Average (SARIMA) is a good statistical model that is good for predicting the linear component of a dataset while Compact Classification Tree (CCT) is also good for predicting the non-linear component of the dataset. The hybridized predictive was formulated using SARIMA and CCT to form SA-CCT model.

2. Literature Review

[11] uses Convolutional Neural Network (CNN) in modelling the response to crop management. The author(s) compares the proposed structure with regression linear model, random forest and support vector machine using the same set of dataset but the proposed model gave a better accuracy than the other models. [12] compares the performance of three machine learning algorithms along with multiple regression for predicting the risk in *stagonaspora nodorum* in wheat. After evaluation, it was indicated that random forest gave an accuracy of 93%. [13] compared different mathematics-based techniques for data processing and prediction of possible fruit disease infection. Six significant weather variables and one variable representing the month in the year are selected as predictor variables. Prediction includes two most

important diseases of cherry fruit: *monilinia laxa* and *coccoomyces hiemalis*. Authors failed to implement the predictive model to give farmers notification of diseases through mobile or internet network. Various researchers have conducted research between a linear model and non-linear model to see their performance on the same dataset. According to [14] in their research work, answered the question that at what condition does a non-linear model outperformed a linear model. They provided an answer by saying maybe the dataset is non-linear without much disturbance, therefore cannot expect linear model to outperform the non-linear model [15]. When a non-linear model is used to model a linear problems, a mixed results is obtained and hence, it is wise to develop a hybridized model for a time series dataset. The concept behind hybridization is to use the component of each model uniquely to capture what they are good at. Since both findings of empirical and theoretical suggest hybridization of model, most especially when the models are different in nature in order to improve the performance of the hybridized model [16]. In addition, knowing the characteristics of real world dataset is difficult, hence, hybridization of model that has both linear and non-linear capabilities would be a very good approach for forecasting. There has been an increment in the literature of hybridizing model since the work of [17]. This was further supported by [18] where they hybridized Radial Basis Function (RBF) and ARIMA models. [19] conducted a research work by hybridizing a rule based system and neural network for making prediction on the price of changes in stock index futures. [20] in their work hybridized ARIMA model with SVM for forecasting stock prices. Also, [21] did a research where they integrated SARIMA with SVM for making prediction. Furthermore, using a hybridization technique that breaks a time series data into its respective linear and non-linear component has been on the increase in literature which they also have shown better result than a single model. The linear SARIMA is used jointly with non-linear CCT to form SA-CCT to detect the relationship that exist in the dataset. There are three cogent reasons why the models used for prediction are hybridized. Firstly, it is extremely cumbersome to pinpoint whether the time series data is generated from non-linear or linear underlying process. With this, it is difficult to determine which model will be suitable hence, the concept of hybridizing the model for better prediction. Secondly, real world dataset is purely a linear and non-linear that is, they have both linear and non-linear pattern respectively. Neither SARIMA nor CCT will be adequate for modelling of the process. Hence, this problem can be solve by hybridizing the two technique. Lastly, it has being agreed from literature that hybridization perform well than a single model when it comes to prediction [16]. Prediction of plant diseases can be performed based on weather data by using the appropriate machine learning technique [22]. [23] concluded in their research that there will be estimated increase of 20% of cocoa diseases which will cost lost in the total worldwide production of cocoa production. There is a correlation between some of the cocoa diseases and weather condition. The next section discusses data visualization, creation of the SA-CCT model and the comparison of the proposed model with SARIMA and CCT.

3. Methodology

This section discusses the proposed model building and simulation. Dataset used for model training and implementation were collected from Nigeria Meteorological agency (NIMET) which covers five major cocoa producing states in South-West Nigeria. After data collection, the dataset were visualized with Principal Component Analysis (PCA). Models creation was based on climatic variables which determines the blackpod disease. After visualization, three different models were trained and evaluated. The models include SARIMA, CCT and an ensemble of SARIMA and CCT to form SA-CCT. Figure 1 below depicts the proposed model. Implementation of the work was done with python programming language.

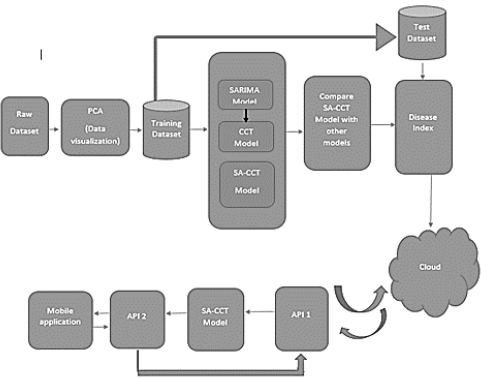


Figure 1. Proposed Model

3.1. Dataset

Dataset used for this research work was retrieved from Nigeria Metrological Agency (NIMET). The dataset covers five cocoa producing states (Osun State, Ogun State, Ekiti State, Oyo State and Ondo State) in South-West, Nigeria. Also, the dataset covers thirty year, from 1988 – 2018.

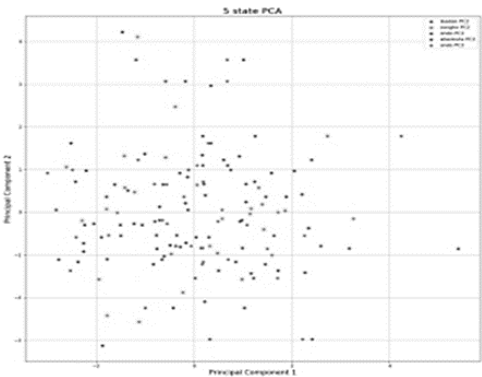


Figure 2. PCA for five states

Two major features were considered from the dataset which include temperature and rainfall. Data preprocessing and visualization was followed which was done with PCA. The dataset was put into the subspace for dimensionality reduction with the PCA using 2D plot diagram. Figure 2 below shows the plot diagram for the five states. The dataset was divided into training dataset and testing dataset which was used to test the accuracy of the three models.

3.2. SARIMA Model

SARIMA (p d, q, P, D, Q)_s has two parts; Non-seasonal part (p, d, q) and seasonal parts (P, D, Q)_s

Where:

1. p: order of non-seasonal AR terms
2. d: order of non-seasonal differencing
3. q: order of non-seasonal MA terms
4. P: order of seasonal AR
5. D: order of seasonal differencing
6. Q: order of seasonal MA terms

SARIMA Process

SARIMA (p, d, q, P, D, Q)_s has the form

$$\phi_p(B^s)\phi_p(B)(1-B^s)^D(1-B)^dX_t = \theta_q(B^s)\theta_q(B)Z_t \quad (1)$$

Below is the polynomial form of Equation 1

$$\theta_q(B) = 1 + \theta_1B + \dots + \theta_qB^q \quad (2)$$

$$\theta_q(B^s) = 1 + \theta_1B^s + \theta_2B^{2s} + \dots \theta_qB^{qs} \quad (3)$$

$$\phi_p(B) = 1 - \phi_1B - \phi_2B^2 - \dots - \phi_pB^p \quad (4)$$

$$\phi_p(B^s) = 1 - \phi_1B^s - \phi_2B^{2s} - \dots - \phi_pB^{ps} \quad (5)$$

Seasonal differencing, If D = 1

Then $\forall_s X_t = (1 - B^s)X_t = X_t - X_{t-s}$

If D = 2

$$\begin{aligned} \forall_s^2 X_t &= (1 - B^s)^2 X_t = (1 - 2B^s + B^{2s})X_t \\ &= X_t - 2X_{t-s} + X_{t-2s} \end{aligned}$$

SARIMA popularity is due to its flexibility that is used on varieties of time series data. The basic assumption made to use this model is that it considers only the linear component of a time series data. SARIMA can only make prediction for the linear form associated with time series data.

3.3. Compact Classification Tree

CCT construct its decision tree making use of historical dataset. Classification of new dataset are then done with the constructed decision tree. When the class value is know, classification tree are then used for each of the instance. During the construction of classification tree, several parameters are considered such as the splitting rule, the rule

that considered the splitting of data when been classified into smaller part. Research has it that there are various impurity functions such as Twoing splitting rule, Gini splitting rule and Deviance [24]. CCT is suitable for prediction making; the internal node is used to split instance space into various subspaces using some function of the attributes values inputted. In some cases, a single attribute is tested and the space is divided with respect to the value of the attributes value. Considering a numeric attributes, the range of the condition is been used. For us to obtain the most appropriate targeted value, each leaf will be assign to a class. Alternatively, the probability vector that indicates the targeted attributes values is uphold by a leaf. Classification of instance is done from the root of the tree down to the leaf based on the test condition. Pruning method and stopping criteria are used to construct the complexity of the tree. Tree depth, total number of nodes, number of attribute used and total number of leaves are used to measure the tree's complexity.

Algorithm for CCT

TreeGrowth (A, B)

1. if stopping_cond(A,B) = *true* then
2. *leaf* = createdNode().
3. *Leaf.label* = Classify(A)
4. Return *leaf*.
5. Else
6. *root* = createdNode()
7. *root.test_cond* = find_best_split (A, B).
8. Let $S = \{s/s \text{ is a possible outcome of } root.test_cond\}$
9. For each $s \in S$ do
10. $A_s = \{sroot.test_cond(a) = s, a \in A\}$
11. *Child* = TreeGrowth (A_s, B).
12. add *child* as descendent of root and label the edge (*root-child*) as *s*
13. end for
14. end if
15. Return root

3.4. SA-CCT Model

Two models were used in formation of the proposed model. SARIMA and CCT. SARIMA a statistical tool which had gained attention of researchers for linear problems and CCT machine learning algorithm which had also gained the attention of researchers over the years were hybridized to form SA-CCT model. SARIMA a statistical tool is good tool for detection and prediction of linear pattern in a given dataset while CCT is an algorithm which is also good for detection and prediction of non-linear pattern in a given dataset. Both linear and nonlinear models have achieved successes in their own linear or nonlinear problems. However, none of them is a universal model that is suitable for all situations. In the research conducted by [17]

they said that a combined model having both linear and nonlinear modeling abilities will be a good alternative for forecasting the time series data. Both the linear and nonlinear models have different unique strength to capture data characteristics in linear or nonlinear domains, so the combined model proposed in this study is composed of the linear component and the nonlinear component. Therefore, the combined model can model linear and nonlinear patterns with improved overall forecasting performance. It may be reasonable to consider a time series to be composed of a linear autocorrelation structure and a nonlinear component.

Mathematical Representation of the Proposed Model

If W_t is a function of X_t and Y_t of the order of n

Where X_t is the linear component of the proposed model and Y_t is the non-linear component of the proposed model.

W_t can be written in the form below:

$$W_t = X_t^n f\left(\frac{Y_t}{X_t}\right) \dots \dots \quad (6)$$

Differentiating Equation 6 partially w.r.t 'X', we have

$$\frac{\partial W_t}{\partial X_t} = nX_t^{n-1} \cdot f\left(\frac{Y_t}{X_t}\right) + X_t^n \cdot f^1\left(\frac{Y_t}{X_t}\right)$$

$$\frac{\partial W_t}{\partial X_t} = nX_t^{n-1} \cdot f\left(\frac{Y_t}{X_t}\right) - X_t^{n-2} \quad (7)$$

Multiplying both sides by X , we have:

$$\frac{\partial W_t}{\partial X_t} = nX_t \cdot f\left(\frac{Y_t}{X_t}\right) - X_t^{n-1} Y_t \cdot f^1\left(\frac{Y_t}{X_t}\right) \quad (8)$$

Differentiating Equation 6 partially w.r.t 'Y' we have:

$$\frac{\partial W_t}{\partial Y_t} = X_t^n f^1\left(\frac{Y_t}{X_t}\right) \frac{1}{X_t} \quad (9)$$

Multiplying both side by y , we get

$$X_t \frac{\partial W_t}{\partial Y_t} = X_t^{n-1} Y_t \cdot f^1\left(\frac{Y_t}{X_t}\right) \quad (10)$$

Adding Equation 8 and 10 we have

$$\begin{aligned} &= X_t \frac{\partial W_t}{\partial X_t} + Y_t \frac{\partial W_t}{\partial Y_t} = nX_t^n f\left(\frac{Y_t}{X_t}\right) \\ &= X_t \frac{\partial W_t}{\partial X_t} + Y_t \frac{\partial W_t}{\partial Y_t} = nW_t \end{aligned} \quad (11)$$

Where nW_t is the predicted values from both linear component and non-linear component.

3.5. Android Client

The android client represents an application (App) that will allow farmers to receive near real time information from the server. The android client is composed of an android mobile handset with an application that will allow farmers to interact with the system. Alert messages or notifications will be transmitted via an application-programming interface to the mobile phone warning farmers on the possibility of cocoa blackpod disease and possible control mechanism such as type of fungicide application. A farmer will use the android application to register their details via a simple registration form and the data will be sent to the server for storage. Figure 3 depicts the registration interface for farmers to register.



The image shows a registration form titled "BLACK POD DISEASE". At the top is a logo consisting of a stylized plant with two leaves. Below the title are five input fields: "Name", "Age", "Residence", "Phone Number", and "Farming Location". Each field has a light blue border and a small blue arrow on the right side. At the bottom of the form is a dark blue button with the word "REGISTER" in white capital letters.

Figure 3. Interface for Registration

3.6. Server

The server acted as a host for both the farmer and climatic database. The database stored information received from the farmers. The climate database will store information on black pod cocoa disease and their symptoms. The server will as well host the data mining application that will use data from both the farmer database and disease database to determine the likelihood of occurrence of a crop disease.

3.7. Application Program Interface (API)

The API 2 gets user data from the application (APP) database. Through the API 2, the API 2 parsed the date to the API 1, once API 1 gets the date and state, it loads the data from the cloud and fit it into the Model.PKL, which make prediction and send it to the APP through API 1 for display. Figure 4 reveals the diagram of the model connection with two APIs and APP. The type of API used is a RESTFUL API that was provided by flask. Flask is a python web framework and it also provides service like Rest API. The API stands as a communication link between the third party

software (such as mobile application and web application) and the model built. This third party software then sends a request in json format to the API.

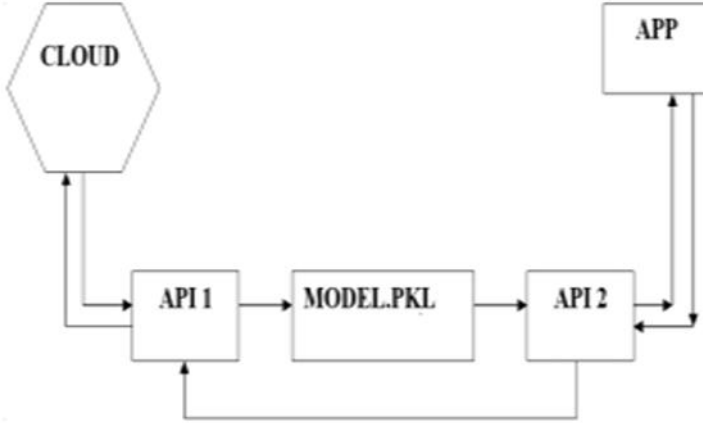


Figure 4. Diagram of the Model Connection with two APIs and APP

3.8. Performance Evaluation

Machine Learning has several ways of evaluating the performance of learning algorithms and the classifiers they produce. But for the essence of this research, the matrix such as accuracy, recall, precision and means square error were used to evaluate our proposed model. They are thus expatiated below.

Recall: it talks about events that are truly positive and are announced as positive.

$$Recall = \frac{TP}{TP + FN} \quad (12)$$

Precision: it describes events that are negative and are announced as negative event.

$$Precision = \frac{TP}{TP + FP} \quad (13)$$

Accuracy: it describes the general effectiveness of the proposed model.

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \quad (14)$$

Means Square Error (MSE): it is an estimator of the overall deviations between predicted and the actual values.

$$MSE = \frac{1}{n} \sum_{t=1}^n e_t^2 \quad (15)$$

Note: Where $e_t = y_t - f_t$ is the forecast error, and n is the size of the test set.

Where y_t is the actual value

And f_t is the forecasted value

4. Result and Discussion of SARIMA Model

Immediately after visualizing the climatic dataset from data space using the Principal component analysis, the dataset is then divided into two sections which are the training set and testing set. 70% of the dataset is used for training while 30% were used for testing. 10 folds validation was also used during the data separation. SARIMA model was simulated and evaluated with the following parameters; precision, recall, accuracy and mean square error. Also, two features were considered during the training and validation stage. The following evaluation was done after prediction: Accuracy: 0.8333%, Precision: 0.6316, Recall: 0.6316 and Mean Square Error: 0.4082. Figure 5 depicts the graph for SARIMA prediction.

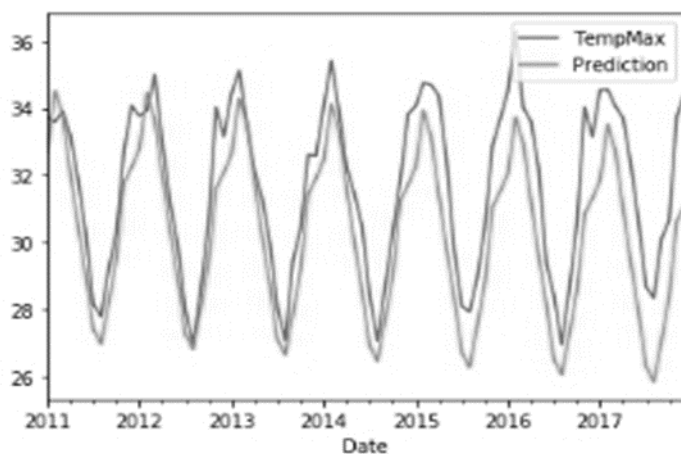


Figure 5. Outcome of SARIMA Prediction of Blackpod Disease

NB: The blue line shows the actual output and the orange shows the predicted output of the model when we fit in the test set

4.1. Result and Discussion of Compact Classification Tree Model

The model was developed using compact classification tree, the first thing done was to import the necessary library. After the successful load of the library, the pandas was used to load the dataset into the system, after that the date was set as the index for the database. The database was splitted into input and output after which the train_test_split library was imported from sklearn.model_selection and the input and output is split into train and test set. After that we load the compact classification tree classifier and fit the x_train and y_train into the classifier to train the classifier, after successful training the x_test was fit for prediction. The following evaluation was done after prediction: Accuracy: 0.911%, Precision: 0.8888, Recall: 0.8888 and Mean Square Error: 0.2981. Figure 6 depicts the graph for compact classification tree prediction.

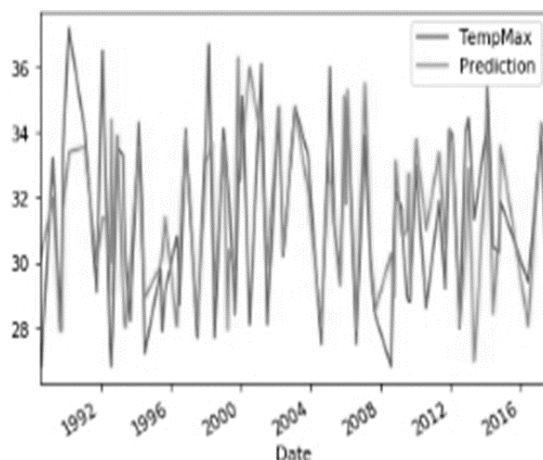


Figure 6. Outcome of Compact Classification Tree prediction of Blackpod Disease

4.2. Result and Discussion of SA-CCT Model

The model was developed using SA-CCT which is the combination of SARIMA and CCT. The following evaluation was done after prediction: Accuracy: 0.944%, Precision: 0.9429 and Recall: 0.9429. Figure 7 depicts the graph for compact classification tree prediction. After evaluation, we import pickle which is used to create model, the model is created and saved in the stated directory with .pkl extension and the model can be used to make predictions.

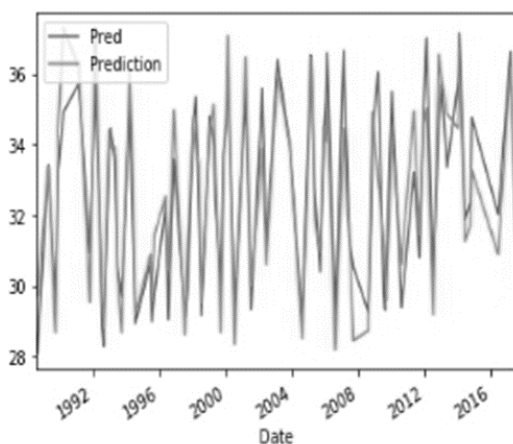


Figure 7. Outcome of SA-CCT Model for prediction of Blackpod Disease

NB: The blue line shows the actual output and the orange shows the predicted output of the model when we fit in the test set.

4.3. SARIMA, CCT and SA-CCT Performance Evaluation Comparison

The proposed SA-CCT model outperformed the other two models by giving the lowest mean square error that is, it gives the least deviations between predicted and actual values and gave the highest accuracy between the three models. As a result, SA-CCT was considered for making prediction to all registered farmers. Table 1 below shows the results of the proposed model, CCT and SARIMA model while figure 8 reveals the graphical representation of the results.

Metrics	SARIMA	CCT	SA-CCT
Precision	0.6316	0.8888	0.9429
Recall	0.6316	0.8888	0.9167
Accuracy	0.8333	0.9111	0.9444
MSE	0.4082	0.2981	0.2357

Table 1. The compared results of SARIMA, CCT and SA-CCT Models

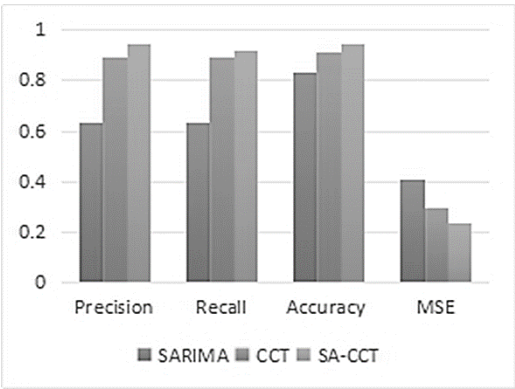


Figure 8. The compared results of SARIMA, CCT and SA-CCT Models

5. Conclusion

This work introduces an ensemble SA-CCT novel approach for predicting of blackpod disease by giving farmers in South-West Nigeria monthly notification of blackpod disease via their mobile application developed. Farmers are expected to install the application on their mobile phone and stay connected so as to receive the monthly notification. The research work also reveals that SA-CCT model performs better than the individual SARIMA (linear) and CCT (nonlinear).

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Scientific Mapping of Social Accounting using Research Indexed in Scientific Databases

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Abstract

Scientometrics is one of the most important scales for evaluating scientific outputs. Co-word and social network analysis (SNA) were used to investigate relationships in the field of social accounting researches indexed on Scopus. The findings of the study indicate that the most frequent topics and vocabulary in this area is economic analysis, economic and social effects. Moreover, the most valuable subject areas were identified: based on closeness, they are water resources, tourism economics and structural adjustment. Based on centrality, economic impact, economic analysis, environmental economics and income distribution. The results of the study indicate that many important social and environmental issues can be assessed through social accounting. Co-authorship analysis revealed that the co-authorship network in this domain was discrete and with low density. By utilizing the co-occurrence map, researchers and policymakers can make policy making more effective through being aware of the research trends and hot topics in social accounting.

Keywords: social accounting, scientific map, word co-occurrence, co-authoring, scientometrics, social network analysis

1. Introduction

According to the legitimacy theory, an organization should be held accountable by increasing the scope of disclosure of social and environmental information in its annual report [27]. Social accounting Includes operations and publications related to accounts of mutual, social, environmental, employee-related, community-related, customer-related actions and activities, along with activities related to other stakeholders, and, to the extent possible, the result of such actions and activities [41]. O'Dwyer (2005) states that social accounts are more similar to combining non-financial numbers and information and include non-numerical information, although

they might include financial information. O'Dwyer argues that since social accounting is not a perfectly logical and consistent environment or activity, it is difficult to define [41]. Social accounting focuses on value transactions between organizations and their stakeholders; both market ones, where the value perceived by the different stakeholders is identified, and non-markets ones, where transactions are monetized at their fair value [46].

In the 1990s, interest in social accounting reemerged, with significant concern in the public sector (government) and the private sector (business) with the global social impacts and the environment, such as human rights, ethics, conduct, and values and quality of life [47].

The past 25 years has been a period in which accounting has had a remarkable impact, be it positive or negative, on global, social and environmental issues. While many people argue that, over the past 25 years, there have been many positive initiatives around the world on social and environmental issues, the increasing number of displaced persons, social and occupational injustice, urban violence and lack of access to favorable public conditions on the social side on the one hand, and acceleration in the extinction of species, climate change, deforestation, desertification, pollution of water and land, and increase in the population in on the environmental side on the other hand indicate worrisome conditions more than ever before. The list of these undesirable conditions includes more than mentioned, becoming longer on a daily basis [14].

In the 1960s and 1970s, a group of accounting scholars systematically questioned the basic assumptions of traditional accounting as well as the notion that accounting is objective, unbiased and invaluable. Critical accountants, for example, believe that accounting generates a particular interpretation of social reality by enumerating specific items in the case of accounting situations and excluding others. This interpretation, consistent with specific assumptions about how society operates and how it should operate has implications for decision-making and policy-making [53]. As experience shows, to better assess the role and trends of each section of accounting science, it is necessary to reasonably differentiate what is a promising direction from what is just a fashionable trend [49]. It is well known by researchers in the field of library and information science that both the classical Web of Science and the rising star Scopus are widely used in bibliometric related studies [57].

The social accounting implies addressing cost-benefit measures on environmental issues, in order to limit pollution and other negative effects on the environment (reduction in biodiversity), but also complementary measures to boost the main macroeconomic indicators through the business component (GDP, total investment, reducing inflation by limiting deviations from the consumer price [39]. The aim of social accounting is to be complementary to traditional accountancy [23]. Social accountability and environmental accounting covers issues that urgently require the attention specially during disturbing circumstances in society, social accounting possibly is pragmatic in order to accomplish consistent and effective change. Social accounting can inform society at large and provide new ways of seeing. social accounting may conducive in shifting management attitudes and practices which promote human rights [50]. Social accounting broadens the factors that are considered

in an accounting model and includes stakeholder engagement as a critical component. Integrated social accounting brings together social and environmental performance with financial performance [36]. "social accounting is three things: (i) a fairly straightforward manifestation of corporate efforts to legitimate, explain and justify their activities; (ii) an ethically desirable component of any well-functioning democracy and, (iii) just possibly, one of the few available mechanisms to address sustainability that does not involve fascism and/or extinction of the species"[50].

Social accounting is more concerned with macroeconomics and includes a study of how industries and institutions relate to the wider economy and society, and how they produce goods and services, generate income, and distribute income together. Social accounting methods have been widely applied in developing third world economies, such as Iran, Malaysia, Sri Lanka, Pakistan, Indonesia, Ecuador and Swaziland [33].

In applying these techniques, social accounting models, or SAMs, can be tailored to fit the specific needs of countries and used as integrated databases to understand the effects of national economic policies. While the UK Treasury has used economic models for more than a quarter of a century, in most less developed countries SAMs are now built similar to the economic characteristics of different local economic conditions. Such models can be graphed, as shown in the literature, and increasingly used in shaping public economic policy [33].

Social accounting also relates to microeconomics, as a growing number of companies are active in social accounting, auditing and reporting. They publish social and environmental reports annually, providing detailed information on relationships with their stakeholders including investors, employees, consumers, suppliers, central and local governments, and environmental associations. Financial rating agencies evaluate firms not only for their economic and financial performance, but also for their social, environmental, and ethical performance [33].

Knowing the state of scientific production and advances in various subject areas, including social accounting, can help gain a complete picture of the type of scientific activities in the field and identify the strengths and weaknesses of the research. One of the most validated methods for evaluating scientific output today is the use of scientometrics, which is informally referred to as measuring science. It has emerged in the scientific community since the late 1960s [4].

Bibliometric methods are statistical analyses used to examine scientific publications, and citation analysis constitutes a significant part of bibliometrics. A citation, in this paper, is understood as an entry in an article's reference list. The foundation of citation analyses is the belief that a citation is a valid and reliable indicator of a publication's influence on, and contribution to, a discipline [3].

Given the increasing volume and substantial production of scientific information in various specialized fields, it is difficult to review all scientific literature produced by experts. Therefore, making use of international databases containing a significant portion of internationally valid information can be the fastest way to access information in any field of study [24]. Scopus was thus searched for all documents containing the subject of "social accounting" which have been published since the

advent of Scopus. Then, the results were analyzed using software programs such as VOSviewer, Gephi, Publish or Perish.

2. Statement of the problem

Social accounting makes possible the broadening of the range of information provided in an accounting statements to represent economic, social and environmental issues, thus enabling the participation of a large group of stakeholders in its compilation. This is a relatively new field, still more novel for nonprofit organizations [53].

The social accounting system has its own principles, rules, and concepts such that it can be seen as a completely separate discipline such as management accounting, government accounting, etc., which aims to social issues. Most of the papers in the field have created a new image of social and environmental accounting. The term 'new concepts' actually means the introduction of new (different) approaches to social and environmental issues by authors, and these new methods can work closely with accounting practices, which represent major changes in practice that can point to the desired range [21].

Social accounting is concerned with how social and environmental activities (which may or may not be worrisome) can be expressed by different elements of a community. Hence, the social accounting process is about responding to non-financial issues that may arise in the arena of a corporate's social responsibility. Analyzing such accounts, or lack thereof, raises the fundamental question whether social accountability can be largely related to economic issues; moreover, it poses the question of what the prioritization and relationship of social and environmental issues are [21].

Social accounting expands the items that are considered in an accounting framework beyond economic accounts, and typically involves a number of stakeholder groups in the process of implementation. It includes a number of approaches including "social responsibility accounting, social audits, corporate social reporting, employee and employment reporting, stakeholder dialogue reporting as well as environmental accounting and reporting" [37].

The key issues in the social and environmental accounting literature are accountability and, in particular, the expansion of the level of accountability of organizations so that their shareholders can at least make informed decisions in support of the organization [13].

Social accounting presents:

- A) a snapshot of an organization;
 - B) an evaluation of the performance of all aspects of the organization's work in a financial period;
 - C) an integrated image of the organization's social product, staff welfare issues, customer care, environmental impacts in the Area and related issues;
 - D) the organization's balance sheet in terms of social impact assessment [51].
- Due to the importance of the subject, we decided to conduct this research using scientometrics. Investigating the research published in the field, we sought to attain and present:

1. a deeper analysis of this area;
2. keywords and important subdivisions of this field;
3. a co-authorship map;
- 4- value offered to the stakeholders;

Considering the above with co-word analyses, both co-citation and co-authorship, which are types of co-occurrence analysis, we looked for a conceptual map of social accounting. Some scientometrics research using word co-occurrence, co-authorship and co-citation is listed in Table 1.

3. Literature review

With the advent and variety of scientometrics techniques, it has become possible for researchers to explore the intellectual structure of their favorite disciplines depending on the method used [30].

The word co-occurrence method was first proposed to depict the dynamics of science. In 1986, Callon et al. published a book entitled *Drawing the Dynamics of Science and Technology*, which is a seminal work in co-word analysis. Many researchers have used this method to explore conceptual networks in different scientific fields.

ID	Article title	authors	method	Year
1	Past themes and tracking research trends in entrepreneurship: A co-word, cites and usage count analysis	Ramírez, L.J.C., Sánchez-Cañizares, S.M., Fuentes-García, F.J.	co-word	2019
2	Mapping the Intellectual Structure of Social Entrepreneurship Research: A Citation/Co-citation Analysis	Hota, P.K., Subramanian, B., Narayanamurthy, G.	co-citation	2019
3	An evaluation method based on co-word clustering analysis – case study of internet + innovation and entrepreneurship economy	Ji, Y., Jiang, Y., He, L.	co-word	2018
4	Structure and evolution of innovation research in the last 60 years: review and future trends in the field of business through the citations and co-citations analysis	Rossetto, D.E., Bernardes, R.C., Borini, F.M., Gattaz, C.C.	co-citation	2018
5	Corporate social responsibility research in international business journals: An author co-citation analysis	Zhao, H., Zhang, F., Kwon, J.	co-citation	2018

6	Is social innovation about innovation? A bibliometric study identifying the main authors, citations and co-citations over 20 years	Silveira, F.F., Zilber, S.N.	co-citation	2017
7	Female entrepreneurship: A co-citation analysis	Ferreira, J.J.M., Fernandes, C.I., Peris-Ortiz, M., Ratten, V.	co-citation	2017
8	Diffusion of Innovations model helps interpret the comparative uptake of two methodological innovations: co-authorship network analysis and recommendations for the integration of novel methods in practice	Cadarette, S.M., Ban, J.K., Consiglio, G.P., (...), Marin, A., Tadrous, M.	co-authorship	2017
9	The focus and frontier of corporate social responsibility: A co-word analysis of articles in SSCI, 2001-2014	Qin, X., Wang, Z., Zhao, H., Kaspersen, L.B.	co-word	2016
10	Through the magnifying glass: an analysis of regional innovation models based on co-word and meta-synthesis methods	Naghizadeh, R., Elahi, S., Manteghi, M., Ghazinoory, S., Ranga, M.	co-word	2015
11	Co-authorship networks and research impact: A social capital perspective	Li, E.Y., Liao, C.H., Yen, H.R.	co-authorship	2013
12	Co-word analysis of domestic network virtual society research hotspots and evolution	Cui, P., Zhang, W.	co-word	2012
13	Innovation performance of university co-authorship network	Li, L., Gao, X.	co-authorship	2012
14	Enabling Policy Planning and Innovation Management through Patent Information and Co-Authorship Network Analyses: A Study of Tuberculosis in Brazil	Vasconcellos, A.G., Morel, C.M.	co-authorship	2012

Table1. international research in the field of scientometrics

Reviewing the literature reveals that there has been no independent research on the application of co-authorship and word co-occurrence methods in the field of social accounting. Therefore, this study aims to identify and map those areas of social accounting research using a co-word method with an analytical perspective and to determine the efficiency of this method in identifying and defining the scientific and research priorities of the field.

4. Research method

Scientometrics can be defined as "the quantitative study of science, communication in science, and scientific policy." What began as Eugene Garfield's idea of creating an index to improve information retrieval in the 1960s leading to the creation of the Science Citation Index (SCI) was soon recognized as a new tool in the empirical study of science [31].

Scientometrics is one of the most important scales for evaluating scientific products. Makias-Chapula argues that "scientometrics indices have become essential to the modern status quo (in line with the latest developments) of a particular subject for the scientific community." Scientometrics relates to and overlaps with bibliometrics and information science interests. The terms bibliometrics, scientometrics, and information science refer to the component parts of studying the dynamics of the disciplines as reflected in the production of their sources [35].

Understanding the impact of scientometrics on the development of academic disciplines is a complex issue, one of paramount importance. Its relevance is due to the recent trend to introduce numerical scales of scientific performance to evaluate research activities and facilitate comparisons at different levels, for example, between researchers, institutions, or the media. These comparisons usually take the form of ratings designed to "measure" the "quality" of universities, scientists, scientific articles, and journals on a single scale. This development also points to a methodological shift in scientometrics whose conceptual origins lie in an interpretive analysis of scientific communication aimed at understanding the characteristics of academic publication discourse [1].

Van Raan (1997) believes that scientometrics research is limited to quantitative studies of science and technology. It aims at advancing science and technology; it is also about social and political issues. He divides the main interests of scientometrics into four intertwined areas:

- (1) developing methods and techniques for the design, manufacture and use of quantitative indicators in important aspects of science and technology;
 - (2) the development of information systems in science and technology;
 - (3) the study of the interaction between science and technology;
 - (4) an overview of cognitive and socio-organizational structures of scientific areas and development processes in relation to social factors [54, 35].
- Researchers in social network analysis understand networks as sets of objects called "nodes" that are connected by one or more relationships called "links". In the social sciences context, nodes can be a wide range of social units such as individuals, groups, organizations, companies, governments, and countries [26].

The present applied research has been conducted using common methods in scientometrics with techniques such as word co-occurrence, co-citation, co-authorship and SNA. The research community consists of all articles indexed on the Scopus database since its advent on the subject of "social accounting". For this reason, the word "social accounting" is searched for in the titles, abstracts and keywords of articles written in English.

After retrieving records related to social accounting, in order to perform co-word analysis, 3970 keywords were obtained from 1338 records, of which, according to Bradford's law, those with frequency of 5 and above (that is, 301 words) were considered frequent.

Next, co-words were examined using expert opinions. Some words that had no special meaning in the structure of their respective sciences were omitted, such as "human beings", "education", "research methods", "developed countries", etc.

Next, keywords with a frequency of 5 and above were included in the final analysis. It should be noted that various studies using word co-occurrence analysis have used different thresholds to include top keywords in the final analysis; for example, Liu et al. restricted their analysis to 66 words, which accounted for about 55% of the total frequency [32], and Hu et al. (2013) limited their final analysis to 181 keywords, representing 29% of the total [25].

For word co-occurrence analysis, hierarchical clustering and multidimensional scaling are commonly used. Hierarchical clustering has the ability to identify clusters of each keyword and show the relationships between them. Therefore, each cluster was visited using "VOSviewer" software. The maps created using the multidimensional scale can also reveal important clusters and their position among other clusters based on the degree of correlation. Therefore, a multidimensional scale map was developed using Gephi.

Other features of the word co-occurrence matrix network, including centrality, density, weight, etc. were measured using Gephi software to find out more about the study area.

Also, for co-authorship analysis, out of 2062 unique authors in the area of social accounting research, it was determined that 65 authors had participated in at least 5 studies. It was further stated in the co-citation analysis that a total of 25474 citations were made in all articles.

5. Findings

The findings are presented in this section.

Reference date	2022-03-26 22:51:03 +0430
Publication years	1946-2021
Citation years	76 (1946-2022)
Papers	1338
Citations	25474

Citations/year	335.18 (acc1=521, acc2=277, acc5=101, acc10=34, acc20=8)
Citations/paper	19.04
Authors/paper	2.21/2.0/multi (mean/median/mode)
Age-weighed citation rate	1627.43 (sqrt=40.34), 963.71/author
Hirsch h-index	73 (a=4.78, m=0.96, 12639 cites=49.6% coverage)
Egghe g-index	124 (g/h=1.70, 15542 cites=61.0% coverage)
PoP hI,norm	54
PoP hI,annual	0.71

Table 2. Citation findings

According to Table 2, there are 1338 articles on social accounting that have been indexed in the Scopus database over the past 76 years, during which time 25474 citations were received, ie 19.04 times per article and 335.18 citations per year.

5.1. Research trend in the field of “social accounting”

The results show that the research and development of scientific products in the field of social accounting in Scopus has been very impressive since its advent, with the growth rate of scientific products more than 4.5 times in the last 10 years. The whole research indexed belongs to the timeframe from 1946 to 1989 (Fig. 1).

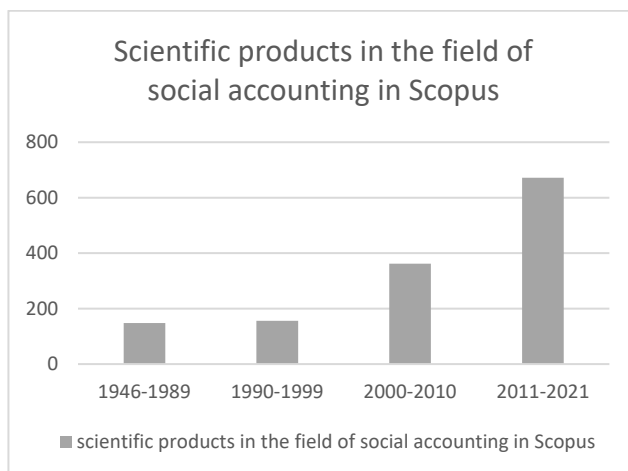


Figure 1. Number of publications from 1946 to 2021

One of the most important channels of information exchange in scientific disciplines is the scientific journals of each discipline. Therefore, identifying active and reputable journals in any field is of particular importance.

Analyzing data related to the contribution of each journal to the published articles indicates that Elsevier commands the largest number (31%), with 91 studies. This is visible in figure 2.

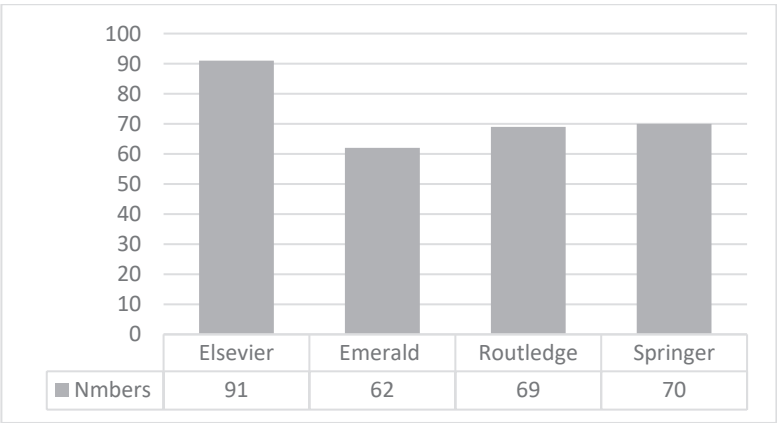


Figure 2. The percentage of published research per publisher

Figure 3 shows that over 80% of the studies were of papers.

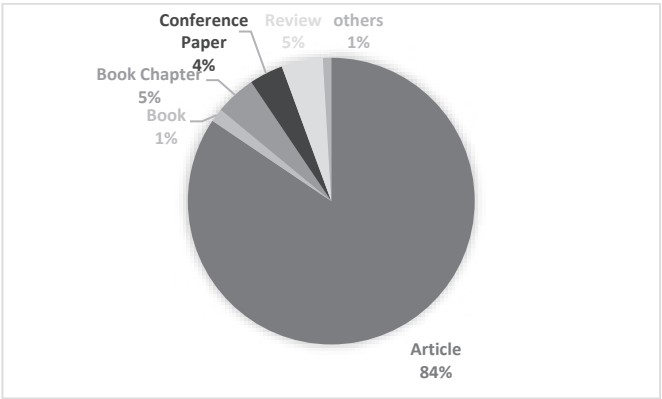


Figure 3. The percentage of submitted research

5.2. Base words in the field of social accounting

According to the table 3, economic analysis and economic impact are the most important base words in the field of social accounting.

Label	weighted indegree	weighted outdegree	Weighted Degree
economic impact	64	179	243
economic analysis	29	166	195

economic and social effects	29	142	171
environmental economics	77	85	162
income distribution	80	60	140
emission control	54	84	138
regional economy	97	27	124
economic development	23	88	111
economic growth	32	78	110
pollution tax	93	17	110
sustainable development	97	10	107

Table 3. Base words in the co-occurrence network analysis

The role of accounting in the occurrence (and recurrence) of corporate and business scandals and the associated crises of public confidence highlights the importance of clarifying our understanding of the relationship between accounting and the public interest and of addressing any deficiencies in that relationship [5].

Social accounting is a branch of accounting, which is the subject for social impact of the organization of economic activity to be measured and reported, applying the accounting basic principle and method [52].

The National Association of Accountants Committee of USA in 1974 identified the following four areas of social accounting:

- (1) Community Development;
- (2) Human Resources;
- (3) physical resources and environmental role;
- (4) the role of products or services.

The environmental role includes activities to reduce water, air and soil deterioration. [56]. Today, a wide range of stakeholders are interested in information related to social and environmental issues, so companies must publicly judge all aspects of their activities and should not restrict them to the just economic activities [12].

Through social accounting, a range of non-financial considerations may be integrated and prioritized in accounts that may be asked for and provided in the context of relationships of accountability between social actors (including, but not limited to, agency relationships) [6] Social accounting recognizes the effects and consequences of traditional accounting worldviews and practices, and can be applied at the level of entities, organizations, and other units of interest, including society as a whole [20]. Therefore, social accounting constitutes an element of social interaction that need not be limited to, or necessarily expressed in, financial terms [5].

5.3. Mapping co-occurrence

After modifying the network and removing from it irrelevant points such as countries, methodology related concepts etc., the final co-occurrence map was drawn. A map of the concepts of social accounting arising from the keywords of the research is plotted

with the keyword density using VOSviewer software (Fig. 4) and closeness degree using Gephi software (Fig. 5).

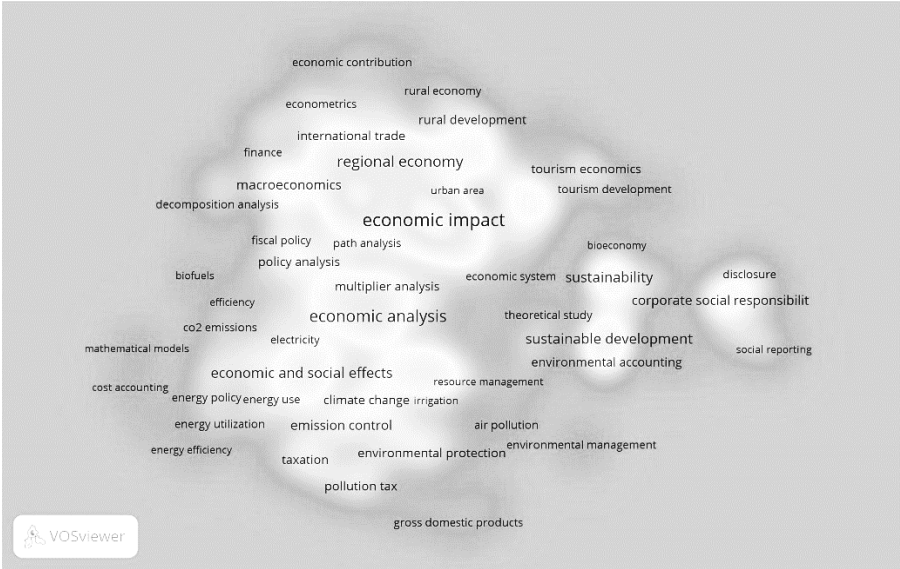


Figure 4. Co-occurrence network using key-word density

VOSviewer software assigns a density to each keyword based on its frequency, and according to co-word analysis, words with higher frequency receive higher densities. On the map, it can be seen that economic concepts such as economic analysis, economic impact, economic and social effects, and regional economy have the highest densities.

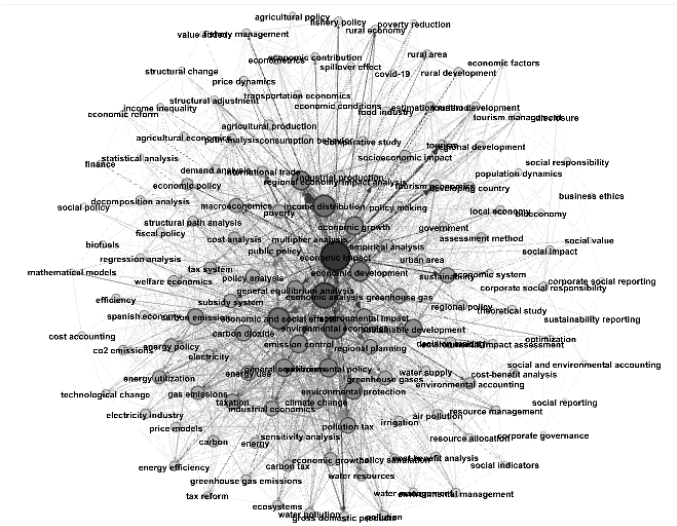


Figure 5. Co-occurrence network drawn with Gephi

The purpose of Gephi is also to study the correlation of node features and to build networks using visual patterns. Classification of social network metrics such as node degree or betweenness centrality can be used for better computation and visualization.

The longest path on the network, or network diameter was calculated to be 5. The average distance between two nodes was 1.921. The diameter of the network is measured by the distance of the longest paths in the network with the distance of the shortest paths (in terms of number of links or connections) between two nodes. The shorter the network diameter is, the faster the communication speed will be [9], and in the present network, each two word can be connected through 5 intermediaries.

5.4. Analysis of co-occurrence network

There are various indicators for word co-occurrence analysis which can be applied to scientific maps. For example, the network size is determined by the number of nodes, and the density of the network by the number of links. Centrality is one of the important indicators in network analysis. This index refers to the position of specific nodes within the network and its are closeness, betweenness, and degree centrality. Degree centrality is the simplest type of centrality. It refers to the value of each node obtained by counting the number of its neighbors. The number of neighbors is obtained based on the links connected to that node. In a word co-occurrence network, the more central the word is, the more communication and network it has and the more effective it is. Closeness is based on the concept of distance and path length. In a network, vertices that have the least distance to all other vertices have a higher closeness [15].

Drawing up scientific maps of social accounting concepts based on research conducted in this field is another result of this study. since science maps have a structure similar to social networks [22], we used social network analysis techniques to interpret scientific maps.

In the present study, closeness centrality refers to the words or points that are linked to other points with the least distance (least number of links). Betweenness centrality also indicates the importance of the node in terms of its location on the map and in terms of information transmission over the network.

analysis of the map shows that there are 144 nodes and 1907 links in this map. Since the number of links is more than nodes, the network is therefore continuous.

5.5. Centrality

Degree centrality index relates to the number of links that each node in a network is associated with. Therefore, degree centrality deals with the role of each node in the network. In networks with directed links, the in-degree is the number of relationships a node receives, while the out-degree is the number of relationships that each node sends out. The higher the node's in-degree (in particular, compared to the nodes with a high in-degree), the more powerful or important the node will be [48].

The centrality of the network nodes can be studied by using the three indices of degree, betweenness and closeness. Degree centrality for each node in the network is

equal to the sum of the nodes entered and the closeness is the average of the shortest paths between that node and the other nodes in the network. Betweenness of a node represents the number of times that the node is placed on the shortest path between the two nodes in the network [44].

5.5.1. Degree centrality

Degree centrality is one of the network metrics or indicators that is useful in analyzing the structure of entire networks and node positions in the network. It measures the number of links going in or out from a node in a network. degree centrality is the calculation of the number of links a node has with other nodes in the network. The subject with the most lines has the highest rank and is the central [7]. Degree centrality can facilitate or prevent the flow of resources between nodes in the network [16]. As shown in Figure 5, each two points or keywords are connected if they have at least one common co-occurrence in this network. The size of each node represents the degree centrality or the number of co-occurrence of that node with the other nodes in the network. Moreover, the more co-occurent two nodes are, the greater the diameter of the link between the two nodes and the bolder the lines. In the present network, the keyword "economic impact" has the highest degree of centrality, which means that it has the highest degree of connection with other nodes (Table 4).

Label	indegree	outdegree	Degree
economic impact	28	76	104
economic analysis	17	70	87
environmental economics	34	41	75
income distribution	37	36	73
economic and social effects	17	54	71
economic development	12	52	64
regional economy	47	14	61
economic growth	14	44	58
emission control	18	39	57

Table 4. Words with the highest centrality degree

5.5.2. Degree centrality

Betweenness centrality of a node as a node's compatibility attribute indicates the importance of the node in terms of its location on the map and in terms of the distribution information on the network. The betweenness centrality is calculated based on the position of people in the network. The node with the highest betweenness centrality is in the middle of a large number of other nodes and passes through other nodes. These nodes have the power to isolate and enhance communication [40].

Analysis of betweenness centrality shows that most of the keywords have a betweenness centrality below 200 and 7 nodes are above 200.

Based on the analysis of the map and on the betweenness centrality, keywords economic impact, income distribution, economic analysis and environmental economics are the most important issues in the transmission of information in the network, that is to say, topics analyzed by interdisciplinary approach in the field of social accounting.

The following table (Table 5) shows the keywords with the highest betweenness centrality:

Label	Betweenness centrality
economic impact	671.604
income distribution	566.571
economic analysis	408.042
environmental economics	337.447
regional economy	290.270
sustainability	243.360
economic and social effects	203.486
Policy analysis	191.033
General equilibrium	155.825
Economic development	150.052

Table 5. Words with highest betweenness centrality

5.5.3. Closeness centrality

How fast an entity on the network can access more entities on that network refers to closeness. An entity with high closeness generally has the following characteristics:

- it has instant access to other entities on the network;
- it has a short path to other entities; it is close to other entities; and
- there is a high visibility about what is happening on the network [55].

The closeness centrality measure is calculated based on geodesic distance. It measures the distance of a node from the other nodes. This index represents the acceptability index [18].

According to the closeness diagram, most nodes are close to one another, having a closeness between 0 and 1, which allows the information to spread very quickly in this network. According to the calculations and the shape of word co-occurrence, issues like water resources, Tourism economics, and structural adjustment have the most impact, i.e., the highest closeness centrality. In fact, such nodes are less distant than all other nodes and are, on average, closer to all nodes. Thus, these nodes are more robust in the network [11, 42]. The following table (Table 6) shows the keywords with the highest closeness centrality:

Label	Closeness centrality
Water resources	1
Tourism economics	1
Structural adjustment	1
Tourism development	1
Social policy	1
Taxation	1
Theoretical stusy	1
Economic impact	0.8015
Sustainable development	0.7692
Water management	0.75
Economic analysis	0.7254
Income distribution	0.7023

Table 6. Words with the highest closeness centrality

The table above shows that environmental issues and resources in the co-occurrence network are of the highest importance based on closeness.

6. Network density

Density is used to check the degree of network cohesion. Network density can be defined as a set of relationships that connect nodes to each other and prevent the network from breaking [17]. Regarding network cohesion, it can be stated that if the connection between nodes is weak or the number of lines between the nodes are low, the network has a low cohesion and there will be many holes in the network. In this case, the network is discrete and the information flow will be very slow. Conversely, when there is a high number of links between the subgroups and there are few holes in the network, it is a continuous network [17, 29]. The co-occurrence network of the present study shows that the network has relatively low coherence due to its density of 0.093. This density indicates that only 9.3% of the potential internal communications in the network is operational. In other words, the number of links in the network can be relatively low, resulting slow information flow. The network density also determines the ratio of the number of relationships available to the number of possible relationships in the network. The density map of the co-occurrence network (Fig. 4) shows that the highest density is formed around the concepts of economic impact and economic analysis, and the words farther away from these two terms have less importance, less occurrence, and a lower number of neighboring nodes.

7. Hub

Network elements can be categorized into different classes through their participation in the network. For example, they may be classified according to the way they interact with other components of the system. One of the important distinctions that can be made based on their effect is the potential effect they have on the overall system and their capacity to transmit or process information. High-impact nodes are often referred to as hubs. Identification of hubs is needed to map the different areas that are most interoperable and contribute to system integration. One issue to note is the nodes which have high communication have a greater sharing factor. The high degree of centrality and their relevance as well as their high degree of interconnectedness in structural communication indicate that they play a vital role in the integration of processes and information flow [19]. Nodes that act as hubs and interconnect many nodes are mentioned in the following table (Table 7): economic impact, economic analysis, and economic and social impact are the largest network hubs.

Label	Hub
economic impact	0302997
economic analysis	0.274909
economic and social effects	0.241773
economic development	0.205063
Environmental economics	0.197799
emission control	0.1946
economic growth	0.191417
climate change	0.178785
environmental policy	0.149609
Income distribution	0.129665

Table 7. Main network hubs

8. Cluster analysis

Clustering means categorizing members of a set without supervision. In this way, clusters or classes are not predetermined and, in other words, cluster labels are not available. Clustering refers to finding a structure within a set of unlabeled data; in fact, cluster is a collection of data that are similar to one another [28]. Classification and clustering are different. In a classification task, you assign a class to a predefined label; but in a clustering task, there is no information about the classes in the data, and in other words, the cluster is extracted from data [43]. Consequently, after performing a clustering task, an expert should interpret the resulting clusters and, in some cases, some of the parameters that are included in the cluster but are irrelevant or of little importance are set aside, and clustering is performed again [10].

Cluster analysis was performed using Gephi. five different thematic clusters were identified and then clustered using expert opinion. The "socioeconomic impact" cluster is the largest cluster with 37 points and contains the social and economic impact related. Thus, in the present study, it is named the socioeconomic impact cluster. Among its points are economic impact and welfare economics.

The clustering results in Table 8 show the number of clusters, their naming, and the percentage of concepts present in each cluster. The clustering shows the automatic structure of the concepts, and the concepts within each group are most similar to each other. All 6 clusters have minimum intra-group differences and maximum inter-group differences. In the economic analysis cluster, for example, the concepts of sustainable development, economic and social effects, social indicators, cost accounting and such are most closely related to the concept of economic analysis.

Network characteristics			
Number of links		clustering coefficient	Number of midpoints
1907		0.51	144
Number of clusters	Name of cluster	Number of nodes in	relation to total network (%)
0	Economic analysis	23	15.97%
1	economic impact	38	26.39%
2	Environmental impact	47	32.64%
3	Economic development	32	22.22%
4	statistical analysis	4	2.78%

Table 8. Network characteristics

The clustering coefficient indicates how much the keywords tend to create co-occurring clusters. The clustering coefficient is always a number between zero and one [34]. In the table 8, the mean clustering coefficient of 0.51 is obtained which estimates the tendency of network nodes to communicate with each other and to form clusters at a low level. Also, the average distance of the network nodes is 2.01, which indicates the closeness of the nodes and the density of the network.

9. Authors and Co-authorship

The results show that there are 2062 unique authors in the social accounting field who have written all of the social accounting research available on the Scopus database.

The minimum number of studies for each author is 5, and 65 authors have the highest number of studies performed.

The co-authorship network density in the area of social accounting was 0.012. The network density is the number of edges available in the network to the number of all possible edges. Density as the number of relationships between elements in a network which hold the highest share among possible relationships in the network is always a number between zero and one. The higher the density of a network, the more the nodes are connected and are closer to each other [38]. Overall, the figure 6 indicates that the co-authorship network is discrete and has a low density.

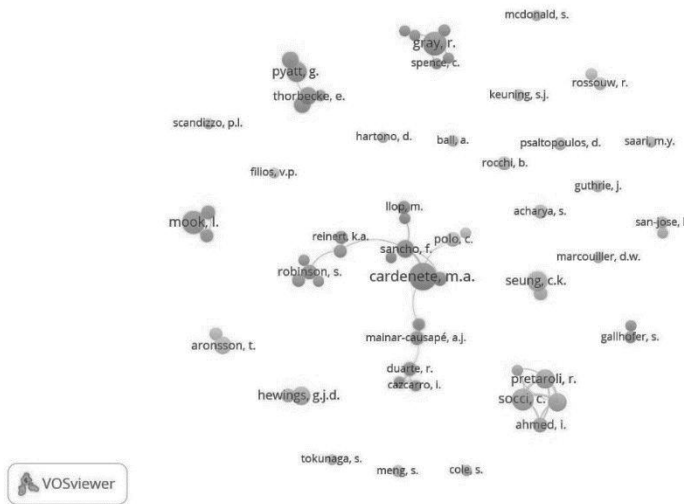


Figure 6. Co-authorship network based on degree centrality

There were 456 one-author studies, 394 two-author studies, 327 three-author studies, and the rest with higher author numbers. Careful scrutiny of the number of authors per article indicates that the dominant authoring paradigm in social accounting research is the collective authoring paradigm, and only about 34% of the articles have used the single author model, confirming that scientific and research papers and reports are the result of teamwork [2] and that the academic work, too, is increasingly the result of teamwork [45].

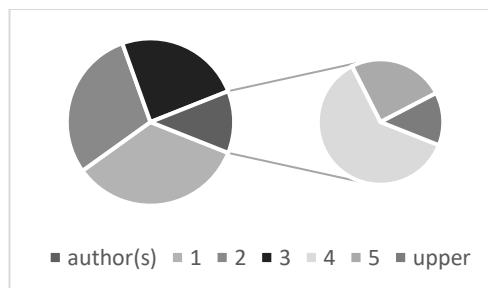


Figure 7. Multi-author research patterns

By looking at Figures 6 and 7, influential writers, writers' relationships with each other, and important clusters can be separated. There are 29 communities and clusters of co-authorship, and the main cluster is cluster 1 with 6 authors, with 20% of the links in this cluster being related to authors such as Adelman, I., Dorosh, P., Reinert, K.A., Robinson, S., Roland-Holst, D.W. and Tarp, F. These authors are the central and influential writers in this network. The authors' names are widely dispersed by the number of documents. On the scientific map, authors such as Cardenete and Gray account for the largest share of productions in the field of social accounting, as illustrated in Table 9.

Author	Productions
Cardenete	36
gray	23
mook	21
Pyatt	16
Hewings	14
Thorbecke	13

Table 9. Prolific authors in social accounting

C. Deegan was also cited as the author of the most cited paper, "Introduction: The legitimizing effect of social and environmental disclosures: a theoretical foundation", which was published in 2002. it received 1516 citations. In table 10 most cited papers are gathered.

Cites	Authors	Title
1011	C. Deegan	Introduction: The legitimizing effect of social and environmental disclosures – a theoretical foundation
528	R. Gray	The social accounting project and Accounting Organizations and Society. Privileging engagement, imaginings, new accountings and pragmatism over critique?
437	J. Bebbington, C. Larrinaga, J.M. Moneva	Corporate social reporting and reputation risk management
422	L.D. Parker	Social and environmental accountability research: A view from the commentary box
387	L. Moir	What do we mean by corporate social responsibility?
344	R. Gray	Social, environmental and sustainability reporting and organizational value creation?: Whose value? Whose creation?

311	R. Gray, C. Dey, D. Owen, R. Evans, S. Zadek	Struggling with the praxis of social accounting: Stakeholders, accountability, audits and procedures
302	B. O'Dwyer	Managerial perceptions of corporate social disclosure: An Irish story
267	A.M. Quazi, D. O'Brien	An empirical test of a cross-national model of corporate social responsibility
265	T. Shearer	Ethics and accountability: From the for-itself to the for-the-other
264	D. Owen	Chronicles of wasted time?: A personal reflection on the current state of, and future prospects for, social and environmental accounting research

Table 10. most cited paper

10. Discussion and conclusion

In this study, using co-occurrence analysis and scientific mapping based on articles on social accounting indexed in the Scopus database, we tried to identify the conceptual structure of this domain using co-word and co-occurrence analysis.

The results show that studies in the field of social accounting have grown significantly in the last decade and the assessment of social impacts has become more important than what it was in the past. The results also show the importance of concepts such as economic impact and analysis, and social and environmental issues.

The scope of the studies was analyzed using hierarchical clustering techniques and 5 clusters were identified in the study period. The second largest cluster with 38 keywords that affect both economic and social issues was found to emphasize that social goals do not reduce the importance of profit motivation.

Keywords such as economic impact, income distribution, economic analysis, environmental economics, as nodes with high betweenness in the network are crucial nodes, facilitating the formation and communication of information in the social accounting field and other areas, topics such as water resources, tourism economics, and structural adjustment have the most impact and the most closeness centrality and are able to access the rest of the network faster.

The co-occurrence network in the study shows that the network has a relatively low coherence, its density being 0.093 and with only 9.3% of the potential internal communications in the network realized.

Keywords economic impact, economic analysis and economic and social effects are the key hubs of the co-occurrence network that are highly interconnected with other nodes and facilitate communication among other nodes.

A careful examination of the number of authors for each article indicates that the dominant authoring paradigm in social accounting research is the collective authoring model, and scholars such as Cardenete and Gray are among the most active in this field, and, Adelman, I., Dorosh, P., Reinert, K.A., Robinson, S., Roland-Holst, D.W. and Tarp, F. constitute the largest social accounting research community. C. Deegan

was the author of the most cited paper, "Introduction: The legitimizing effect of social and environmental disclosures: a theoretical foundation", which was published in 2002 and received 1516 citations.

The findings also showed that the Elsevier publishing company has published the largest number of articles in this field. Investigations such as word co-occurrence analysis are capable of answering questions of this kind: What is the focus of researchers in a scientific community? What are the different scientific fields and subfields? What evolution have they gone through? What topics will probably be in the forefront of scientists' attention in the near future? The results of this study show that social accounting is closely related to important socioeconomic categories and related analyses. Even though most accounting scholars do not currently promote their research to the general public and policy makers, these kind researches suggest that such efforts can have promising results [8].

Although social network analysis research itself does not provide suggestions, it can be helpful in understanding the current situation and guide scientific trends in social accounting. The results of the present study help researchers in social areas, especially social accounting, to explain the study and policy-making process in this area based on the identified effective areas.

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Croatian Journals Covered by SCIE/SSCI: the Story from the Periphery

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Abstract

The study analysed Croatian journals covered by Web of Science (WoS) Science Citation Index Expanded (SCIE) and Social Science Citation Index (SSCI) over three time periods. The first two periods were the periods of inclusion of Croatian journals in SCIE/SSCI, and the third period was the period of exclusion of journals. In 1999, there were 12 Croatian journals indexed, and in 2011, mostly as a result of the WoS Regional Expansion Programme, there were 50 Croatian journals covered by SCIE/SSCI. The IF range of the Croatian journals showed an increase over the years from 1999 to 2011, but most journals remained in the fourth quartile (Q4). Although Croatia is considered as a country from the scientific periphery, in comparison with neighbouring Italy, Hungary, Slovenia, and Serbia in 2005, 2011, and 2018, Croatia had a permanently strong journal representation in JCR.

Keywords: Croatian journals, SCIE, SSCI, international visibility, bibliometric analysis

1. Introduction

Croatia is considered a country from the scientific periphery, with a small economic potential and low share of gross domestic product (GDP) allocated to research and development [1], [2]. Majority of Croatian scholarly journals are published by organizations and institutions funded by the government [3]. Journals of cultural, national or regional importance receive financial support from the Croatian Ministry of Science and Education and should be non-profit [4].

Scientific journals are the major medium of exchange and dissemination of scientific information [5] and reflect potential and performance of scientific community [6]. Journals from the periphery usually have poor international recognition due to many factors such as small author pool, poor review process, limited finances, language of publication other than English, and low visibility [7]. Although they strive to become included in the major indexing databases, most are rejected. Although such journals may publish important results, they cannot reach a broader scientific community.

In 1961, the Institute for Scientific Information (ISI) from Philadelphia, USA, began to compile Science Citation Index (SCI) database, which included journals

from the field of natural and applied sciences. The selected journals were considered to the “core of scientific production”[8]. In 1970, another ISI database was compiled – Social Science Citation Index (SSCI). Both databases use clearly defined criteria that journals have to meet in order to be included, and both are available through the Web of Science (WoS) database service owned by Clarivate Analytics. In 1975, Eugen Garfield, the founder of ISI and creator of SCI/SSCI indices, created another special statistical database called Journal Citation Reports (JCR) as a quantitative tool to rank, evaluate, categorize and compare journals [9]. Every journal after being indexed in the WOS SCIE or SSCI for at least two years receives an impact factor (IF) and quartile (Q) ranking in the relevant subject category based on the IF. A journal’s IF is a ratio where the numerator is the number of citations in the current year to items published in the previous two years (all items including editorial material, letters, news, book reviews, bibliographical items, etc.) and the denominator is the number of original research articles, case studies, short communication, professional papers, proceeding papers, and reviews published in the same two years [10].

Wos SCI and SSCI had been the only data sources available for citation analysis until 2004, when Scopus and Google Scholar were launched. Scopus is Elsevier’s bibliographic and citation multidisciplinary database. In comparison with WoS, it has lower inclusion criteria and covers more journals. Google Scholar is a search engine that crawls the web and indexes any document with a seemingly academic structure, counting the citations [11].

Journals published in developing, non-English speaking countries from the scientific periphery were poorly represented in the SCI and SSCI databases [12]. Although many of these journals did not meet the required standards nor publish “good” manuscripts, it was obvious that regional journals were not seriously evaluated for the inclusion in WoS indexes. Journals from the USA and Western Europe were clearly favoured in the selection process [13]. In response to this and to the emergence of new citation databases, the Editorial Development Department of Thomson Reuters, the owner of the ISI and WoS from 1992 to 2016, started the Regional Expansion programme in 2006 [14], which indexed the best of the regional journals on the basis of their regional relevance. Thus WoS ensured regional research to become visible to the broader international scientific community. As for the Croatian journals, in the period from 2006 to 2011, forty more of them became indexed by SCI/SSCI. Most of them still are.

Hrčak, the central portal of Croatian scientific journals, was launched in 2006 as an outlet for journals without the infrastructure for e-publishing and an interface for free access to journals’ content [4]. Due to Hrčak, Croatian scientific journal obtained greater international visibility, but they also had to upgrade their editorial practices to meet the Hrčak requirements. Together with realization of WoS Regional Expansion programme, the improvement of editorial practice created good conditions for indexation. Also, to increase the number of Croatian journals covered by their services and to speed up the indexing process, cooperation with Elsevier and Thomson Reuters has been established [4].

According to the number of scientists, Croatia has a considerable number of indexed scholarly journals as the result of a long-term and systematic government support of scholarly publishing [15]. In 2005, Croatia had more than twice as many JCR-indexed journals as Hungary, Italy, Slovenia, Serbia, and Montenegro when normalized to GDP [16].

Within this historical, bibliometric, and context, the chronological order of inclusion and exclusion of Croatian journals from SCI/SSCI is presented. The analysis was performed to determine the number of Croatian journals that were and still are covered by SCIE/SSCI; the effect of citation data before indexing on covering the journals; the types of articles published by Croatian indexed journals; the JCR subject categories that Croatian journals belong to; the level of international orientation for Croatian indexed journals; and the reasons for the exclusion of individual journals from SCIE/SSCI.

2. Methods

The analysis included Croatian journals covered by WoS SCI and SSCI since 1975, when the first Croatian journal was indexed in SCI. Three time periods were analyzed: the period of journal inclusion from 1975 to 1999, the period of intensive journal inclusion during Thomson Reuters' Regional Expansion Programme from 2006 to 2011, and the journal exclusion period from 2011 to 2015.

For both journal inclusion periods, the first indexed volume of a journal was selected for analysis. It was assumed that the first indexed volume had the same qualitative and quantitative characteristics as previous volumes evaluated for the covering. On the other hand, for several journals the first indexed volume was the first volume ever, for their start year was the same as the year of their indexing. As editors set the criteria they adhere to and apply to every volume, it may be assumed that a single volume can represent the entire journal.

Eugene Garfield defined three broad criteria that are used in the evaluation of journals for SCI/SSCI coverage: citation data, journal standards, and expert judgment [17].

Citation data for Croatian journals before the coverage were calculated using WoS tool - Cited reference research. Citation data spanned the period from 1955 to the year of indexation. Journal standards, such as regularity (frequency), peer review of submissions, requirements for abstracts, titles, and references set by professional associations of publishers and editors, editorial board membership, and similar characteristics were not included in the analysis as journals would not even be considered for the inclusion had they not met these basic standards.

The analysis was focused on the number of papers published by an indexed journal within one volume, the first indexed volume, and types of articles published: research paper, short communication, review, case report, professional paper, conference paper, editorial, letter to editor, book review, biographical item, news item, and meeting abstract. As WoS offers no information on the type of article, older journals were manually searched to determine the types of articles, while other

journals were searched by HRČAK, the central database of full-text articles published in Croatian scientific and professional journals, which was established in 2006.

JCR subject category is added to every journal.

Garfield suggested that if a journal is of interest to only a small region of the world, ISI indexes are less likely to cover it [17]. A Croatian journal's international orientation was determined from the language of publication (Croatian, English, other), national affiliation of the journal's editorial board members (national/international), and author affiliation (national, foreign, collaborative). Authors who published before 1991, the year when Croatia became an independent country, and indicated having a Yugoslavian affiliation were considered Croatian authors.

IF and Q are presented for 1999, the end year of the first inclusion period, and for 2011, the end year of the second inclusion period.

The exclusion period was the period from 2011, when two Croatian journals were excluded from SCI, to 2015. Each of the excluded journals was evaluated during the last years of indexation according to bibliometric indicators, such as IF, Q, total cites and self cites, and cites and self cites used in IF calculation.

3. Results

3.1. The 1975-1999 inclusion period

The first Croatian journal covered by SCI was *Croatica Chemica Acta* in 1975 and the first Croatian journal covered by SSCI was *Collegium Antropologicum* in 1980 (Table 1). Until 1980, 4 journals had been indexed, 3 covered by SCI and 1 covered by SSCI. After a huge gap between 1980 and 1994 when no Croatian journals were indexed, 8 journals became indexed between 1994 and 1999: 7 covered by SCI and 1 covered by SSCI. Finally, 12 Croatian journals were indexed in 1999, 10 covered by SCI and 2 covered by SSCI.

Journal/start year	Year of inclusion	Citation index*	No. of citations before coverage (from 1955)	No. of citations per year before coverage
Croatica Chemica Acta/1956	1975	SCIE	4698	247.3
Periodicum biologorum/1970	1976	SCIE	618	103
Strojarstvo (Mechanical Engineering)/1959	1976	SCIE	11	1.5
Collegium Antropologicum/1977	1980	SSCI	168	56

Društvena istraživanja (Social Research)/1992	1994	SSCI	132	66
Neurologia Croatica/1991	1994	SCIE	26	8.7
Chemical and biochemical engineering quarterly/1987	1995	SCIE	77	9.6
Metalurgija (Metallurgy)/1962	1995	SCIE	1955	45.5
Tekstil (Textile)/1952	1995	SCIE	376	11.1
Food technology and biotechnology/1963	1996	SCIE	223	6.8
Mathematical inequalities & applications/1998	1998	SCIE	-	-
Croatian Medical Journal/1992	1999	SCIE	1422	203.1

* SCIE = Science Citation Index Expanded; SSCI = Social Science Index Expanded

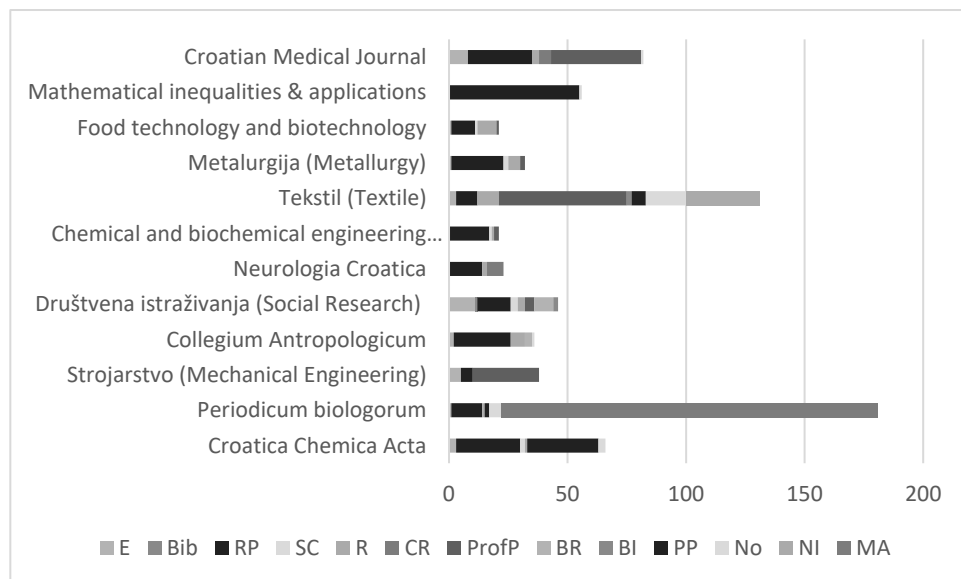
Table 1. Journals in the first 1975-1999 inclusion period and respective citation data before coverage

The citation data in SCIE/SSCI for Croatian journals before coverage (Table 1) show great variation in the number of citations (range: from 11 to 4698). By the time of inclusion, 36.4% of Croatian journals had less than 10 citations per year, 72.7% had less than 100 citations per year, and only 27.3% had more than 100 citations per year.

The number of articles varied from 23 to 181 per volume. In 8 out of 12 journals, the predominant type of paper was research paper (Figure 1). Review papers were not published by many journals, the exception was *Food technology and biotechnology* with 38% of review papers. *Collegium Antropologicum* and *Društvena istraživanja* (Social Research) covered by SSCI published book reviews in Croatian, whereas book reviews in English published by *Croatian Medical Journal*, *Croatica Chemica Acta* and *Neurologia Croatica* were not covered by SCIE.

Of all analysed journals, 58.4% published articles only in English, 25% only in Croatian, 8.3% in both English and Croatian, and 8.3% in English, Croatian, and German (Figure 2).

Editorial boards of 42% of Croatian journals consisted of national members only, and 58% of journals had an international editorial board (Figure 3).



E-editorial; Bib-bibliography; RP-research paper; SC-short communication; R-review; CR-case report; Prof P-professional paper; BR-book review; BI-biographical item; PP- proceeding paper; No-note; NI-news item; MA- meeting abstract

Figure 1. Type of articles published in SCI/SCIE-covered journals

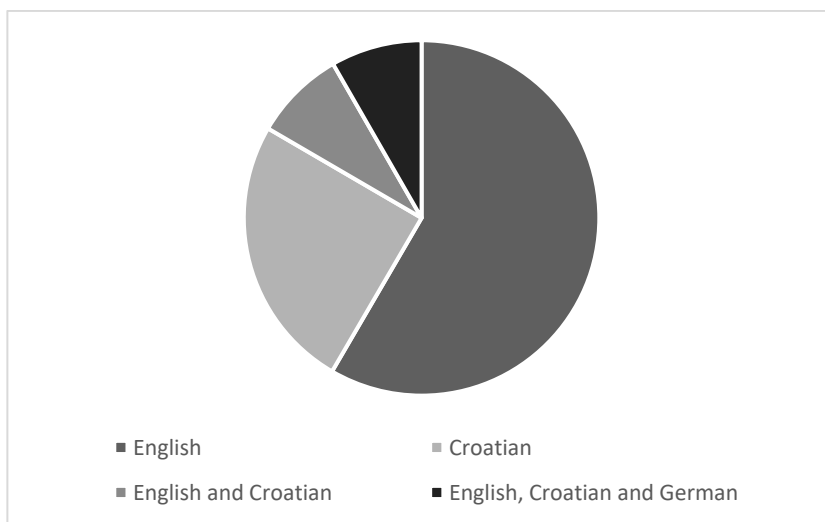


Figure 2. The publication language of articles published in Croatian journals

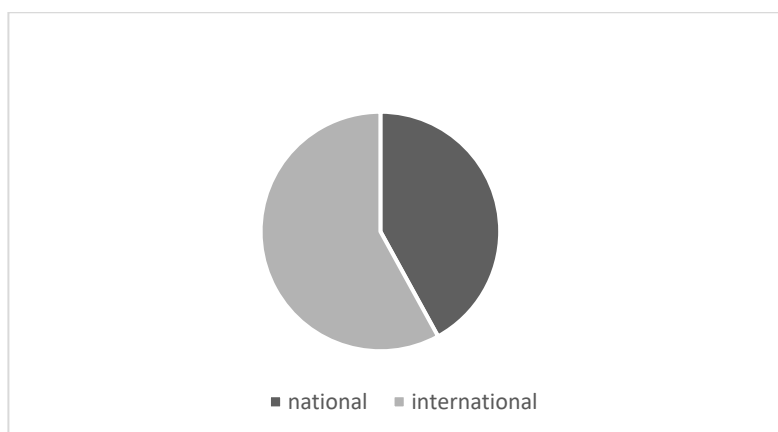


Figure 3. Editorial board structure

One of the requirements for non-English journals to be included in SCIE/SSCI was to publish article titles and abstracts in English [14]. To be more visible, a few Croatian journals also published their content in other languages in addition to English: *Strojarstvo* (Mechanical Engineering) published entire articles (title, abstract and body text) in English, German and Russian, and *Društvena istraživanja* (Social Research) and *Tekstil* (Textile) published their content in English and German.

The analysis of author's affiliation showed that 6 journals published more articles written by local authors, and 6 journals published more articles written by foreign authors (Figure 4). The collaborative papers were more commonly published by two journals, *Metalurgija* (Metallurgy) and *Mathematical Inequalities & Applications*, in comparison with others.

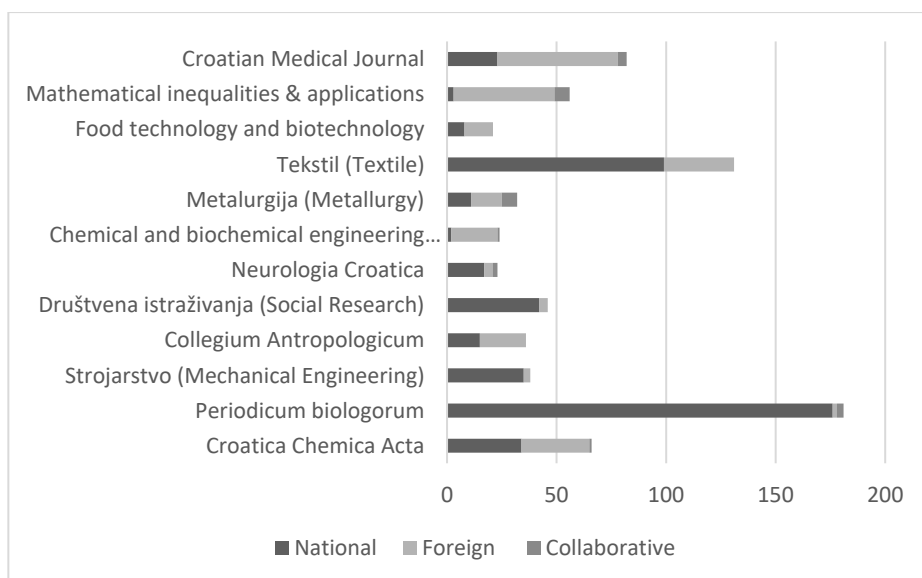


Figure 4. Distribution of papers by author's affiliation

In 1999, 9 of 12 journals had an IF ranging from 0.056 to 0.533 (Table 2). Although indexed since 1994, *Neurologia Croatica* had no IF in 1999 and *Periodicum Biologorum* was delisted from 1993 to 1997 and re-included in 1998, but in 1999 was still without an IF. *Mathematical Inequalities & Applications* had an IF calculated from one year only. *Croatian Medical Journal* did not have an IF in 1999 because it was the year of its inclusion. Because journals can be categorized into more than one JCR subject category, 12 Croatian journals were categorized into 15 subject categories.

Journal	IF (1999)	Q (1999)
Croatica Chemica Acta	0.533	Q3
Periodicum biologorum	-	-
Strojarstvo (Mechanical Engineering)	0.081	Q4
Collegium Antropologicum	0.376	Q3
Društvena istraživanja (Social Research)	0.061	Social issues Q4; Sociology Q4
Neurologia Croatica	-	Q4
Chemical and biochemical engineering quarterly	0.438	Biotechnology & applied microbiology Q4; Engineering, chemical Q3
Metalurgija (Metallurgy)	0.056	Q4
Tekstil (Textile)	0.106	Q4
Food technology and biotechnology	0.404	Biotechnology & applied microbiology Q4; Food science & technology Q3
Mathematical inequalities & applications	0.250	Q3
Croatian Medical Journal	-	-

Table 2. IF and Q ranking in 1999

3.2. The 2006 – 2011 Inclusion Period

In 2006, James Testa, Director of Editorial Development of Thomson Reuters, the owner of ISI Web of Knowledge, presented four main components of the journal selection process: journal publishing standards, editorial content, international diversity, and citation analysis [14].

As the regional journal was measured by the specificity of its content rather than its citation impact [14], citation data before coverage were not included in the analysis of the journals in the 2006-2011 period of intensive inclusion of Croatian journals in indexing databases. Over this period of five years, 40 new Croatian journals were covered by SCIE/SSCI (Table 3): 28 journals by SCIE, 10 by SSCI, and 2 (*Kinesiology* and *Psychiatria Danubina*) by both SCIE and SSCI.

Journal/start year	Year of inclusion	Journal/start year	Year of inclusion	Journal/start year	Year of inclusion
Signa Vitae/2006	2006	Suvremena psihologija (Contemporary Psychology)/1998	2007	Drvena industrija (Croatian Journal of Forest Engineering) /1949	2008
Revija za socijalnu politiku (Croatian Journal of Social Policy)/1994	2006	Ljetopis socijalnog rada (Annual of Social Work)/1994	2007	Šumarski list (Journal of Forestry Society of Croatia)/1877	2008
Mljekarstvo (Dairy)/1951	2007	Jezikoslovlje (eng. Linguistics)/1998	2007	Automatika (Automation)/1960	2008
Psychiatria Danubina/1989	2007	Ekonomski istraživanja (Economic Research) /1988	2007	Tehnički vjesnik (Technical Gazette)/1993	2008
Biochemia Medica/1993	2007	Odgojne znanosti (Educational Sciences)/1999	2007	Gradevinar (Journal of Civil Engineers)/1949	2008
Operators and matrices/2007	2007	Govor (Speech)/1967	2007	Brodogradnja (eng. Shipbuilding)/1950	2008
Geofizika (Geophysics)/1984	2007	Geodetski list (Journal of Geodesy)/1919	2007	Geologia Croatica/1911	2009
Acta Dermatovenerologica Croatica/1993	2007	Promet (Traffic& Transportation)/1989	2007	Journal of Mathematical Inequalities/2007	2009
Acta Adriatica/1932	2007	Acta Pharmaceutica/1950	2008	Veterinarski arhiv (Veterinary Archives)/1931	2009
Croatian Journal of Forest Engineering/1976	2007	Kinesiology/1971	2008	Hrvatski Casopis za odgoj i obrazovanje (Croatian Journal of Education) /1999	2011
Paediatrica Croatica/1956	2007	Arhiv za higijenu rada i toksikologiju (Archives of Industrial Hygiene and Toxicology) /1950	2008	Nanomaterials and nanotechnology/2011	2011
Transactions of FAMENA/1970	2007	Glasnik matematički (Messenger of Mathematics)/1966	2008		
Acta Clinica Croatica/1962	2007	Acta Botanica Croatica/1925	2008		

Zbornik Radova Ekonomskog Fakulteta u Rijeci (Proceedings of Rijeka Faculty of Economics /1971	2007	Mathematical Communications/1996	2008		
Sociologija i prostor (Sociology and Space)/1963	2007				

Table 3. Journals in the 2006-2011 inclusion period

The number of papers in analysed volumes varied from 8 to 162 per volume. In 65% of journals, the predominant type of paper was research paper, whereas review predominated type of paper in 5 journals (Figure 6). The only journal covered by SCIE with book reviews was *Veterinarski arhiv (Veterinary Archives)*.

With respect to the publication language, 60% of journals published papers exclusively in English, 15% exclusively in Croatian, 17.5% in both English and Croatian, 5% in English, German, and Croatian, and 2.5% in English and French (Figure 5).

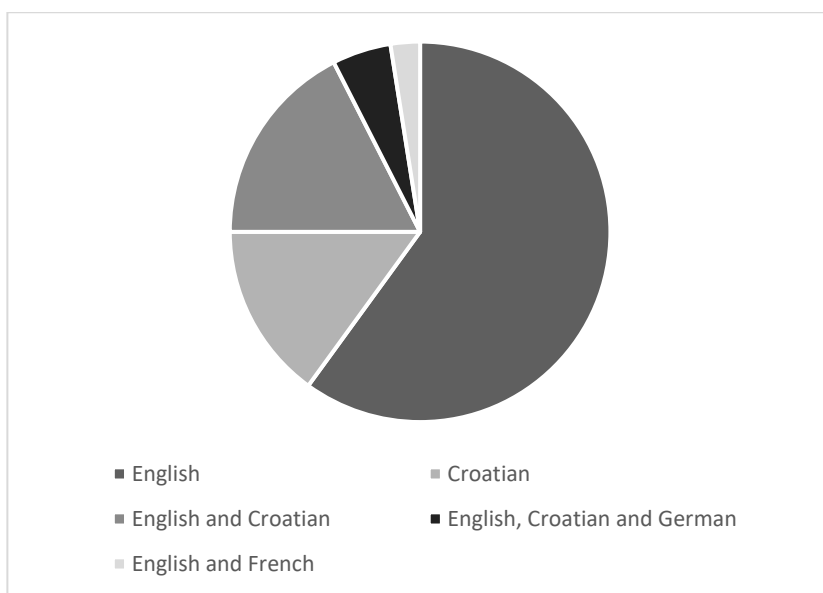
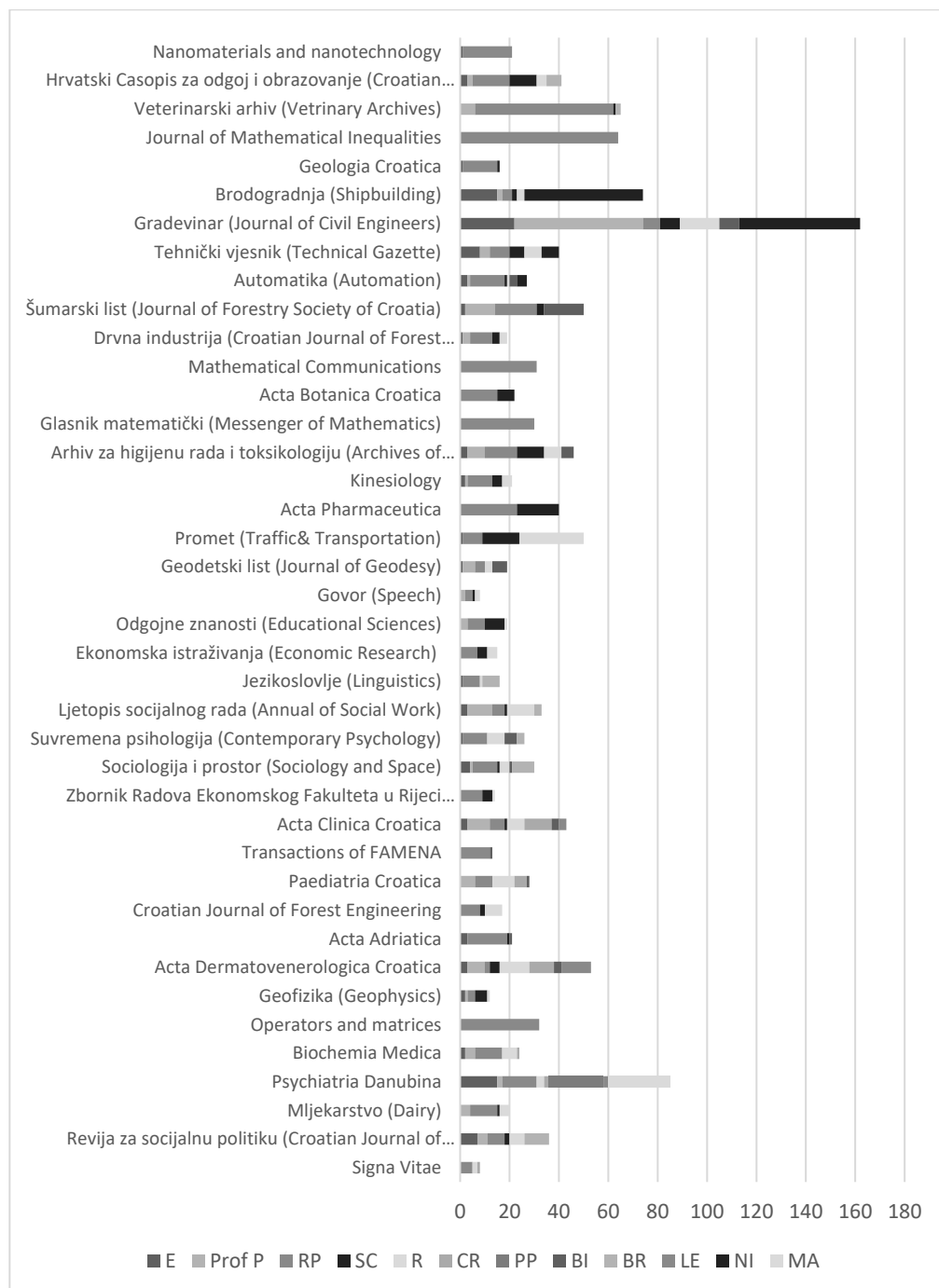


Figure 5. Language of publications in 2006-2011 inclusion period



E-editorial; Prof P-professional paper; RP-research paper; SC-short communication; R-review; CR-case report; PP- proceeding paper; BR-book review; BI-biographical item; LE-letter to editor; NI-news item; MA- meeting abstract

Figure 6. Type of papers published in 2006-2011 inclusion period

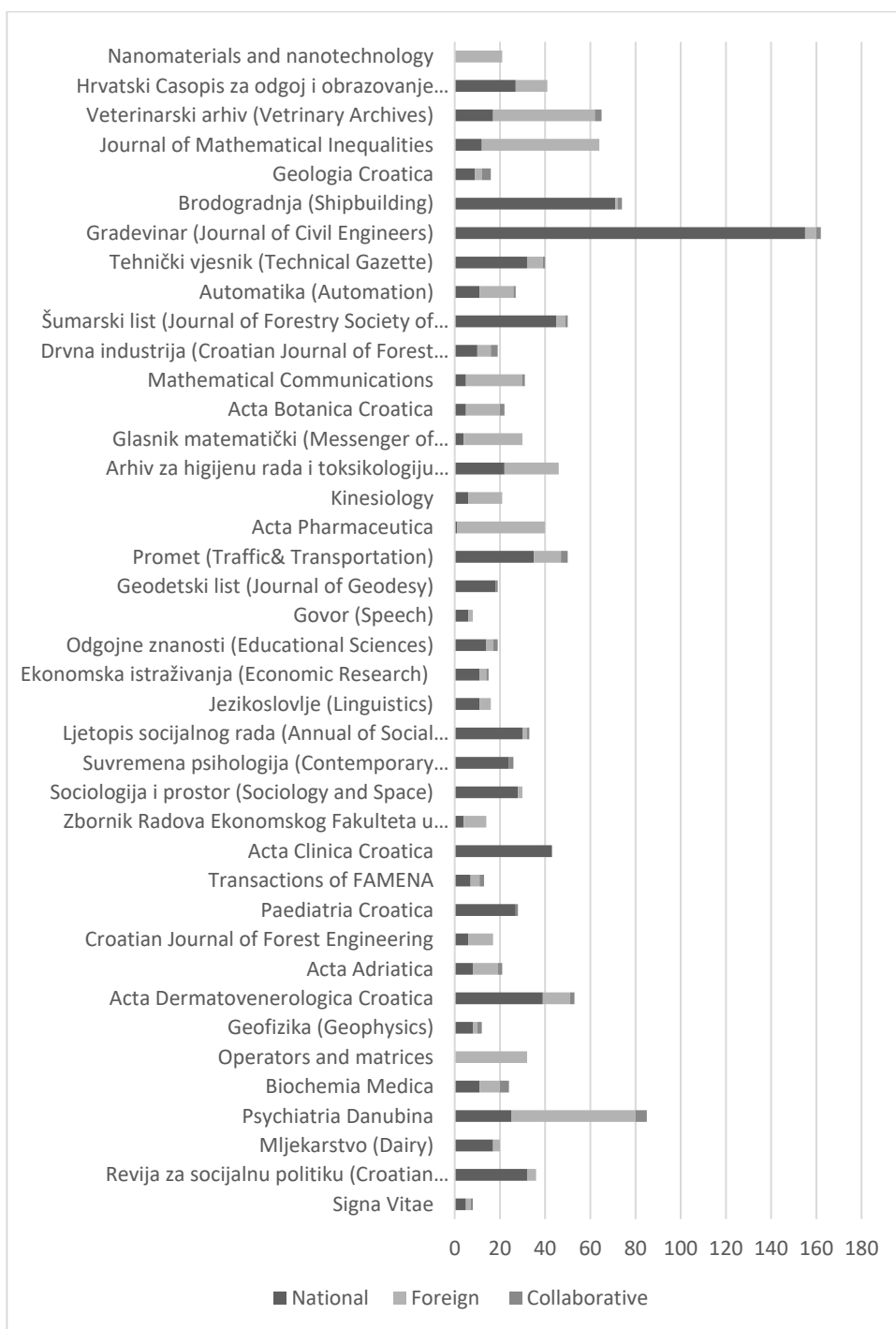


Figure 7. Distribution of papers by author's affiliation

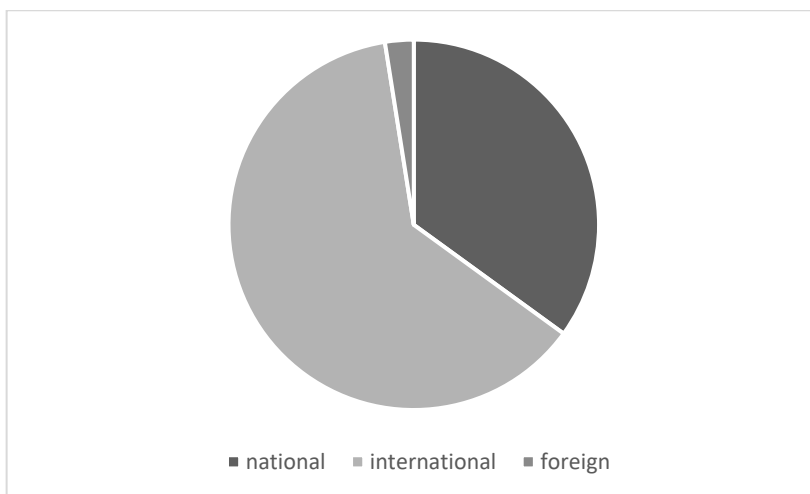


Figure 7. Editorial board structure

In 35 % of Croatian journals, the editorial board members were national, 62.5% of journal had an international editorial board, and 2.5% of them had foreign editorial board (Figure 8).

The analysis of papers by their authors' affiliation showed the prevalence of papers written by domestic authors in 62.5% of journals, and the prevalence of articles written by foreign authors in 37.5% of journals (Figure 7). The percentage of the collaborative papers by authors' affiliation was above average in only three journals: *Biochemia Medica*, *Drvna industrija (Croatian Journal of Forest Engineering)* and *Geologia Croatica*.

The start year and the inclusion year was the same for three journals: *Signa vitae* (2006), *Operators and Matrices* (2007) and *Nanomaterials and Nanotechnology* (2011).

Finally, in 2011, there were 50 Croatian journals covered by both indexes. Forty-four Croatian journals had an IF ranging from 0.030 to 1.796. *Croatian Journal of Education* and *Nanomaterials and Nanotechnology* were included in 2011, so they could not have an IF calculated.

Croatian journals in 2011 were categorized into 52 subject categories; in 47 categories they were ranked into quartiles. None of them was ranked into Q1, two were ranked into Q2, eight were ranked into Q3, and 37 were ranked into Q4 (Figure 9).

According to the WoSCC (SCIE/SSCI) databases in 2011, Croatian scientist published most of their papers in the following categories: Anthropology, Medicine General Internal, Chemistry multidisciplinary, Biochemistry molecular biology, Physics particles fields, and Mathematics.

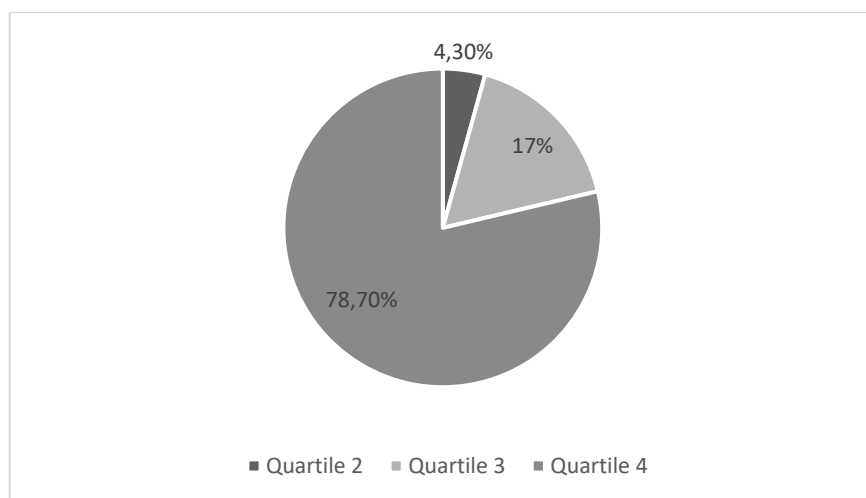


Figure 9. Q ranking in 2011

3.3. The 2011-2015 Exclusion Period

From 2011 to 2015, 12 Croatian indexed journals were excluded from the indexing databases: two were excluded in 2011, four in 2012, four in 2013, one in 2014, and one in 2015 (Table 4).

Journal	Inclusion year	Exclusion year
Strojarstvo (Mechanical Engineering)	1976	2011
Geodetski list (Journal of Geodesy)	2007	2011
Tekstil (Textile)	1993	2012
Sociologija i prostor (Sociology and Space)	2007	2012
Jezikoslovlje (Linguistics)	2007	2012
Govor (Speech)	2007	2012
Neurologia Croatica	1992	2013
Paediatrica Croatica	2007	2013
Suvremena psihologija (Contemporary Psychology)	2007	2013
Odgojne znanosti (Educational Sciences)	2007	2013
Collegium Antropologicum	1980	2014
Metalurgija (Metallurgy)	1995	2015

Table 4. Journals excluded in the 2011-2015 exclusion period

In the last five years before being excluded, the journals from the 1975-1999 inclusion period – *Strojarstvo (Mechanical Engineering)*, *Tekstil (Textile)* and *Neurologia Croatica* – had a very low number of cites used in IF calculation. *Tekstil (Textile)* also had a high percent of total self-cites and self-cites used in IF calculation. All journals were ranked in Q4, at the very bottom in their subject categories, with a low IF (Table 5).

Journal	Year	Total Cites	Total self-cites	Cites used in IF calculation	Self cites used in IF calculation	IF	IF without self-cites	Q
Strojarstvo (Mechanical Engineering)	2010	45	3 (7%)	16	3 (19%)	0.222	0.018	Q4 (107/122)
	2009	50	21 (42%)	4	1 (25%)	0.048	0.035	Q4 (114/116)
	2008	-	-	-	-	-	-	Q4 (105/105)
	2007	18	10 (56%)	2	0	0.045	0.045	Q4 (105/107)
	2006	35	22 (63%)	9	8 (89%)	0.281	0.031	Q3 (79/106)
Neurologia Croatica	2012	8	-	-	-	-	-	Q4 (192/193)
	2011	31	1 (3%)	4	-	0.174	0.174	Q4 (187/192)
	2010	21	1 (5%)	2	1 (50%)	0.125	0.062	Q4 (181/185)
	2009	26	-	3	-	0.077	0.077	Q4 (164/167)
	2008	18	-	4	-	0.069	0.069	Q4 (152/156)
Tekstil (Textile)	2011	101	58 (57%)	12	6 (50%)	0.086	0.043	Q4 (21/21)
	2010	114	72 (63%)	7	4 (57%)	0.05	0.021	Q4 (21/21)
	2009	115	64 (56%)	25	17 (68%)	1.171	0.054	Q4 (18/19)
	2008	136	59 (43%)	23	3 (13%)	0.137	0.119	Q4 (16/16)
	2007	81	37 (46%)	22	6 (27%)	0.107	0.077	Q4 (15/15)

Table 5. Bibliometric indicators of 3 excluded journal five years before the exclusion

Three years before the exclusion, *Metalurgija (Metallurgy)* was permanently in Q2, but the percent of self-cites used in IF calculation increased significantly from 13% in 2010 to 54% in 2014 (Table 6). *Collegium Antropologicum* was continuously in Q3 with a high number of total cites and cites used in IF calculation, but self-referencing

rate increased 2.5-fold in only two years, from 22% in 2009 to 57% in 2011 (Table 9).

Journal	Year	Total Cites	Total self-cites	Cites used in IF calculation	Self-cites used in IF calculation	IF	IF without self-cites	Q
Metalurgija (Metallurgy)	2014	517	*	256	138 (54%)	0.959	0.442	Q2 (29/74)
	2013	380	*	142	64 (45%)	0.755	0.415	Q2 (31/75)
	2012	263	*	80	30 (38%)	0.690	0.431	Q2 (29/76)
	2011	145	*	29	7 (24%)	0.259	0.196	Q3 (56/75)
	2010	166	*	39	5 (13%)	0.348	0.304	Q3 (48/76)
Collegium Antropologicum	2013	1632	427 (26%)	402	148 (37%)	0.609	0.384	Q3 (48/82)
	2012	1441	344 (24%)	291	79 (27%)	0.414	0.301	Q3 (52/83)
	2011	1326	459 (25%)	388	221 (57%)	0.614	0.264	Q3 (41/81)
	2010	1127	381 (34%)	269	111 (41%)	0.491	0.288	Q3 (47/76)
	2009	865	265 (31%)	251	56 (22%)	0.503	0.39	Q3 (41/68)

Table 6. Bibliometric indicators five years before the exclusion

From 2011 to 2013, seven journals from the 2006-2011 inclusion period were excluded: Sociologija i prostor (Sociology and Space), Geodetski list (Journal of Geodesy), Jezikoslovlje (Linguistics), Govor (Speech), Paediatrica Croatica, Suvremena psihologija (Contemporary Psychology), and Odgojne znanosti (Educational Sciences). Periodicum Biologorum was suppressed from 1993 to 1997 and re-index in 1998 and Mljekarstvo (Dairy) was suppressed from 2010 to 2011 and included again in 2012.

4. Discussion and Conclusion

There were only four Croatian journals covered by SCIE/SSCI while Croatia was part of Yugoslavia. After the independence, within a five-year period their number tripled. The efforts of the Croatian academic community to create a larger number of journals with the international visibility were successful. The academic community was aware that internationally visible journals contribute to national recognition and culture promotion.

Although one of the three broad criteria for journal SCI/SSCI coverage was the citation data [17], the results showed that the journals with a low number of citations

in SCIE/SSCI before the inclusion were still indexed. The lack of citations was not the reason for journal exclusion. The time between the journal's start year and inclusion year did not affect the citation rates. For example, *Croatian Medical Journal* received 1422 citations in SCIE in seven years and *Strojarstvo (Mechanical Engineering)* received only 11 citations in SCIE in 17 years. Nevertheless, *Strojarstvo* was covered by SCIE because its value was obviously recognized regardless of the low citedness.

The start year and the inclusion year was the same for four Croatian journals. No information could be found on the exact year when these journals were accepted for indexing by SCIE. If they were indexed from the first volume, editors had to guarantee high journal standards required by ISI. We can only speculate that ISI experts based their decision on the evaluation of papers previously published by the editorial board members. In other words, editor's reputation was crucial. The fact that *Mathematical Inequalities & Applications* had an IF calculated from one year only speaks in favour of this speculation.

Research papers dominated in volumes published in the two inclusion periods; however, there was a lack of review papers, especially in the volumes in the 1975-1999 inclusion period. Although original research papers are regarded more highly than reviews in scientific terms, the studies investigating the relationship between the article type and number of citations received showed that review papers receive more citations than other types of articles [18].

Book reviews were covered by SSCI, but not by SCIE, which is not unusual because the book as a scholarly communication in social sciences is more important than in science and technology [19]. Book reviews, editorials, and letters to the editor also receive a certain number of citations, which are included in the numerator of the IF, but not in the denominator [10]. Theoretically, if these items are highly cited and original articles and reviews receive less cites, the journal's IF can increase. Golubić et al. [20] confirmed that IF decreased when only citations to original research articles and reviews were used for IF calculation.

Considering the publication language and national composition of editorial boards, most Croatian journals in the inclusion periods had an international orientation. Authors' affiliation showed prevalence of domestic authors in the 2006-2011 inclusion period, which was expected, since the regional studies published by domestic authors were in the focus. On the other hand, there was a balance in the representation of domestic and foreign authors in journals from the 1975-1999 period.

Only 25% of journals from the 1975-1999 period and 15% of journals from the 2006-2011 period were published exclusively in Croatian. This may be interpreted as a trend towards greater international orientation at the time. During the 2006-2011 period, journals were chosen by their regional relevance, and papers were mostly written in English.

The editorial board is viewed as a body with decision-making authority, and editors even more so. Greater internationalisation of editors and editorial boards of academic journals is desirable for the evolution of knowledge [21]. Most editorial boards of indexed Croatian journals were ethnically diverse. This certainly had a positive effect on the reputation of the journals.

The number of journals covered by SCIE/SSCI has gradually grown over the years. For example, in the period from 1998 to 2005, their number increased by 649 journals. During the Thomson Reuters' Regional Expansion Programme from 2006 to 2011, the number of journals increased by 3358 journals. During that period, a total of 40 Croatian journals were covered by SCI/SSCI, accounting for 1.2% of the total number of indexed journals in that period.

In 1999, Croatian journals accounted for 0.17% of the total number of journals indexed in SCIE/SSCI (0.18% in SCIE and 0.12% in SSCI). In 2011, as a result of the Regional Expansion programme, Croatian journals accounted for 0.46% of all journals indexed in SCIE/SSCI (equal percentage in both databases). For a small country like Croatia, it was a significant progress. The study carried out by Sambunjak et al. [16] in 2005, which explored representation of journals from Italy, Hungary, Slovenia, Croatia, and Serbia in JCR, found a disproportionately strong representation of Croatian journals in JCR, especially with regard to the gross domestic product and scientific productivity. A quarter of Croatian articles were published in 12 Croatian journals covered by JCR. When comparing the representation of these countries in JCR in 2011 and 2018, the status of Croatian journals remained the same (Table 7).

Country	Number of journals in JCR		
	2005	2011	2018
Serbia	0	20	22
Slovenia	4	21	19
Hungary	15	35	37
Italy	64	140	125
Croatia	12	47	38

Table 7. Representation of journals in JCR

From 1999 to 2011, the number of Croatian indexed journals increased from 12 to 50. However, according to the bibliometric indicators, Croatian journals were not highly ranked, like most of the journals from the scientific periphery.

More than a few studies tried to reveal why journals from the scientific periphery and from non-English speaking countries have lower citation counts although they publish in English. Bordons et al. [22] suggested that scientists prefer to cite research from mainstream countries rather than from the periphery. Liu [19] investigated the association between the number of citations and the language of publication and found that most papers in languages other than English suffer from lower citation counts in WoS indexes. Skopec et al. [23] suggested that geographic bias in some form was impacting peer review and that reviewers and editors preferred sources from high-income countries.

Jokić [8] analysed bibliometric indicators of Croatian journals covered by JCR and found that Croatian scientists did not publish their best papers and most cited ones in Croatian journals. González-Alcaide et al. [24] confirmed that, despite publishing in international journals in English, authors from some non-English speaking countries have fewer citations in WoS than authors from the USA. They also

concluded that the journals of Anglo-American origin occupy the top ranks in all disciplines or fields of knowledge.

Croatian journals show lack of international collaborations in the 1999-2011 period. Low et al. [25] and Tuan V. Nguyen et al. [26] showed that papers with more coauthors attracted more citations. They highlighted a linear correlation between the proportion of international collaboration and the journal impact factor, suggesting that papers with international authorship were of higher quality than those without such collaborations.

The results from both inclusion periods suggests that Croatian scientists in the field of chemistry, anthropology and general medicine (second inclusion period) published most papers in national journals.

WoS Editorial statement about dropped journals [27] suggests that journal coverage is constantly under review and journals must maintain high standards and relevance to the WoS. The reasons for deselecting a journal are usually poor performance (delayed publishing, poorly cited by other journals, etc.), high self-citing rate, and very high volume of material, which is not a positive trait. Self-citation rate of 20% or less is characteristic of the majority of high-quality journals in JCR.

In the period of four years, from 2011 to 2015, 12 Croatian journals were excluded from SCIE/SSCI. The reasons for exclusion usually were low number of cites used in IF calculation, high self-citing rates, low IF, and consistent ranking into Q4, at the very bottom of the subject category. The exceptions were *Metalurgija (Metallurgy)* and *Collegium Antropologicum*, which were also delisted, although they had relatively good bibliometric indicators and stable position in JCR. According to the bibliometric indicators, it is not entirely clear why these two journals were excluded. We can only assume that self-referencing rate was too high in both journals.

In 2018, there were 38 Croatian journals covered by SCIE/SSCI, 7 of them in SSCI and 33 in SCIE (Kinesiology and Psychiatria Danubina were indexed in both SCIE and SSCI). Journals were categorized into quartiles in 51 JCR subject categories (Figure 10).

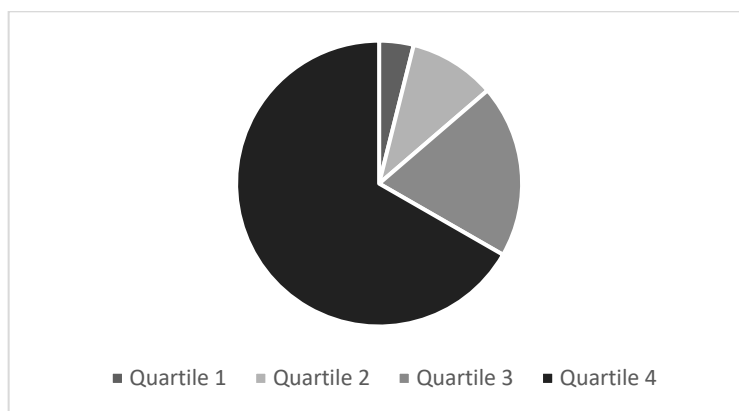


Figure 10. Q ranking in 2018

Table 8 shows a representation of Croatian journals in quartiles for the years 1999, 2011 and 2018. The highest percentage of journals was ranked in Q4 and in Q3, but there was an increase in number of journals in Q2 and Q1 over the years. The analysis of representation of Croatian journals in quartiles for the years 1999, 2011 and 2018 showed that the highest percentage of journals were ranked in Q4 and in Q3, but the distribution of Croatian journals in quartiles in 2018 showed progress when compared to the previous years. It indicated a continuous positive trend in the Croatian scholarly journals publication and efforts in raising the quality of Croatian journals.

	Percentage of indexed Croatian journals		
	1999	2011	2018
JCR quartiles	n=12	n=50	n=38
Q1	-	-	3.9
Q2	-	4.3	9.8
Q3	38.5	17.0	19.6
Q4	61.5	78.7	66.7

Table 8. Representation of Croatian journals in JCR quartiles

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The Impact of Information Technology Methods on Accounting Information Quality: Empirical Evidence From Iran

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Abstract

Information Technology is a key factor in eliminating the limitations posed by time and location and gives a much better and a faster access to information. In other words, technology has revolutionized work methods as a result of which, the paper which was used as a substrate for writing the work upon it has now been replaced by an electronic substrate. The changes created by technology include the use of Blockchain, IoT (Internet of Things), Cloud Accounting and Big Data to do accounting in automated form. The statistical sample of this study is given on the basis of the 171 person Cochran formulae consisting of financial managers, accountants and auditors of the Tehran city. Empirical results show that the use of Information Technology has a very significant role on the quality of Accounting Information and all these factors are influential in the quality of accounting system.

Keywords: Cloud Accounting, Internet of Things, Blockchain, Big Data, quality Accounting Information

1. Introduction

In the recent years, due to the integration of Information Technology and Accounting, new tools and methods have come into use and has resulted in the continuous increase of speed and accuracy and also the omission of the use of paper for office work thereby also saving time and money. Information Technology thus by revolutionizing work methods has become electronized. The rapid development of Information Technology and its extensive uses has prompted every organization to use new softwares which in turn has further increased the use of computers and the accounting work to be

performed faster and with more precision. The accountant should be able to keep up with the new technologies so that he may be able to give useful information to the users[1]. Implementing digital solutions in accounting is also a product of price reductions in software, internet-based applications and the need for access to information. In addition to this, standardisation of technology and software also resulted in the increase of employees' productivity, increase in the speed of data collection, and also increase in saving of important data[2]. Today the accountancy experts emphasises upon technology development which is one of the most important expectations that has arisen in the field of accounting and its implementation is increasing at a considerable rate which is described as a model that helps this growing trend and the promotion of business having a lasting affect on business procedures. Therefore, the development of technology today in the field of accountancy is more prominent than ever. Although the development of technology is a very wide concept, but it is an important element[3]. Information Technology comprises of skills such as computer operations, databases, accountancy softwares, etc[4]. One of the uncertain aspects of implementing Information Technology in accounting is whether the merits of its implementation outweighs costs of its implementation. The complete replacement of traditional systems and procedures is not feasible at present because the full benefits of Information Technology is not achievable unless there is participation by organized owners and investors[5].

2. Therotical Background

Drives are one of the most common Cloud tools that provide you with an information space on their servers and you can transfer your required files, images and information to these spaces and then have an access to these information from anywhere and anytime just by having an internet connection and username and password. Some of these Cloud platforms allow you to share your files with others also[6]. Because of quick accessibility and no need to install new software on your PC and usability of various tools such as tablet, smartphone, etc, using Cloud systems can help you in many ways. There is also no need to pay for expensive software licences if you use the system[7]. The Internet of Things can simply be defined as the communication between objects that can receive and transmit information through computer networks and act on information received from their sensors or other systems within the network or network administrator. Of course, recently, in order to have ease of use and non-interoperability with the existing networks, specific protocols have been developed, but there are no limitations for using the type of communication network for creating a platform for IoT[8]. Wireless communication between objects is defined as the interaction between units to achieve a common goal. Typically all units have internet connection which generate data from devices such as phones, cameras, and any other data production device, and all are considered as one device. In IoT, all objects in the network platform communicate with each other, and the data are constantly processed by using smart creation devices such as wireless sensor networks, web-based middleware and platforms and the parallel use of Cloud computing to have permanent access to information, as a result of which a tremendous power is created for the

integration of information and the careful monitoring, control and updating of this information for asset management [9]. In this structure, each server workstation, PC, laptop, network-connected devices and everything else on the platform of these networks maintains the full version and updates of the entire database. Any new data that seeks to enter the network uses a participant feedback mechanism on the network based on a time/date entry to be recorded as a new event in the general ledger[10]. In short, Blockchain can be considered as a database built on distributed ledger technology. In order to enter new data in this database, permission of the majority of the active users in the Blockchain should be obtained. This database does not have a manager; it is governed by the rules of collective consent. Moreover, in a Blockchain structure, each user saves and maintains a complete copy of the available data of the database. These databases are constantly updated in a concurrent manner[11]. Big data is a huge amount of data that is significant enough to be impossible to analyze manually or using traditional accounting software. Another factor is that Big Data includes both structured and unstructured data, which creates a problem in the analysis process when using traditional software[12]. Big Data consists of large datasets that are not typically analyzed by database management systems or traditional software applications. The reason for the acceptance of this term is the growing volume of information which, with the increasing development of computing technology and remote communication especially internet communication and environmental assessments, are accessible to an extent that various types of data become reachable. Big Data will be having a major impact on financial accounting. Textual information, video, audio and visual information become accessible through Big Data, which can improve financial accounting information and financial reporting methods[13]. [14]studied the impact of the automation process on global accounting services and the results showed that automation technology has a significant impact on individuals and organizations in changing the work time reductions, which can also lead to a reduction in the number of workers. [15] studied environmental technology change and the future of accounting research behavior. The results showed that changes in technology and research and behavioral environments in accounting would occur only when acceptance of changes in the timely development and design of a research approach would take place provided that accounting research moved toward better and standard decision making policy. [16] examined automated accounting in accounting companies: A qualitative study of attitudes. The results showed that consultants' attitude towards automated accounting was positive and this attitude could influence the changes and development of technology in the future of accounting. [17]made the assessment of accounting staff based on computer environment, and the results showed that use of computerized system brings job promotion. All persons in a computerized accounting system can be divided into three categories: 1) persons competent in business; 2) persons competent in accountancy; 3) persons competent in information technology. [18] examined the skill and training needs of accountancy students and accountants for the automation of accountancy. The results of the data analysis showed that there is a significant relationship between the need for technology skills and the training of accounting students and automation of accountancy. These skills include software development, computer operations and

analytical ability in automation system. [19] examined information and auditing systems. In fact, security is one of the most important technological issues, and its importance is due to the lack of security in a system for reporting information with sufficient reliability which may prevent reporting of the required information to people inside and outside of the organisation and also may increase the opportunity for forgery, manipulation and cheating. At present due to the lack of sufficient security within the framework of professional accounting in the form of systems and networks, world trade is facing many problems. Fraud and deliberate exaggeration in corporate accounting and other embezzlements have led to an increase in bankruptcies of financial companies. Examples of the collapse of large companies such as Enron, WorldCom, Global Crossing in the United States, and others have all severely undermined the credibility of financial reporting and their accountability. Such cases can partly lead to undesirable effects on the economic situation of countries. Moreover, fraudulent activities have had a damaging effect on investment and financial markets, as people argue these problems happen due to the insecurity of the accounting and auditing profession. [20] have undertaken the task of identifying and ranking the challenges of employing information technology in accounting, as defects in accounting system prevents the timely and proper availability of information to the users due to which irretrievable losses are inflicted to them. Accounting has been introduced as a kind of information system whose task is to process raw data and convert it into comprehensible information. However, today in many of the accountancy courses, students get into the position of using accounting information, and in almost none of the courses do they learn where this information comes from. [21], undertook to study the role and effect of knowledge and skill of auditors concerning the fundamentals and methods of information technology and accounting information systems for evaluating internal controls and performance of auditing operations, and this study was performed by distributing questionnaires among auditors, and for the analysis of this data the T-test was used. The results showed that in spite of the correlation between all independent and dependent variables of this research, only four basic factors including knowledge of accounting information systems, knowledge of system security levels, familiarity with data processing and familiarity and working with accounting software had significant effect on evaluation of internal control and performance of auditing operations. [22] have investigated the role of information technology on the development of accrual accounting system in one of the medical sciences universities of Iran (Kermanshah University of Medical Sciences). The results showed that information technology has a very decisive role in the planning and decision making activity of the managers, management of data and information, evaluation of the performance of organizations and employees, improvement of information security, financial reporting, and human resource management, and that all these factors are influential in the advancement of an accrual accounting system, and that an information technology appropriate to that system can be regarded as the key pillar of the influence of these factors. [23], investigated the role and influence of auditors' knowledge and skills on the basics and methods of information technology and accounting information systems on evaluating internal controls, assessing audit risk, and performing audit operations. The results showed

that despite the correlation between all independent and dependent variables of the study, only four basic factors including knowledge of accounting information systems, understanding of system security levels, familiarity with data processing and familiarity with the usage of accounting software had a significant effect on internal control assessment and the implementation of audit operations; and factors such as familiarity with types of operating systems, knowledge of computer applications and knowledge of programming language have no significant influence on the assessment of internal control and auditing operations. Furthermore, the results showed that the extent of knowledge about security of accounting information systems as well as knowing the electronic data processing facilities of the owner would be effective in more accurate estimation of audit risks. The quality of Accounting Information is an important indicator that shows accurate information related to financial reporting, information about the company's operations especially cash flows expected by the company and the accruals, which help the investors to make the right investment decisions.

3. Hypotheses Development

In the short run, Blockchain technology can be used as a platform for the voluntary disclosure of information by the companies. This is a quality mark which enables the companies to solve the problem of investor confidence[24]. In the long run, this program can have a tremendous effect on financial accounting. This technology can reduce errors in disclosure and profit management effectively and greatly improve the quality of information, reducing information asymmetry. Blockchain technology has features such as transparency, security, stability and immutability, as well as the capability of fostering trust among market participants[25]. Effective implementation of Blockchain technology into the accounting ecosystem increases the potential for improving the quality of information that is given in the financial reporting process[26]. Therefore, the first hypothesis of the research is as follows:

Hypothesis 1: Blockchain has a significant influence on the quality of Accounting Information.

Recently, advances in the field of Information Technology in the field of accounting have developed significantly. For example, based on smart contract technology, a systematic framework for collecting information has been created to achieve a holistic approach for personal online behavioral ratings. To improve performance and also the efficiency of smart contracts and IoT technologies, an official language was developed to specify the interaction between bids and requests and a method for negotiation independence of smart contracts[27]. This method investigates the costs and changes needed to reach an agreement[28]. A framework based on smart contract that includes several accessible information control contracts is presented. Better access control of distributed and reliable information for IoT systems is achieved under this framework. However, an understanding of the challenges of IoT usage in Accounting Information quality is also very important[29]. Therefore, according to the above mentioned points, the second hypothesis is expressed as follows:

Hypthesis 2: Internet of Things has a significant influence on the quality of Accounting Information.

Organizations that use Cloud accounting need less infrastructure to store their data on the server. Also, these businesses do not require IT specialists to maintain and update software. Cloud accounting is similar to cloud computing. In today's global upheavals and business turmoils, top financial managers must understand the financial delivery patterns of the business in which computational resources are presented as services[30]. This is really an opportunity for companies. With pricing policies that influence profitability, companies should make changes in their accounting and financial systems. The traditional information technology model is different from Cloud computing, and the result is that accounting as an information system with its main feature of providing information at the right time should find its information in Cloud computing[31]. Therefore, the third hypothesis is given as follows:

Hypothesis 3: Cloud accounting has a significant impact on the quality of Accounting Information.

The integrated use of Big Data analytics and Accounting Information is a key factor in improving the main competitiveness of a company [32]. Accounting information has qualitative issues such as high cost and poor efficiency. In fact, the present study provides theoretical support for accounting data processing based on Big Data analysis[33]. Analysis of Big Data can perform high level analysis and visual search of Accounting Information[34]. Thus the fourth research hypothesis is presented as follows:

Hypothesis 4: Big Data has a significant impact on the quality of Accounting Information.

4. Research of Model

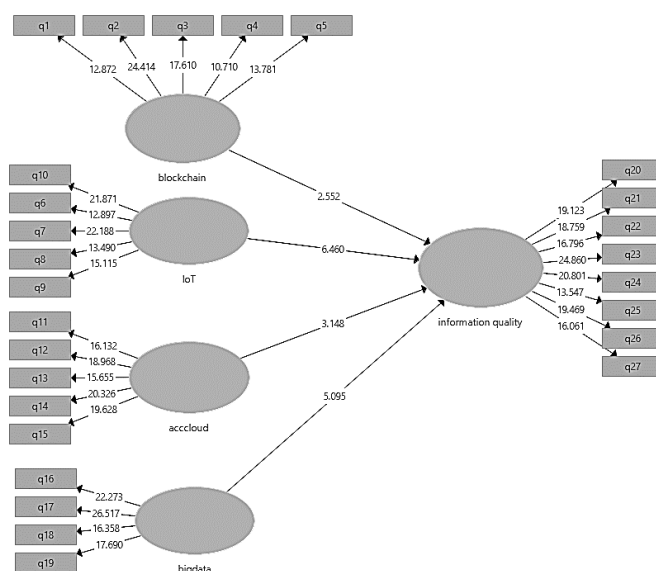


Figure 1. Conceptual model of research

5. Research Method

The research method is of applied and descriptive-survey type. In order to collect the theoretical foundations of the present study we used library studies, scientific and research articles and journals. For the survey research, questionnaires and interviews were used as data gathering tools. Therefore, in this study to collect data, the standard questionnaire tool [35].was used, such that, questions 1 to 5 were about Blockchain variable, questions 6 to 10 were about Internet of Things, questions 11 to 15 were about Cloud accounting, questions 16 to 19 were about Big Data and finally questions 20 to 27 were about Accounting Information quality. The statistical team for this study consisted of financial managers (103 persons) and managers of accounting and auditing companies (200 persons) and accounting software providers (109 persons) who were located in Tehran for the month of February 2010, totally comprising of 309 persons. Statistical sample was according to the 171 person Cochran formula. The sample is in the form of random-class such that they were selected from a particular industry and class.

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{n} \left(\frac{z^2 pq}{d^2} - 1 \right)} = 171 = \frac{\frac{(1.96)^2 \times (0.5)(0.5)}{(0.05)^2}}{1 + \frac{1}{171} \left(\frac{(1.96)^2 \times (0.5)(0.5)}{(0.05)^2} - 1 \right)} = 171$$

In this formulae, $z1.96$, $p0.5$, $p0.5$, $d0.05$ and n are the statistics research team. The validity and reliability of this research tool questionnaire based on Cronbach's alpha coefficient is Blockchain variable 0.72. Internet of Things 0.76, Cloud Accounting 0.78, Big Data 0.75, and Accounting Information quality 0.86, respectively. The software used in this study is SPSS26, which is capable of testing hypotheses and providing descriptive and inferential analysis. Descriptive statistics are presented in this research in two sections. In the first section, descriptive statistics of the demographic variables of the respondents to the given questionnaire are provided and in the second section, descriptive statistics of the questions of the questionnaire are given in the form of variables. In the statistics section, inferential statistical tests such as determination of data normality (Kolmogorov-Smirnov test), regression test, and Pearson correlation coefficient are given.

6. Descriptive Statistics

Demograph ic factors	Type	frequency	Percentage	Cumulative percentage	Average	Standard deviation
Gender	female	68	39.8	39.8	1.60	0.49
	Male	103	60.2	100.0		
Age	Between 31 to 41 years	44	25.7	25.7	1.87	0.60
	Between 41 to 50 years	105	61.4	87.1		
	Above 50 years	22	12.9	100.0		
	Graduate	24	14.0	14.0	2.11	0.61
	Post graduate	104	60.8	74.9		

	Doctorate	43	25.1	100.0		
Work experience (proprietorship)	Between 6 to 12 years	23	13.5	13.5	2.46	0.92
	Between 12 to 18 years	73	42.7	56.1		
	Between 18 to 24 years	47	27.5	83.6		
	Between 24 to 30 years	28	16.4	100.0		

Table 1. Descriptive statistics of demographic variables of research

As seen in table 1, the descriptive statistics of the demographic variables of the study is most frequent in the gender variable of the statistical population, with 103 being of male gender. The highest frequency of age variable is between the ages 41 to 50 years with a frequency of 105. Furthermore, the highest frequency of education belongs to postgraduate level of education with a frequency of 104, and finally, the highest frequency in proprietorship (work experience) is related to 12 to 18 years work experience group with a frequency of 73.

Accounting Information quality	Big Data	Cloud Accounting	Internet of Things	Blockchain	
171	171	171	171	171	Number
0	0	0	0	0	Lost data
3.2054	3.2485	3.2702	3.2713	3.3123	Average
.61232	.63158	.60292	.58676	.56737	Standard deviation
.719	.175	.596	.769	.549	Skewness
.524	.430	.344	.368	.109	Kurtosis

Table 2. Descriptive statistics of research variables

As seen in Table 2, the descriptive statistics of the research variables had 171 respondents, among which the independent research variables are respectively Blockchain variable with an average of 3.312, Internet of Things 3.271, Cloud Accounting 3.270, and the Big Data variable 3.248. The average of the dependent variable, namely the quality of Accounting Information is equal to 3.205. Among the indices of distribution and symmetry, the Blockchain variable has the lowest kurtosis of 0.10. This index in other variables is respectively, Internet of Things 0.36, Cloud Accounting 0.34, Big Data 0.43 and finally in the research dependent variable it is seen to be 0.52 and so the dependent variable has the highest kurtosis index level.

7. Inferential Statistics

If the alpha coefficient is greater than 0.7, the test has an acceptable reliability, so the above test has a satisfactory reliability. As indicated, the level of significance was significantly greater than the type 1 error at the 0.05 level in all the variables under

study. Therefore, the assumption that the variables under study are normal is not rejected. Also, significant level diagrams show that the indices and variables of the study are independent and dependent on the confidence level of 0.95 with normal distribution.

Test	Coefficient	Blockchain	Internet of Things	Cloud Accounting	Big Data	Accounting Information quality
Cronbach's Alpha	Coefficient	0.725	0.766	0.784	0.750	0.869
Komogorov-Smirnov	Coefficient	0.103	0.117	0.132	0.108	0.113
	Significance level	0.78	0.72	0.52	0.92	0.61

Table 3. Reliability & normality test results

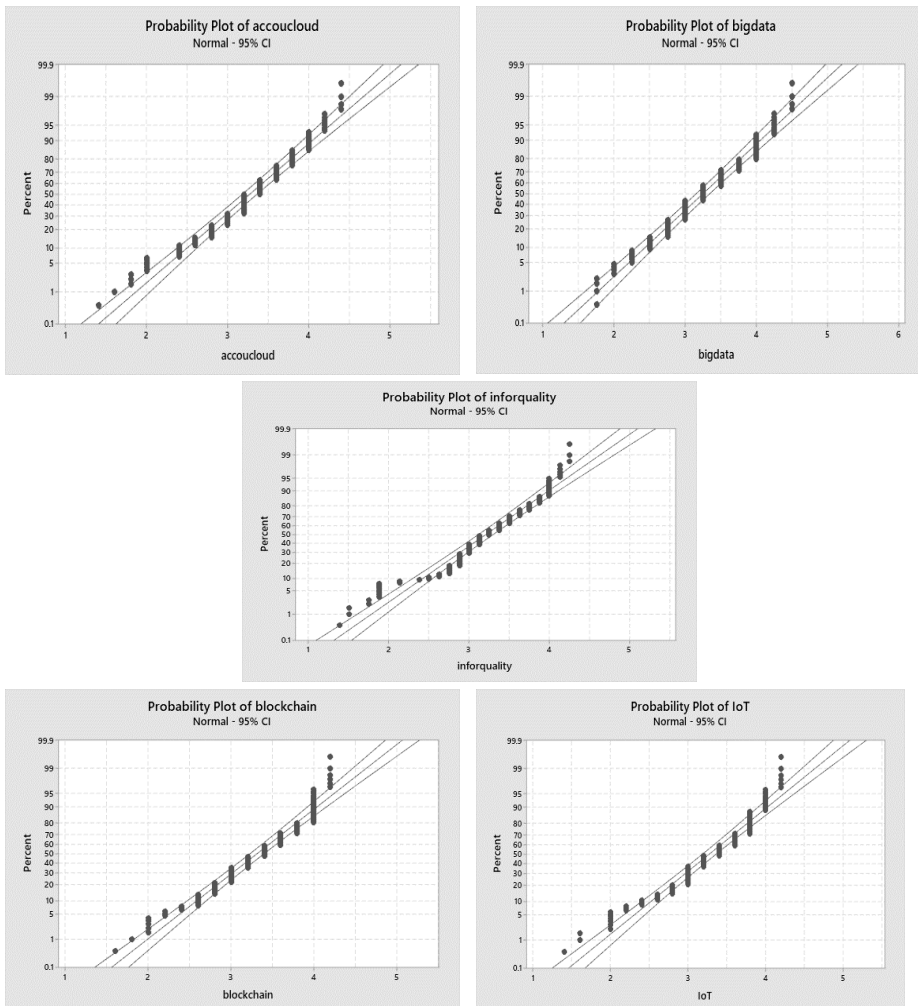


Figure 2. Probability plots of accoucloud, bigdata, inforquality, blockchain and IoT

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	52.636	4	13.159	196.746	.000 ^b
	Residual	11.103	166	.067		
	Total	63.738	170			

Table 4. Test results of research regression

Analysis of regression variance is to investigate the existence of a linear relationship between independent and dependent variables. In other words, it shows whether or not at least one of the independent variables has a linear relationship with the dependent variable[36]. In the present study, as the significance level is less than 0.05, hence it can be concluded that at least one of the independent variables has a linear relationship with the dependent variable.

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.189	.126		-1.503	.005
	Blockchain	.173	.057	.161	3.035	.003
	IoT	.357	.058	.342	6.151	.000
	CloudAccounting	.237	.067	.233	3.553	.000
	BigData	.270	.050	.279	5.373	.000

Table 5. Test results of standard coefficients of the research regression

In the present study, standardized coefficients columns show that Internet of Things with 0.34, Big Data 0.27, Cloud Accounting 0.23 and Blockchain with 0.16 had the highest and lowest impact on the dependent variable, namely the quality of accounting information. Moreover, as the significance level of the regression coefficients equality test is less than 0.05, hence the assumption that the regression coefficients are equal to zero is rejected and it is not necessary to remove them from the regression equation. In other words, these four independent variables affect the dependent variable.

		Blockchain	Internet of Things	Cloud Accounting	Big Data	Information Quality
Blockchain	Pearson Correlation	1	.701**	.765**	.682**	.769**
	Significance Level		.000	.000	.000	.000
Internet of Things	Pearson Correlation	.701**	1	.795**	.681**	.830**
	Significance Level	.000		.000	.000	.000

Cloud accounting	Pearson Correlation	.765**	.795**	1	.760**	.840**
	Significance Level	.000	.000		.000	.000
Big Data	Pearson Correlation	.682**	.681**	.760**	1	.798**
	Significance Level	.000	.000	.000		.000
Information Quality	Pearson Correlation	.769**	.830**	.840**	.798**	1
	Significance Level	.000	.000	.000	.000	

Table 6. Pearson Correlation Coefficient

As shown in Table 6 of the correlation matrix, the Cloud Accounting variable with a correlation coefficient of 0.840 and a significance level of less than 0.05 has a significant effect on the dependent variable, namely the quality of Accounting Information, whose correlation value is strong. Correlation coefficient of 0.830 and significant level of 0.000 have strong and positive correlation with Accounting Information quality. The variables of Blockchain variable with 0.769 and Big Data variable with 0.798 have strong and positive correlation with dependent variable.

8. Conclusion

In the present study, the impact of using informatin technology methods on the quality of Accounting Information was investigated. As the hypothesis test results show, regarding the hypothesis 1: Blockchain with a correlation coefficient of 0.769 has a strong and positive correlation with the quality of Accounting Information. Hypthesis 2: Internet of Things with a correlation coefficient of 0.830 and significance level of 0.000 has a strong and positive correlation with quality of Accounting Information. Hypothesis 3: Cloud accounting with a correlation coefficient of 0.840 and a significant level of less than 0.05 has a significant effect on the dependent variable, namely the quality of Accounting Information, with a positive and strong correlation value. Hypothesis 4: Big Data with a corelation of 0.798 has a strong and positive correlation with the quality of Accounting Information. Based on the results of this test, it was found that the effect of using Information Technology methods on the quality of Accounting Information has a significant relationship. Therefore, it is suggested that for achieving more accurate results on the impact of using Information Technology methods on the quality of Accounting Information, other factors besides these four variables be taken into consideration. The results of this study show that the use of Information Technology has led to significant changes in accounting and financial reporting. Today, IT with various tools has brought new achievements for the accounting staff. With the increasing utilization of Information Technology in organizations and companies, there have been huge changes in the way things are being done. Information Technology has changed the way of doing things by making it electronical. Due to the speed by which things are changing in the field of IT, the business and economic environments have been greatly influenced by technological

developments. Accounting as a language of commerce and informaton system has to synchronize itself with new technologies. Information Technology is a complementary tool whose usage at the same time provides quick access to the information required for preparing financial reports at a lesser cost, preparing and setting up mid term reports, increasing efficiency and saving costs, and hastening decision making by managers and investors, creating a office system which doesn't use paper anymore as it is no longer necessary or justified in today's world of Information Technology as accounting has to use all or some of the Information Technology techniques to deliver its services and fulfill its tasks. By taking into consideration the swift transformation that is taking place in Informaiton & Communication Technology, it is hoped that even in the field of accounting there will be rapid developments in the future.

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Proposing a New Term for Organizational Behavior Literature: Achilles's Tendon Syndrome in Businesses

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Abstract

In spite of threatening external factors such as uncertain environmental structure and market pitfalls, the companies struggling with the difficulty of retaining the current customer and finding the potential ones should first realize the existence of “Achilles Tendons” within themselves. To prevent this potential problem, they should focus on the labor which can be a very substantial weak point and an important asset as well. Regarding serious problems arisen from labor force, this study proposes a new term called as “Achilles Tendon Syndrome” to be used in organizational behavior literature. Various theories from different disciplines such as medicine, psychology, physics, economics and sociology support development process of the term. Similarities and differences with other close concepts are also provided throughout the paper. The current study aims to inspire future studies by filling an important gap in the organization and management literature.

Keywords: Achilles Tendon Syndrome, Organizational Behavior, Service Sector Organization, Brand Value, Corporate Reputation

1. Introduction

Business enterprises are defined as open systems because of the input-transform-output loop's providing them endurance and interaction [56]. While these open system enterprises comprise internal and external environments depending on the characteristics of the relationship they build upon [88], they both keep interacted with this environment and depend on those environmental factors to keep their sustainability [12]. The interaction with both its internal and external environments in

competitive conditions [96] presents some opportunities and threats for enterprises [97].

In order to ensure competition and sustainability, the enterprises need agents that will carry them forward. One and maybe the most important of these agents that enterprises need are customers who are also one of the close-external environmental factors [37]. The perception of customers is vital to enterprises. In order to retain the existing customers and accessing the new potential ones, enterprises need to have a positive place in the perception of them. The image or interaction that customers gain about the business enterprises develops as a general impression, reflecting the respect [35] and trust that the enterprise has gained so far. This critical concept, which can also be associated with the success of competition [28], is corporate reputation [9]. Furthermore, each perception that occurs in the minds of the customers towards enterprises also reflects onto brand. In other words, the brand is an image that is in the minds of customers and the reflection of their perception [92]. The relationship built between the customers and brand is called as brand value in the literature [98]. This term refers to how the brand is positioned by the consumer and the value assigned to the brand. In order to preserve and increase the brand value, it is necessary to attach great importance to the value of the customer, which expresses the perception of the enterprise and its output in the customer's mind [13]. Because, brand value and corporate reputation are both long-term earnings for enterprises [24].

The concept of *corporate reputation and brand value* are of paramount importance in working environments where customers and employees communicate directly, especially in enterprises operating in the service sector [6]. Therefore, problems that may occur in an environment where customer and employee come together will have a negative impact on brand value and / or corporate reputation for the enterprise. The reason is that individuals tend to pay attention to negative experiences and information more when making an impression, especially in such a situation where the production and consumption of service are occurred at the same time. In other words, negative information outweighs even an individual tries to make a general impression. This situation, called as “negativity effect”, shows that although people think that evaluation is fairly equal, they actually emphasize and attach importance to negative qualities more [87].

On the other hand, if the customer has a negative perception about the enterprise, potential customers with whom they share their experiences will tend to focus on negative information. According to this condition defining as the “impact of negative information”, when people try to obtain information about an enterprise, they give more importance on negative information they acquire, which results in the negative information they have acquired plays a more prominent role when they make decisions [87]. These attitudes or behaviors point a process of word of mouth having a negative effect. Word of mouth statement includes informal communication among consumers about products and services [47] and as described by Arndt in 1967 [7], is a statement of circulation of information from mouth to mouth. Word of mouth has a strong effect on judgements about products and / or services [52]. It was also found that information spread from mouth to mouth was more effective in creating negative value as well as creating positive value [61].

In this context, considering that people attach more importance on negative information in the process of acquiring information, it may be said that even a small problem between the customer and the employee may lead to greater losses for the enterprise. Thus, a negative situation experienced by the customer in a service business will be able to progress by increasing its effect in a way that leads to a negative perception both in his/her own perception and in the minds of potential customers.

Until here, actualization of the problem and its results have been shortly discussed. On the other side of the medallion, there is a process which involves beforehand of this problematic issue. That means, individuals as human beings, are complicated creatures and naturally they are not always pure-minded. Besides committing to society they belong to, they may also wish not to obey the social norms. They may behave in anomie, which is a classical term in sociology used by Emile Durkheim and means that people sometimes intend not to obey the rules [80] and they become normlessness. That results in the situation that their behaviors are not predictable. Likewise, some employees may not obey the norms of the organization because of either psychological, physical, job related or organization related factors. This situation is called as workplace deviance (WPD) in fact. But in WPD the source of harms may arise from anyone in the organization. Thus there is a need for specificity to point a potential risk at the lower levels. In WPD the bad intention may be either towards the organization or people and the severity of this harm may not be so serious to affect whole organization badly.

At all, there is a gap in the literature that explains service sector's hierarchically lowest-level employees' deliberately harmful attitude or behavior towards organization via interaction with customers that results in damaging either reputation or brand image. Thus the aim of this paper is to bring a new term called as Achilles Tendon Syndrome to fill the gap of such situations. Although there is a study [25], which emphasizes the importance of business performance on the concept of Achilles' heel in individuals exist in organizational sense and the study claims that an organizational weakness caused by Achilles' heel of an individual may leave enterprises vulnerable. However, that study focuses on increasing the performance of enterprises and protecting themselves against threats from competing firms. The element generating the danger in ATS which is planned to be introduced to the literature originates from the off-norm behaviors of the employee in the lowest position "within" the enterprise proves that its originality from Drago and Folker's (1999) study. For this reason, this study was needed because of the lack of focus on the problem and the lack of the concept to define the problem.

Thus, within the aim of this paper our research questions are thereby; is there a need for a new term to describe such a problem in management field? If yes, why? What are possible reasons determining this problem? What are possible outcomes of this problem? What should be done to prevent or handle this problem? Throughout the paper, both in process of developing the term and in answering these questions, we benefited from multiple theories from different disciplines as well as reflections of practical experiences and analogies.

2. Theoretical Background

In service sector organizations, the situation, in which a customer's experiencing an insignificant problem growing by one mouth to another with negative qualifications increasingly is like an example in which the process that starts with the overthrow of a domino stone's ability to topple a much larger stone than itself in the Domino Effect Theory. This theory is used both as a good explanatory of the mechanics of rigid bodies used in physics [45] and as a metaphor in the social sciences to express the situation in which respectively social, economic and political events in local contextual may cause a global effect [83] such as the phrase of "if U.S. sneezes, the rest of the world catches cold".

Similarly, in the science of physics, a small stone thrown into a still pond, and then the reflex of movement creates regular and growing circles around it [85]. The best-known example about this topic is the "Butterfly Effect Theory" indeed. The Butterfly Effect Theory, which has also contributed to the "Chaos Theory" explains the situation that insignificant events can have major impacts after a while, a situation that is valid in both natural and social sciences [49]. The theory is based on the fact that a butterfly's flapping wings in Brazil can lead to a storm in Texas that is if the flapping of a tiny insect such as a butterfly can be effective in the formation of a hurricane in the other sphere of the world, then this situation can be equally effective in preventing the same hurricane [49].

Another example is the term known as "Avalanche Effect" in crypto science, which is used to describe the situation in which a minor change in the encryption algorithm greatly affects the outcome [93] that results in failure in entire system. In economics, "Multiplier Effect" serves for the similar purpose. It is the fact that a change in any of the variables making up an income will have a greater impact on national income [99]. These examples from different disciplines have a common point. It is that the events considered as insignificant at first may cause in outstanding and perhaps unpredictable consequences. Since Hawthorne studies, 1924-1933, organizations have been regarded as social and living structures and the human part is more important than considered [90]. If it is natural and possible that a problem, which seems insignificant at first, causes major problems in humans' lives, which are of living organisms, it is likewise possible for the same situation to occur in organizations.

All these examples are for the logic of ATS in the sense of transformation of reasons that were considered insignificant at first into outstanding results. Another important issue that lies in the rationale of ATS is that why it is originated by hierarchically lowest level employees. Why does that kind of employees engage in such attitude and behaviors toward organization? Adams' Equity Theory proposes that when employees perceive inequity about the ratio of their inputs such as effort and performance over the outputs as salary and promotion, they intend to correct this situation by lowering productivity or reducing the quality of their work [2]. But the issue here is that the theory is based on reciprocity, which means the inequity perception arises from the input/output ratio by the comparison of others. But according to this theory, to make a comparison, people should give the same amount

of input despite gaining a different amount of output. Thus, this theory does not meet exactly the requirements of the situation where ATS may emerge. Because, in ATS, we think that a lower-level employee feels this injustice when s/he compares him/herself with different positioned-employees, within him/herself or with the organization. Maybe Siegrist's Effort-Reward Imbalance Theory would be more explanatory in this syndrome. This theory proposes that when employees perceive lack of reciprocity regarding low gains as output and high costs as input, they reveal negative emotions [82]. It occurs especially when the anticipations are high, such as expecting achievement supplying no promotion or any reward in such demanding and unstable jobs [8].

Similarly, Upward Social Comparison Theory is also beneficial in explaining this situation. This theory refers to individuals believe others perform better than themselves [15] and so that they are dissatisfied with their own situation [79]. The theory also claims a situation where individuals compare their own situation with those at the higher level, for reasons such as thinking that the people above them are lucky, and even thinking that they are being treated unfairly and unrighteously in the organization [65]. Employees can compare themselves upward with these emotions, observe the higher rewards/income/position achieved by others, see the underlying injustice, and act on feelings of envy, wrongedness, and injustice that trigger behaviors that potentially harm productivity [64].

2.1. Developing a New Concept: Achilles's Tendon Syndrome

In the literature, analogies are frequently used when developing a new concept. Icarus Syndrome is defined as the situation in which people are overly self-confident and arrogant in a subject that they are very good at, is also known as "invincibility error" [10], Andromeda Syndrome, also known as "Cinderella Syndrome", is defined as women's expecting to be rescued by a man in order to get rid of the difficulties and pressures they have fallen into [23]. Similarly, if it is to compare corporate organization to Achilles, who is a mythological hero, then the situation in which the employees of the lowest level hierarchical position as seen in Figure 1, moving away from the norms and their conducting attitudes or behaviors intentionally damaging the corporate reputation and / or brand value of the organization would be called as Achilles Tendon Syndrome (ATS). The reason for using "syndrome" when making this definition is that the results and symptoms of it can be easily distinguished [55]. In other terms, the reasons why the employee goes out of the norms that s/he must comply with and the losing corporate reputation and brand value in the perceptions of the customers are separable. But when they come together, they form an interrelated whole.

2.1.1. The Role of Size, Institutionalism and Leader

ATS is a problem that is more likely to be seen in large-scale and institutional enterprises. Because the size of the enterprises can negatively affect employee satisfaction, morale and motivation, work performances and continuity [26].

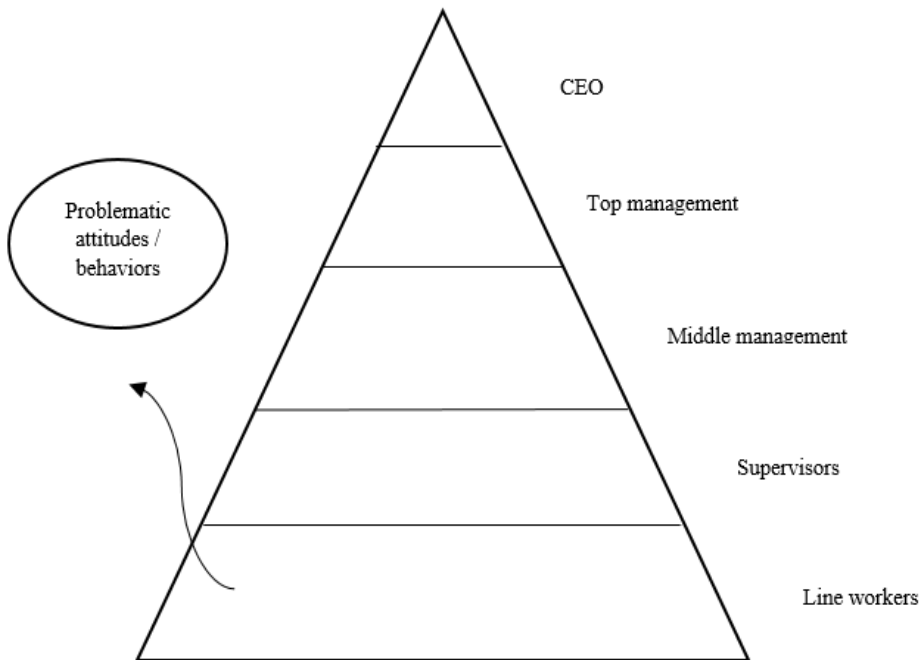


Figure 1. Organizational Structure and ATS

Davis (1972) described this situation as “Behemoth Syndrome” which is the tendency to increase absenteeism, lack of coordination, and low efficiency of that most likely seem in larger organizations [21]. Moreover, it may cause setting new rules and creating new problems, and at the end may have a demoralizing effect on human relations.

In this context, ATS is more likely to occur in institutional enterprises. However, such enterprises relying on their large-size and institutionalism may also get the idea that they will never experience these problems. Smith and Saint-Onge (1996) explain this attitude as every manager may not wish to believe that their Titanic is sinkable, just as the ship had never foreseen to sink. Executives raise more superficial issues with the idea that their ships will never sink when “Titanic Syndrome” begins [84]. Because the managers are driven by the urge of arrogance by relying on the institutionalism, size, and success of the enterprise in the past.

Another point that can be mentioned about this syndrome is that although it is predictable in the cause-effect context, its source may not be predicted precisely. The overwhelming sense of arrogance of the leaders or the unwillingness to see them deliberately could cause this unpredictability. The term “Willful Blindness”, which is a doctrine in law, is used to express the situation in which a person evades information about a fact [94]. Mcgee (2011) added a managerial meaning to this concept because it can be encountered among leaders [54]. They may even provide short-term comfort by blinding themselves to the impending dangers [67]. The thought that the entire world comprises themselves explains the reason for this type of behavior of leaders

[62]. In this context, leaders who do not wish to see the likelihood of having this syndrome deliberately or who think that the enterprise will never experience such a problem can actually support the unpredictability of ATS.

Clarkson (1994) explains Achilles' heel on the sociological basis with the conclusion that "every person has a small but important flaw" bases on the weaknesses that leaders ignore potential threats by relying on the corporate or past success of the enterprise [18]. In that defined concept by Clarkson, the Achilles Heel of such leaders constitutes arrogance. Leaders who exhibit this behavior, which is described as "Hubris Syndrome", do not seek advice and never consider another idea, resulting in weak assessment and even inadequate focus on the problems because of their excessive self-confidence [68]. In addition, high levels of management and past success of the managers' increases the likelihood of experiencing this syndrome by triggering hubristic [69]. When all those attitudes and behaviors are taken into consideration, they serve as another brick in the wall of ATS.

2.1.2. ATS in Practice

Although it does not seem so rational for the entire organization to be harmed by the deliberate attitude or behavior or a relatively minor important employee in the hierarchical perspective of the entity, this may be exemplified with a server's working in a five-star hotel or flight attendant working in an airline company being rude to customers or not paying attention to his or her dress in terms of hygiene and tidiness; a hospital housekeeper does not show diligence in cleaning the restroom; or a call center employee of a bank crossing the lines of emotional labor during a phone conversation with the customer. Despite seeming to have similarity with the phrase of "a chain is as strong as its weakest link", in this phrase all links have the equal importance and there is no hierarchy among them. But in ATS, the problem arises from the hierarchically lowest level employee as seen in Figure 1. Actually, it is more like system approach. In this approach, systems are constituted by sub-systems. In the 1950s when system approach is adopted by organizations, it was understood that organizations are comprised sub-systems which work collaboratively as a whole. Considering these sub-systems are equally important or some of them are relatively more/less important than others, we could say that a system is as strong as its weakest sub-system [40].

2.1.3. Origin and Scope of Achilles Heel/Tendon

When the literature is reviewed, it is seen that the widespread use of mythological elements in different disciplines provides a universal similarity and simple expression. For this reason, mythology is frequently used when making new definitions or conceptual studies [78]. The mythological hero Achilles forms the primary name of ATS. According to the mythology, mother of Achilles is Thetis who is the Goddess of the seas, and father of him is mortal, Peleus who is also the king of Phthia [78]. Thetis is sad that her child will die because she married a mortal and wants to immerse her son in the waters of the River Styks. However, he could not be immortal at all

because she immersed Achilles by the heel [31]. In the ongoing process, Achilles is killed in the Trojan War with a poisoned arrow thrown at his heel by Paris [63]. A strong and invincible hero, Achilles, was killed by his non-vital and yet vulnerable part of his body. As a mythological figure, Achilles is also important in medicine and psychology, used metaphorically as well as in sociology.

In medicine, the mythological hero Achilles' vulnerable heel was established by the similarity to the structure of the heel was called as "Achilles tendon" [3]. The Achilles tendon in the heel, which is not attributed much importance as other organs in the body such as heart and brain, causes a decrease in the quality of human life and severe pain in case of any damage.

Considering a heel is forming the basement of a body and helps him stands straight, employees at hierarchically the lowest level of the organization stands so for the same purpose. In psychology, Achilles Syndrome is used for so-called competence or fear of hidden failure of people for who do not feel self-confident even though they are considered as competent by their environment [18]. Furthermore, there is also a study [89] in the management literature that considered as the fear of hidden failure experienced by the managers in the sense that the concept of Achilles Syndrome defined in psychological field.

As mentioned above, it is clearly seen that some definitions and concepts have been created in different fields from the Achilles legend. ATS is similarly based on the Achilles example. It occurs when the enterprise faces loss of brand value or corporate reputation seriously by the results of the negative attitudes and behaviors presented by an employee deliberately who is relatively less important within the body of an organization.

2.1.4. *A Similar Concept: Workplace Deviance*

ATS also identifies a probable problem in the management field. The most important point to be mentioned here is that the *conscious attitude or behavior* must belong to hierarchically the lowest level employee, and majority should perceive this attitude or behavior with the same level of negativity that is the problem should be generalized. These two features determine the differences between this syndrome and WPD behaviors, which can be seen as a close concept.

Robinson and Bennett (1995) define WPD as the deliberate violation of the organizational norms [77]. The widespread impact of these behaviors is particularly evident in service enterprises where employees are confronted with customers, which is the area where employees meet customers directly. Deviant behaviors can be directly related to the person (harassment, assault, insult, rude attitude etc.), as well as towards organization (misconduct, abuse of duty etc.) [86].

First characteristics that distinguishes ATS from WPD behaviors is that the hierarchically low-level employees perform the deliberate out-of-norm behaviors specified in the definition in ATS. However, in terms of WPD behaviors, this type of behavior can be exhibited at all levels of employees. Therefore, WPD behaviors may be counted among the reasons that cause ATS.

Second difference between two concepts arises from the perception of the movement that produces negative results in the same importance degree. While in ATS, everyone should perceive the act resulting in worse conditions in equal danger; there is no such necessity in WPD behaviors. Robinson and Bennett (1995) first proposed the typology of WPD comprising two dimensions [77]. First dimension is about its target as whether towards organization or its members. Second dimension is about if the behavior is severe. After 5 years, Bennett and Robinson (2000) realize that severity is based on quantity rather than quality and cannot be measured [11]. Thus, by omitting the severity dimension, they re-proposed the typology comprising its target only.

2.2. Factors Resulting in ATS in Organizations (Paris' Arrows)

ATS occurs mostly in enterprises in the service sector where hierarchically lowest level employees are held responsible for the first and one-to-one relation with the customers. Apart from service sector, such a problem will be less likely to occur in manufacturing sector. In the view of customers, it will be the product itself or the setbacks in the post-purchase service that will directly affect the value perception of the businesses. In short, for the emergence of such a syndrome in a company that produces goods, the problematic attitude or behavior of an employee who is employed in the service department and is in a hierarchically lower position is required. For example, a factory worker who handles the problem occurring in the production process of a manufactured product will not face the customer because of this problem. The problem would be solved within the organization and this situation will not directly affect the customer's value judgement. This responsibility will again be left to the personnel involved in the sales and or post-service.

Besides its unpredictability of causes, there may be many factors causing ATS in organizations. Although the factors to be specified here are the ones that trigger the occurrence of such a syndrome regardless of a sector, it is possible that such a problem occurs for more specific reasons depending on the sectors. The factors that lay the groundwork for ATS in businesses will be examined under two main headings, apart from managerial reasons mentioned above. These are reasons arising from individual factors of the employees and the organizational factors.

2.2.1. Individual Factors

Job alienation is defined as the employees' inconsistent behaviors towards the norms and values of the organization as a result of individual or organizational problems related to their jobs [57]. In another definition, it is explained as negative feelings that arise because of the difficulty in realizing professional norms due to the individual problems [81]. For this reason, the deformation that occurs in the quality of working life causes employees who become alienated, a decrease in productivity and efficiency of them and eventually of organizations [91].

Employees' alcohol consumption habits and drug addiction also have many negative effects on businesses. The change in alcohol and drug consumption leads to consequences such as finding the job insignificant and negatively affecting the work order [16]. In a study, it is stated that alcohol and drug addiction are among the reasons that reduce job satisfaction and productivity in businesses [75].

Many people spend most of their time outside of their working time to get ready to work again. This prevents individuals from spending time in other areas of life such as time spent for the road trip, preparing for work, relaxing to work efficiently, which are not subject to pay [27]. This situation is related to insufficient work-life balance which is a state of well-being that enables individuals to manage multiple responsibilities at work, at home and in other areas, and to define their own goals [20]. In addition, work-life balance is a state of balance in which both work and personal life of a person have equal shares [48]. If this balance is broken, deterioration in employee relations, decrease in productivity and unethical business practices will come to the fore as problems that businesses will frequently encounter [48].

The demographic characteristics of the employees working together in the organization are also important. Organizational norms are the behaviors that employees are expected to follow and apply [4]. However, the personality and demographic characteristics may affect the decisions of employees about if obeying the norms [33]. People may not behave align with the aims, norms and principles of the organization due to their demographic characteristics (age, gender, educational status, marital status, working time, salary amount) [60]. Considering that ATS occurs mostly at the hierarchically lowest level employees; intergenerational differences in value judgments, negative effect of low education level on self-discipline, financial distress, dissatisfaction and feeling of worthlessness caused by low wages could be some of demographic factors. In addition, the socio-economic status, socio-cultural structure, and severe physiological arousal of the employees can also cause some problems. Employees may have negative feelings about the organization they work for or their work life for these and many similar reasons, and they may harm the organization by violating the institutional norms [59].

Another personal cause is *a lack of motivation*. The importance of interest in motivation or job satisfaction actually stems from the fact that it affects performance and productivity [43]. The lack of motivation of the employee causes him to be reluctant in his job and his performance to decrease [17] which directly reflects on customers in service sector organizations. According to Hackman and Oldham's Job Characteristics Model (JCM), a job should have five basic features those are autonomy, task identity, task significance, skill variety and feedback to motivate employees [51]. At the lowest level jobs, some of these characteristics may not exist in the job itself or either the employee's perception. These lowest-level jobs may require more physical effort but less of mental, which means to seem more simple than managerial duties, for example. Thus the responsible employee may feel like the duty is not significant for organizational goals, which prevents motivating oneself and one's job performance. According to Grant's study (2008) for simple types of jobs, task significance has a positive effect on the job performance, which was indicated by job dedication with self-disciplined and commitment-driven behaviors [30]. Similar

to JCM, person-job fit also plays an important role in motivation and employee behaviors. In countries where unemployment rates are high, young people may have to work in positions which are beneath their skills and levels. In these situations, the person and the job itself do not fit each other. According to attitude dimension of person-job fit [74], employees evaluate the components of the job such as colleagues or the task, and if there is an unfavorable situation, then it reflects on their work behavior in the same way.

2.2.2. *Organizational Factors*

Perceived organizational injustice [66], provocative behaviors [44], injustice in wage charges [72], insufficient organizational support [1] and other deficiencies in organizational structure [60] could cause WPD and eventually emergence of ATS. Especially in service businesses, these behaviors do not leave a positive impression on the customers, and they can damage the reputation and brand value of the institution.

Human resources management, which plays a role in the solution of many problems within the organization, can cause problems when it is insufficient. Because human resources practices play a central role in the creation and maintenance of organizational capability [19]. Human resources are of vital importance, especially for businesses operating in the service sector where customers are often physically present at the workplace during producing and offering the service. For this reason, both employees and customers make up the human resources field of service businesses [36], [34]. As a result, human resources management should produce practices that will lead to customer satisfaction and perception during the time the customer has spent in the organization. In this critical process, assigning the right people to the right jobs and at the right time has a direct effect on the value and existence of the organization [39]. In a management process, where the correct personnel selection is not made [39], training and communication are not established properly [22], these problems can easily be reflected on the customer in a management process in which HR is inadequate to solve problems.

In order to ensure organizational harmony, *leadership* is an important factor as well as HR management. According to Lipman-Blumen (2005), the situation when leaders cause serious and permanent damage to their followers using tactics that will have a harsh or bad effect is called toxicity [46]. Toxic leaders exhibit destructive behaviors that try to undermine the morale, motivation and self-confidence of groups under their influence [71]. Toxic leaders often make hasty decisions, constantly changing decisions, and do not accept responsibility for the results. Employees who are exposed to these conditions will feel confused and insecure as they are constantly drawn in different directions, and this will ultimately reflect on their behavior in their work lives [5].

Role ambiguity and *role conflict* in businesses can also result in ATS among employees. There is a causal relationship between role ambiguity and role conflict. As the uncertainty perceived by the employee increases, the perceived conflict increases [53]. While role ambiguity and role conflict increase stress in the work

environment, it also decreases job satisfaction and work commitment [41]. This situation will cause the employee to act outside the rules and norms of the business in the workplace.

One of the most important environments that ATS can affect is the customer environment of the enterprises in corporate reputation and brand value regards. For this reason, one of the organizational reasons that will lead to this syndrome is the deficiencies arising from *customer relationship management (CRM)* which is a strategic process applied in order to ensure a stable income, retention of the customer and maximum customer value [95] and includes continuous corporate change in organizational culture and management process. Customer information collected within CRM is transformed into corporate information and in this context requires extensive changes in both the organization and the employees [32]. In addition, the smooth functioning of the CRM depends on the trust environment of the organization, and this environment of trust can be realized with the efforts of all employees [101]. As a result, the lack of CRM in businesses may lead to the fact that employees do not show the necessary care and importance while doing their work, which may negatively affect customer perception.

2.3. Precautions, Proactive Measures and Solution Recommendations

It is often not enough to just describe a problem. It is also necessary to offer proactive measures before the occurrence of this problem or reactive solution recommendations for after it occurs. In the Butterfly Effect Theory, Lorenz's (1972) conclusion of "If the butterfly's wing beat can cause a hurricane, it can be equally effective in preventing a hurricane" also applies at this point. Human capacity to identify and rectify errors and to adapt to unexpected events before insignificant factors develop into disastrous failures, what is called as "organizational mindfulness" [29] is required. Thus, since the root point of the problem is the effect of negative behaviors intentionally performed by the employee, a correct HR management will form the basis of the solution process. In order to define the link between HRM and human capital affecting firm performance, the universal approach based on the 'best practices' perspective and contingency approach, which foresees the strategic behavior of the enterprise in cases where a sudden decision is required, is used [100]. HR practices that will decrease or increase the performance of the company should be human-oriented, especially since the most important capital in enterprises operating in the service sector is the human factor [100]. Since the areas where ATS is likely to occur may be businesses operating in the service area, HR practices to be carried out in terms of precaution or problem solving should be human-oriented. In this context, strategies that focus on the human factor should be developed through practices such as fair remuneration and promotions in the organization, clarity of job description, organization of in-house trainings, seminars, events, determination of working hours within humanitarian limits, and that provide psychological support to personnel [70].

If high level organizational performance is aimed at an organization, business and HR activities should be compatible with each other and support each other [50]. For this reason, organizational commitment should be increased, brand-institution

awareness should be created by introducing the corporate culture and brand to employees, and an effective diversity management should be applied to ensure that the organization has access to the widest possible pool of skills, experience and ideas [76]. It is also vital to identify and prevent toxic leaderships by HR and CEOs in the organization [5], and ensure leader-member interaction. In addition, a participatory management approach should be adopted and emphasis should be placed on the experience and ideas of employees, and this harmony should be reinforced [58]. In this way, the employee who can express his opinion in the decisions made and feels that his views are valued will be provided more ownership of his work.

Besides the applications to be carried out for current employees, HR should also be meticulous during the recruitment phase. In the recruitment process, HR should pay attention to the abilities and skills as well as habits or addictions (alcohol, smoking), previous work experiences, and the capacity to represent the company [38]. The candidates who may contain risk factors for the organization will be thoroughly evaluated and eliminated during the recruitment process, which will help prevent potential problems that organizations may encounter.

When ATS occurs, the first area where it shows its effect is the customer base of the organization. The perception of the customer, who is adversely affected because of this syndrome, directly affects the institution. For this reason, it is important to manage customer relations management effectively. The most important point in CRM is the method of developing strategies for attracting new customers and improving the company's ability to keep existing customers, known as relationship marketing [14]. With the CRM strategies to be applied, customer relations can be strengthened to prevent negative effects on customer perception. These important applications listed above actually require a continuous improvement process. This process is a total quality management that expresses the integration of all functions and processes within an organization that aims to achieve customer satisfaction, which is the ultimate goal for continuous improvement of the quality of goods and services [73]. As the adoption of total quality management understanding will mean continuous improvement of quality for an organization, unlawful and anti-norm behaviors of the personnel will be prevented, as in the ATS.

Considering antecedents, possible outcomes, precautions and solution suggestions we propose a conceptual framework of ATS in Figure 2.

Discussion and Conclusion

We believe that this study has both theoretical and practical contributions. First of all this research was conducted in order to contribute to an organizational literature with a new phenomenon which identifies the situation that may occur because of the deliberate negative behaviors of an employee at the lowest level in the enterprises and which may cause an outstanding negative outcome by starting with an insignificant effect. The second one is by pointing out an internal threat, we added a new phenomenon that could affect brand image, corporate identity and corporate reputation seriously if proactive measures are not taken.

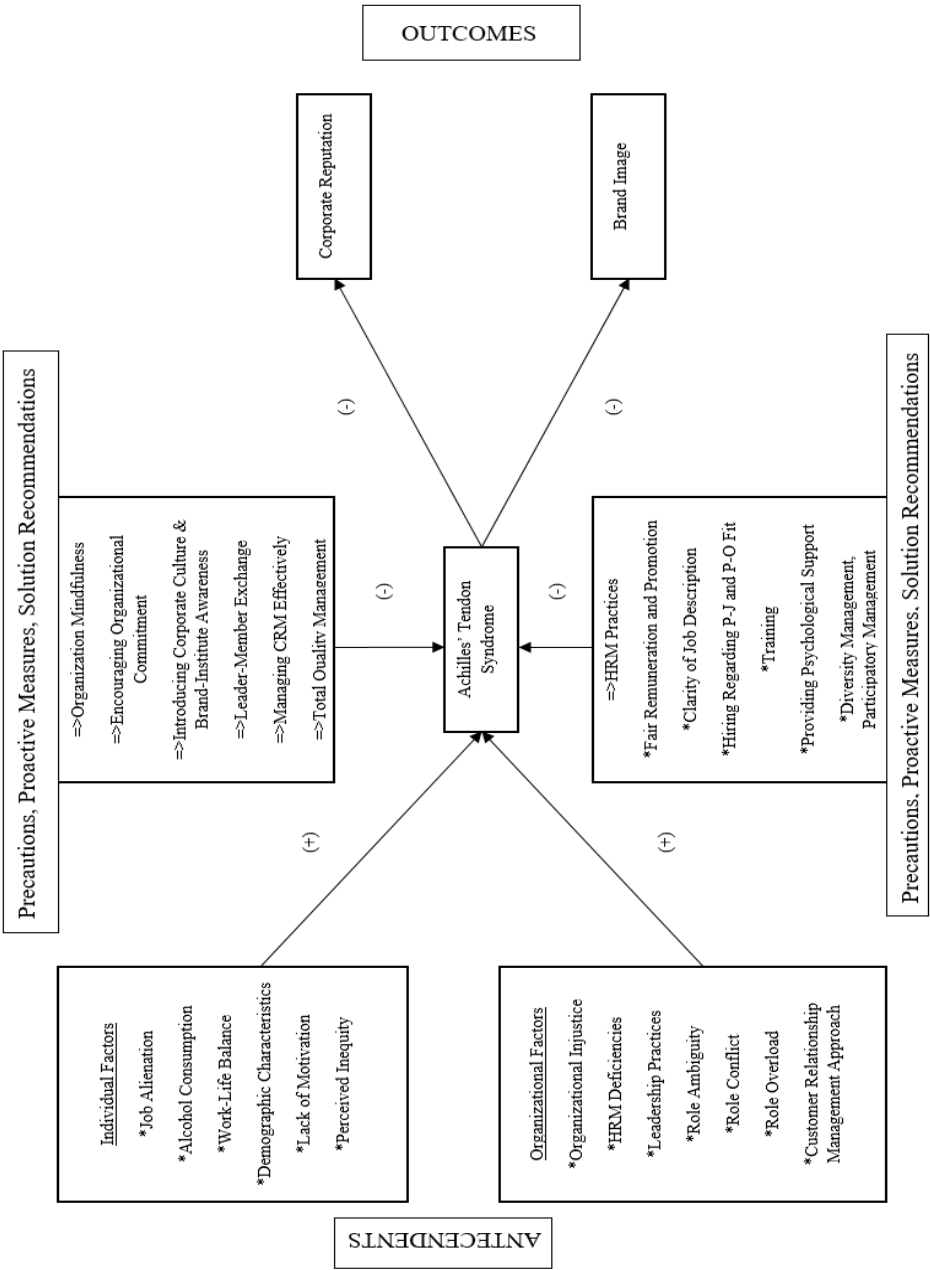


Figure 2. Conceptual Framework of ATS

Practically, we underlined what kind of steps organizations should take to prevent such potential dangers by recognizing them early, how they can cope when it is too late to take precautions, and what important consequences will arise if they do not take precautions or ignore them. In addition, when organizations take the proactive

measures mentioned before, they will be able to gain competitive advantage when they turn such crisis-creating situations into opportunities. Furthermore, we made suggestions on how to protect the concepts of corporate reputation and brand value, which are difficult to build and maintain for success, with the prevention of ATS.

ATS, which may cause possible macro-scale results in organizations, has a theoretical background in managerial terms. In addition there are important boundary points that form the theoretical framework of ATS. These are WPD behaviors, chaos theory and Drago and Folker's (1999) study which refers to Achilles analogical in managerial field. While ATS is fed from these border points, it is also differentiated by its nature with important differences. These differences constitute the systematic features of ATS.

The formation of ATS and its consequences occur at two important points. The first point is the non-normative behaviors that the hierarchically lower-level employee deliberately performs. In this context, ATS is fed by WPD behaviors defined by Robinson and Bennet (1995) as the non-normative behavior of the employee in the organization with the intention of deliberately harming the organization or other organization members. At this point, 'deliberate' and 'non-normative behaviors' constitute the points where ATS is fed. When WPD behaviors are examined in detail, it expresses the intention to harm the organization or other employees, and that this damage is done by physical/tangible methods such as vandalism, theft, sabotage, violence, and unjustified absence [44]. In line with this statement, the nature of ATS differs from WPD behaviors in that it is carried out by employees at the 'hierarchically lowest level', having a direct intention only to harm the organization and that the macro-level damage it may cause is more like intangible and simultaneously harming ways as of attitudes and behaviors.

The second point that constitutes the importance of ATS is that it gains momentum from the beginning and progresses towards the result and ultimately leads to a great negative effect compared to the beginning. Here, it is fed by the theory supported by the Butterfly Effect Theory and eventually placed in the management literature as the Chaos Theory [49]. Because the Chaos Theory is based on the fact that a small change that may occur in the initial state of a nonlinear dynamic system can lead to unexpected big results and this has an unpredictable and unavoidable feature [42]. In addition, the Chaos Theory develops over time based on the interaction between internal and external environmental factors such as organizations, governments, institutions, competitors and consumers. In this context, ATS differs in that it focuses only on the 'internal environment' and is 'preventable' with strategic and correct managerial steps, while it is fed by Chaos Theory with the assumption that a small behavior/movement can cause huge consequences. Finally, while there is an evolutionary transformation in Chaos Theory and the actors that provide stability and cause a re-transformation by adapting to it [42], the adaptation of the organization to the possible negative consequences that will occur in the ATS will threaten the life of the organization.

To the best of our knowledge and as far as we can reach in the literature, the closest use of ATS in the field of management has been the study of Drago and Folker (1999) in which they investigated the 'effects of organizational competencies on firm

performance'. The similarity of the study with ATS was to draw attention to the weaknesses that could not be noticed by comparing the organizations to Achilles. Apart from this similarity, ATS maintains its originality in terms of focusing on different areas.

As a result, ATS has some distinguishable features in terms of both its theoretical framework and managerial originality. These can be listed as 1) an action to be taken by the lowest level hierarchically, 2) deliberate non-normative behaviors directly targeting the organization, 3) intangible and simultaneously harming methods, 4) being focused on the internal environment of the organization, 5) being unpredictable but preventable and 6) insignificant seem-like attitudes/behaviors resulting in outstanding outcomes.

ATS phenomenon's never been studied before in the management field, which is likely to occur because of literature research in management, entailed the study. In subsequent studies, the issue can be addressed in more detail in terms of cause-effect and preventions with empirical studies. Developing an attitude scale and associating with other organizational concepts such as performance, commitment and so on by placing in both dependent and independent variables will help for the development of this phenomenon. It is also necessary to whether the antecedents and outcomes are empirically related with ATS that we drew upon in Figure 2.

Naturally this study has some limitations. First of all, we claimed that ATS mostly occurs in service sector due to reasons aforementioned. Thus we cannot conclude that this syndrome is valid and generalizable for any organization. The second is, also the assumption of ATS that the problematic situation should be considered in equal or at least similar dangerous perception. That means that even a minority of group see the outcome of this syndrome as insignificant, then this syndrome is more like any of WPD behavior. The last one is that we aimed at hierarchically lowest-level employees' attitudes and behaviors because of ATS' nature. These kind of off-norm attitudes and behaviors could be originated from mid-level or managerial people too which also result in damaging brand image and/or corporate reputation. But this damage would be in different ways and methods. Thus any off-norm behaviors originated from anyone in the organization but hierarchically lowest-level employees are out of the ATS scope.

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Towards an Improved Framework for E-Risk Management for Digital Financial Services (DFS) in Ugandan Banks: A Case of Bank of Africa (Uganda) Limited.

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Abstract

One of the predominant challenges facing banks in low resource countries is the management of Digital Financial Services (DFS) risks. Many banks are making worthwhile efforts to boost the factors that make them come on top of the challenges, unfortunately they have fallen short. This article sought to develop an e-risk management framework for DFS in Ugandan banks. Design Science Research paradigm, a mono-method qualitative research method and a case study research strategy was adopted. Questionnaires, interviews and document review were the main data collection methods. Findings from this study indicate that banks in Uganda use a handful of DFS business models and face a number of DFS risks including; talent for DFS, technology, strategy, governance, product, client acquisition, crime/fraud, regulation, and agent management among others. Notwithstanding, Ugandan banks should carefully balance IT spend across customer expectations, improve cybersecurity and internal process and regularly check its IT security.

Keywords: E-Risk, Digital Financial Services, Digital Risk Management, Bank Risk Management, Information Security, Cybersecurity

1. Introduction

The importance of Digital Financial Services (DFS) in creating a more inclusive, stable and secure financial sectors globally cannot be over emphasized. Today, the growth in mobile telecommunication service availability is expanding the reach of financial services across wireless networks in low resource countries—Uganda inclusive, creating the potential for significant growth in financial inclusion. While the benefits of DFS are easily identifiable, grave concerns have emerged with respect to the risks that users of these services are likely to face. Several researchers and practitioners have observed that the risks that are inherent in all retail payment systems

including; money laundering, privacy and security, consumer protection, fraud, and credit and liquidity risks are also present in the digital space [23], [24], [7], [25].

With evidence of a large number of nonbank participants in the delivery of DFS, such as Mobile Network Operators (MNOs) and their agents, as well as the technology vendors, there is likely to be additional risk considerations for banks. Against this backdrop, it implies that, as DFS evolve, there are numerous issues that need to be considered in managing the risks that wireless payment systems may introduce; and given the unique experience of the growth of DFS most especially in emerging markets and low resource countries, the need to solve every day lived experiences and challenges is inevitable. It is essential that the risks that can occur via the use of digital technologies in financial service delivery be recognized by all stakeholders and measures be put in place to ensure that problems do not arise. This study therefore aims at designing a comprehensive e-risk management framework for DFS delivery in banks which will also help in addressing any possible confusion and problems in existing regulation vis-a-vis emerging trends in DFS delivery.

2. Background

Globally, the providers of financial services for commercial reasons are rapidly matching towards the digital age, by partnering with MNOs and/or other payment service providers. This can be exemplified in Pakistan where Tameer Bank in Pakistan in cooperation with its telco owner Telenor expanded payment services leading to significant growth in transaction fee income. On the other hand, MFIs (Microfinance Institutions) including Musoni in Kenya, are establishing digital field applications in order to alter traditional banking business models [1]. DFS are on course to be strong tool in the establishment of a more secure, stable and inclusive financial sectors. Today, a significant section of the bankable population in the world still live outside the formal financial system. In reference to the World Bank report of 2014, Global Financial Inclusion (Global Findex) database, about 38 percent of people above 18 around the world do not have an account at a conventional financial institution or mobile money provider.

In Uganda, the market for DFS is at present marshaled by MNOs, and the main operant MTN and Airtel overseeing the vast majority of transactions and users [3], [25]. In order to remain competitive, a number of banks have entered into strategic partnerships with these MNOs to provide financial services to their customers. A number of these cooperation are two-way relationships leading to inadequacy and frailty in the payment systems.

The growth of the digital economy comes with an array of associated disbenefits. The ramification is on end users, workers, and businesses and could be translated as part and parcel of unfavorable inclusion and blend into digital markets, with increased indebtedness as the digital economy heightens, resulting to persistent incidents of security breaches targeting shared interests of businesses, national governments, and end users [17]. As reiterated by [10], the most exposed to such security issues are low resource countries, because they are portrayed and seen as an “ideal testing ground” by hackers for the most grievous attacks. Due to the weak infrastructure for security

in low resource countries, hackers are in position to evade detection and they always use these vulnerabilities to experiment their malware before making use of it against more polished defenses. Examples include hackers stealing billions of shillings in a mobile money heist from Ugandan banks and telecom companies-MTN (Mobile Telecommunications Network) and Airtel [12], defrauding of US\$4m from financial accounts in Zambia [21], or hackers stealing US \$81m from the Bangladesh bank [28].

As DFS evolve, there are numerous issues that need to be considered in managing the risks that wireless payment systems may introduce. The multiple regulatory domains governing banking and telecommunication in most of the low resource countries today, Uganda inclusive, has been accustomed to operating autonomously from one another and is likely to be challenged to learn how to effectively cooperate to provide oversight for DFS [8]. According to [19], some of the risks stem from demand-side factors, such as limited consumer digital literacy, unfamiliarity with formal finance, and issues of financial capability.

Given the unique experience of the growth of DFS most especially in emerging markets, the need to solve every day lived experiences and challenges is inevitable. It is essential that the risks that can occur via the use of digital technologies in financial service delivery be recognized by all stakeholders and measures be put in place to ensure that problems do not arise.

2.1. Digital Financial Services, Risk and e-Risk Management

Risk is described as the ‘effect of uncertainty on objectives’. An effect is a departure from the anticipated—positive and/or negative [11]. Risk is described by [20] as ‘the likelihood for loss or misstep to meet business objectives as a result of internal or external events’. An e-Risk is defined as the likelihood of a vengeful electronic event; whose happening causes loss to e-business. These comprises of: (i) Identity theft, (ii) Destruction or compromise of perimeter network security components, (iii), Denial of Service (iv) Application or Internet Service Provider failing, (v) Graffiti, (vi) Cyber-extortion and fraud, (vii) Attack by wireless devices, (viii) Attacks by disgruntled employees, among others.

2.1.1. DFS delivery Infrastructure and Ecosystem

According to two DFS supporting organizations, vendors in the market offer DFS tenets [26]. The vendors and operators majorly comprises of MNOs and banks but can also encompass value-added service providers, third-party service providers, and juxtaposed players such as retailers and other enterprises. Being guided by regulators, providers do offer services to the market and get involve in market share competition, by part of the time getting involved in partnerships and ‘co-opetition’. Providers are hereby designated into three main classes: Banks, MNO and third-party operators.

2.1.1.1 DFS Technology Components

DFS uses a combination of four elements as a technology platform, these include a physical device, an application – this runs on the device to be used in providing DFS,

a channel for communication – data interchange between the device and the service provider's host system occurs through the communication channel, and last but not least, the mode of authentication – this is used to approve the identity of the channel user.

2.1.1.2 DFS Ecosystem

A stereotypical ecosystem for DFS comprises of end users (businesses, government agencies, consumers, and NGOs) [4]. They present demand for digital and interactive financial products and services. The actors that include banks, non-banks, and other licensed financial institutions come up with those products and services digitally and the financial, technical, and other infrastructures provide the possibility of those products. The qualification and fitness for use and operation are provided by governmental policies, laws and regulations that allow them to be delivered in an attainable, inexpensive, and safe manner.

2.1.2. DFS delivery models and channels

A business model is referred to as a visionary framework used by businesses to present a fundamental economic logic and system that presents a picture and proof of how a business can deliver value to customers at a reasonable cost and make profit out of it [27]. E/M-Banking business model revolves around nine (9) building blocks [18], [15], p. 8-10). These are: 1) Revenue streams; 2) Value propositions; 3) Key activities; 4) Customer relationships; 5) Customer segments; 6) Key resources; 7) Channels; 8) Key partnerships; and 9) Cost structure. According to [2], there are around six (6) DFS delivery models; Bank-based model, Bank-led model, Non-bank-based model, Payment Services Provider (PSP), Third-party provider, MNO/bank model, and Government Provider/Bank Model.

DFS delivery channels can be self-service or Over the Counter (OTC), whereby the customer interacts with staff or third party representatives such as an agent or merchant—which is dedicated or not. The categorization of a channel as either OTC or self-service becomes somewhat cumbersome when it comes to issues such as e-wallets because these channels habitually needs some level of interaction of OTC to cash in/out and then it can be used afterwards in self-service mode. The channels include; ATM, Internet banking, Agent/Merchant, Extension services (field staff, mini branch, branch on wheels), Mobile banking, E-wallet (m-wallets, prepaid cards, store cards), and Call center.

2.2. DFS delivery challenges and risks

The following are the challenges and risks associated with DFS delivery, as noted by [6], [9]. It should be noted that some of these challenges and risks are associated to the aforementioned DFS delivery models and channels and others are not. They include: Human error, Strategic risk, Regulation, Operational Risk, Technology, Financial Risk, Political risk, Agent management, Fraud, Reputation, Partnership,

Talent, Governance, Product risk, Service delivery, Management, Crime, Competition, Client acquisition, and Funding among others.

2.2.1. DFS risk mitigation requirements

There are many requirements that need to be met by DFS providers in order to mitigate DFS risks, some of which are presented by [2], [9] as follows: Agent Due Diligence (ADD), Biometric Identification System, Know Your Customer (KYC), Risk-based Approach, Business Processes, Adequate Internal Control System, Adequate Internal Audit, Segregation of duties, Adequate External Reporting, Adequate External (Financial) Audit, Execution, Delivery and Process Management, Reconciliation and Account Variances, Agent Management Excellence, Deposit Insurance, and Trust Accounts.

2.3. Risk Management Frameworks and DFS Best Practices

In this sub-chapter, a description, analysis and review of the two (2) commonly used RMFs (Risk Management Frameworks) are given, these are: 1) ISO 31000:2018 RMF, and 2) NIST SP 800-37:2018 RMF for Information Systems and Organizations.

2.3.1. ISO 31000 Risk Management Framework 2018

ISO 31000 was originally published in 2009. An updated version was published in February 2018. Nonetheless, the overarching goal of ISO 31000 is still the same – that is, integration of risk management into a strategic and operational management system. It should be noted that the risk management principles and the framework are related intimately. Version 2018 is very much similar to the original version (2009), except for the following changes: 1) risk management principles have been reviewed, as these are the key criteria for successful risk management; 2) the importance of leadership by top management is strongly emphasized, as well as the integration of risk management, beginning with the governance of the Organisation; 3) a lot of emphasis is placed on the iterative nature of risk management, as new knowledge and analysis leads to revision of processes, actions and controls; and 4) the sum and substance of the RMF is paired with a great focus on constantly holding up an open systems model to fit multiple needs and contexts. ISO 31000-2018 encompasses much treasured information and it represents a robust and high-level guideline for the management of risk. It asserts that the purpose of risk management is the creation and protection of value. In summary, ISO 31000 locates greatly, an emphasis on understanding the Organisation and its context.

2.3.2. NIST RMF for Information Systems and Organizations 2018

NIST SP 800-37: 2018—RMF for Information Systems and Organisation was released in December 2018. The RMF lays bare parameters for putting into practice the RMF to information systems and organizations. The Framework provides a

disciplined, structured, and flexible process for managing security and privacy risk from two angles—an information system angle and a common controls angle and is “purposefully mapped-out to be technology neutral in a sense that the methodology can be applied to any type of information system without modification”. The RMF also emphasizes “automation” wherever necessary and possible to increase the speed, effectiveness, and efficiency of executing the steps in the RMF. It further requires organizations to modernize their IT infrastructure and systems and recognizes the increasing interconnectedness of information systems and networks. The RMF consist of seven (7) steps; a preparatory step to ensure that organizations are ready to execute the process and six main steps: Categorize; Select; Implement; Assess; Authorize; and, Monitor.

2.4. Design requirements (criteria) for quality and updated RMF

Requirements serve not only to describe what to build and why it is being built but also provide a way to measure whether an activity has been successful [5]. The first step in developing an updated DFS e-RMF (e-Risk Management Framework) approach is to capture a set of design requirements/criteria (derived from literature review and classroom experience). Thirteen (13) requirements are hereby put forward to guide the Framework design efforts as listed and described in Table 1.

Requirement	Description
1. Purpose and Scope	The framework should be new, interesting, and true. There should be enough information to argue that the RMF is new and interesting to the relevant research and practice community.
2. Business and Technology Awareness	The framework should take both business and technology into consideration.
3. Ease of Use	The framework should be understandable among different user groups, such as within members of risk management, IT, DFS channel management, Agency banking, sales and marketing, finance, internal control and compliance, management of the bank, as well as external experts, consultants, and facilitators.
4. Genericity	The framework should be adaptable to different banks and risk situations and environments. The RMF should provide for evolution, adaptation, or learning of any resulting artifacts without affecting the RMF. The RMF should have a degree of permanence and range of coverage so that one does not have to create a new version of the RMF for each new situation.
5. Layered Structure (abstraction)	The framework should prefer abstraction in order to hide unnecessary details. The RMF should not loose meaning when changed in any way.

6. Modularity	The framework should consist of different parts or modules that could be combined in different ways.
7. Reusability	The framework should be reusable in order to be adaptable into different risk situations.
8. Concepts, Tools and Technique Neutrality	The framework should support different risk management concepts, tools, technique, and platforms.
9. Constructs	All the existing and new concepts and entities that are needed to fully understand a RMF should be fully described.
10. Principles of Implementation	There should be a clear cut description of the process for instantiating and/or implementing a RMF.
11. Justificatory knowledge	There should be references to justificatory-knowledge tacit theory (such as informal experience-based insights and intuitions) that can provide a reasonable degree of justification of the framework. There should be insights provided into why one should believe in the framework.
12. Evaluation and Validation propositions	There should be a clearly stated description of how a RMF should be evaluated/tested for truthfulness, usability, efficacy, and quality. There should be artifact meta-requirements, meta-design, and evaluation criteria and measures.
13. Knowledge of Form and Function	There should be a clear explanation of how a RMF contributes/has contributed to the body of knowledge.

Table 1: DFS e-RMF Design Requirements (criteria)

2.5. DFS best practices

Below are the five basic steps that should be taken to manage risk in the digital environment [29]: Step 1: Risk Identification; Step 2: Risk Analysis; Step 3: Risk Evaluation; Step 4: Risk Treatment; and Step 5: Risk Monitoring and review. It should additionally be noted that, for proper and safe delivery of DFS, providers need competencies in; Information and Cyber Security; Resilience and disaster recovery; Vendor and third party management; Project and change management; Architecture development and testing; Data quality and governance; and finally, ICT compliance [13].

3. Methodology

This study adopted the Design Science Research paradigm, a mono-method qualitative research method and a case study research strategy. Research was realized between March-June 2020 by collecting data from employees of one Ugandan bank and industry practitioners. Questionnaires, interviews and document review were the

main data collection methods. Data analysis was conducted using Colaizzi’s (1978) framework for qualitative data analysis. Focus group interview and engagement with the field were incorporated into the data collection and analysis. The test-retest, triangulation, and ‘thick description’ methods were employed in this study and the design of the questionnaires and interview guides was based on literature from previous similar and/or related studies, all in an endeavor to ensure validity and reliability.

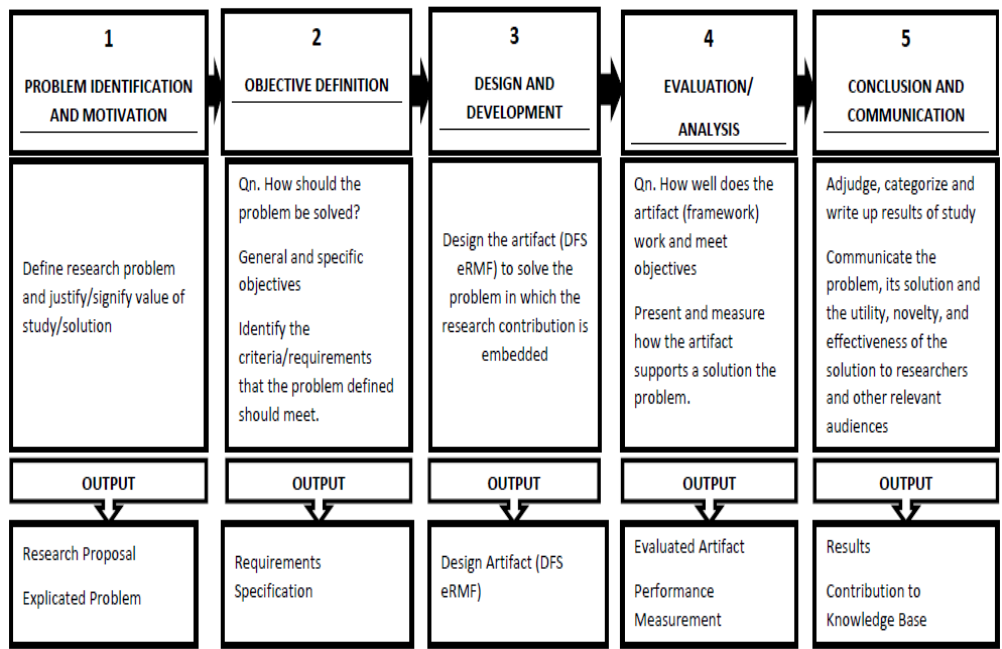


Figure 1: DFS e-RMF design process with outputs at every stage

4. Results

The rate of response to the researcher’s requests for interviews with various selected participants was fairly good. Within the bank, the number of participants proposed was nearly achieved, with the exception that more department and functional managers were found willing and available to be interviewed than had been planned while a fewer number of lower level employees participated than originally proposed. Among the banking industry experts, consultants, and facilitators, only three out of the six proposed were eventually interviewed. This was found to be helpful within a case study because the various interviewees came from different departments/designations and they displayed somewhat different and varied responses to DFS risk and risk management.

Category	Office/Department/Designation	Estimated Population	Proposed Sample	Actual Response
Bank Employees (#BOA)	Management	8	6	5
	Agency banking	2	2	2
	IT	2	1	1
	Customer Care	2	1	1
	Finance	2	2	1
	Other Staff	12	10	7
	Agency banking	8	2	2
	IT	6	2	1
	Sales and Marketing	5	1	1
	Finance	5	1	1
	Compliance	4	2	1
	Customer Care	5	2	1
Banking Industry Practitioners (#BIP)	Consultants, Experts, & Facilitators	8	7	5
	DFS Specialist	3	2	2
	Financial Inclusion Consultant	2	2	1
	Uganda Bankers' Association	3	2	2
Total		28	22	17

Table 2: Proposed and Actual Participants and Respondents

4.1. Emerging themes from Interview data

The thematic and content analysis performed on the interview manuscripts produced a number of themes discussed below. Overlaps will be found between some of the themes. All the themes are discussed in 2 categories of respondents, i.e. bank staff (both management and other employees) and banking industry practitioners (experts, facilitators, and consultants).

4.1.1. DFS delivery models, challenges and risks of Ugandan bank

The bank has a fairly robust DFS/mobile banking technology platform available providing seamless and real-time access between, for example, a mobile phone and a bank account and a fairly mutually aligned DFS business model and synchronized DFS strategy.

The bank has already forged strategic multi-industry alliances to offer DFS to the un/underbanked segment. Rapid technological innovations, evolving DFS delivery models and state initiatives such as National ID programme have greatly facilitated the improvement of DFS conditions at the bank and the bank is considering building self-sustaining DFS alternatives to extend banking and other financial services to the excluded.

4.1.1.1 DFS delivery models and channels of Ugandan banks

Bank Employees

The bank runs the following models of DFS delivery: 1) option “b” of the bank-based DFS model where the bank is licensed or otherwise permitted by the regulator to provide DFS, 2) Bank-led model— the bank is the primary driver of the product or service. The bank manages all angles of marketing, branding and customer relationship management, 3) Payment Services Provider (PSP)—the bank provides services enabling funds to be deposited and withdrawn from an account. The bank also performs payment transactions that involves transfers of funds, issuance of payment instruments such as checks, e-Money, credit cards and debit cards, and remittances and other services central to the transfer of funds, 4) Third-Party Provider—the bank uses agents to act on their behalf pursuant to a services agreement and other contractual arrangement and the bank is liable for the actions of the third-party providers acting on their behalf, and finally.

The bank uses extension services and agency banking as DFS delivery channels. For the purpose of this study, the researcher needed to differentiate between the two. While agency banking relies on use of third-party operators, extension services involves equipping the bank staff with technology solutions. The bank also provides DFS through technology and technical interface including ATM, web and USSD interfaces accessible through smart/mobile handsets.

Other channels the bank uses in delivering DFS includes Internet banking, Extension services, Mobile banking, and E-wallet. The bank also operates a call center that is used for receiving and transmitting requests through telephone and handling customer complaints and queries.

The bank reported having full control of most of the sections of the DFS value chain including user accounts and brand, the communication channels like data and USSD (except for SIM which is partly shared with the telecoms), physical channels like agents and ATMs. The bank also controls user/transaction data.

The bank’s financial infrastructure consists of payment clearing and settlement systems, which enable the processing of various types of payments. In this environment, the mobile network operator provides both ICT infrastructure and an agent network, while the bank provides both payment services and payment infrastructure.

Banking Industry Practitioners

DFS implementations by Ugandan banks employ many delivery approaches and use different terminologies, such as ‘e-banking’ and ‘branchless banking’. Modern technologies are being implemented by these banks leading to quite a number of benefits.

Respondents also noted that banks in Uganda use a combination of delivery channels in executing DFS. An overlap clearly exists wherein banks may sometimes opt to use non-bank services as one of their delivery channels, such as when banks are linked to e-wallets services.

4.1.1.2 DFS delivery challenges and risks of Ugandan banks

Bank Employees

Strategically, bank management is lacking in fully investing in DFS resources for targets to be met. “DFS operations here is understaffed, marketing is under-resourced and the bank sometimes fails to meet targets for customer acquisition and activation” noted one respondent. Sometimes de-prioritization of DFS products and channels is a result because of poor performance leading to the bank reorienting around competing priorities. Competitors are also gaining market share owing to superior service or lower prices.

There was concern about management risk – this touches on several points, including the quality of management, the availability of talent, the incentives offered to management, and the ability of management to handle this atmosphere of rapid technological change. Many respondents blamed poor management on inappropriate qualification, inexperience or sheer incompetence.

Client acquisition is a big problem. Getting DFS out to rural areas poses a rather special challenge. Most Ugandan villages are too remote, largely illiterate, subject to particular risks (such as weather and floods), and unattractive to DFS suppliers who mostly have short-term profit goals. As respondent #BOA06 pointed out, “many people don’t have electricity or even ID leave alone National ID documents”.

Respondent #BOA03, reported that “the extent of transactions assisted by agents have exposed inexperienced customers to risks, in a case where agents and their employees have insufficient capacity, training, and support or are dishonest”.

ATMs and other digital interfaces used by the bank is also known to present a lot of problems. Respondent #BOA04 reported: “Many of our DFS consumers are first-time users of formal finance and background and they sometimes struggle with issues like language barriers, complicated interfaces, and systems of many operational steps (multi-step processes) ... this is because most are using phones with basic feature having limited interface options.”

The ICT security officers consulted in the bank and banking sector told the interviewer they are challenged by identifying assets across the bank and keeping track of their status and configurations, including hardware and software. This boils down to Enterprise Architecture failure.

DFS systems at the bank is sometimes unavailable and customers cannot access their accounts or their transactions can fail due to this. Customers sometimes fail to access account through an application or agent due to the bank’s system experiencing temporary system downtime or because of the unavailability of a mobile network. Other technological risks affecting the bank sometimes but not all the time includes; malwares, transaction delays, hardware failures, loss of data, and failure of DFS hosting environment.

There is a lack of “data intelligence” that is supposed to draw on data management, data science and cybersecurity tools to verify data from its origin through its full life cycle, and scrutinize how it is used to make DFS risk decisions and ensure that it is safely and securely stored.

The bank is also employing very limited tools in managing risk and yet the bank management are increasing their focus on risk management as an emerging core competency, and most of them see the need for better data and information, so the bank can take action on an ever-evolving inventory of DFS risks. One challenge risk managers at the bank face is that risk data is scattered across the organization and not shared across business unit silos and there are no specific tools to help in solving these challenges.

Further to the risks, there is a problem with agent management being faced by the bank. This includes poor communication by network agents, lack of agent liquidity, agent inactivity, agent unavailability, poor quality customer experience at agents and agent business case.

Banking Industry Practitioners

The country's banking sector faces underdeveloped technology and venture capital ecosystems - shortage of skilled tech/finance people and entrepreneurs, small markets, and limited revenue potential of citizenry. There is a relatively weak infrastructure such as underdeveloped payment systems, customer credit data, legal enforcement mechanisms for payment obligations, power, and telco/Internet coverage.

Ugandan banks see the arrival of new technology posing the greatest risk to their business because of its complexity, the high cost of investment involved and the enormous changes it is bringing to financial services. Many banks have reported the same issue and that is-failure to master new technology could mean elimination from the market. Inability to transact due to unreliable network/service (network downtime) is logged as one of the top customer concern.

Ugandan banks face the risk of partnership. Developing, establishing, and overseeing an inclusive DFS ecosystem involves engagement with a more diverse and larger group of actors and stakeholders. This is needed in two domains: a) stakeholder management and b) infrastructure management of which most Ugandan banks are having problems executing successfully.

A lot of technology issues have been reported in Ugandan banks such as complexity of the interface for the DFS clients (ergonomics) - The level of literacy or the poor ergonomics of the DFS applications (commercial or client) impacts the ability of the clients/customers to master the different platforms; Missing features - The platform is sometimes limited in functionality, negatively impacting transactions or interactions with the clients; Web front poor ergonomics - In some cases, banks do not fully understand its target market for DFS as reported by a respondent 'sometimes there is an incorrect understanding of the customer which leads to development of products and channels not suited for the target customer'.

Competition as a result of changes in the market are pitting different types of institution in Uganda against each other – FinTech companies, commercial banks, MFIs – with different strengths and weaknesses. Respondent #BIP01 noted "Many Ugandan banks feels the playing field on which they operate is not level. Banks has got greater liquidity, FinTechs possess the technical know-how, commercial groups such as DFS suppliers are after profits, microfinance lenders see themselves playing a social role".

Finally, the supersonic speed of innovation and technological/platform change greatly affects the DFS channel strategies. Respondent #BIP05 noted that “the rapid speed of innovation and technological change has affected the Ugandan banking industry by making DFS strategies redundant and obsolete before a technology/platform and/or innovation is used.”

4.1.2. DFS risk mitigation requirements of Ugandan banks

4.1.2.1 General DFS risk mitigation requirements

Bank Employees

The bank uses incident investigation, auditing, and Internal communication and Periodical reports in identifying DFS risk. From this view, it can be noted that the bank leaves behind very important DFS risk identification approaches including Industry benchmarking, risk survey, Inspection by the bank risk staff, Incident investigation, and brainstorming. The bank is however making progress on ideas and solutions to reduce customer related DFS risks such as operational risks and is endeavoring to improve the awareness and ability of customers to avoid DFS risks. The bank reports of planning to spend a reasonable amount in their budget towards digital transformation.

The bank uses Know Your Agent/Customer (KYA/KYC) also sometimes known as Customer/Agent Due Diligence (CDD/ADD) methodologies to ensure they understand and know their customers and agents. Internal and external audits are carried out by the bank in an endeavor to manage risk.

Digitization of core business functions and processes is being taken by the bank including the digitization of sales and marketing, human resources, IT, etc. However, there is limited and less efficient risk management information systems in place and yet the standard goes ‘as banks digitize, so must risk and treasury’ because it is becoming increasingly common that banks are no longer “owning” the client interface because of digitization.

Traditional risk management frameworks are being used by the bank-to be specific, ISO 31000 even in managing DFS related risks like operation and credit risk. This is important although the complexity comes in situation where there are unique risks being brought about by digitization and DFS.

Banking Industry Practitioners

Most Ugandan banks are considering the use of biometric devices to reduce fraud. They are adopting policies and procedures to enhance fraud detection such as on utilization of PINs and conducting customer education on PIN protection. While the bank and the banking industry actors still lack the full picture on DFS risks and risk management, they are becoming increasingly aware of them and the need to improve mitigation.

4.1.2.2 *Information/DFS Systems risk mitigation requirements*

Bank Employees

Security Operations Management: This is the on-the-ground process by which security incidents at the bank are managed, security controls are implemented and maintained, and people with a higher level of access to IS/DFS systems and data are subject to oversight.

Business Continuity Planning (BCP): On BCP at the bank, in order to figure out how IS/DFS systems can resume normal operations during a disaster, the business continuity officers are, as reported, works with each business unit at the bank as closely as possible.

Disaster Recovery (DR): the bank works with IT/IS subject matter experts (SMEs), to figure out a way to bypass for example a particular electronic feed or file dependency that may be needed to continue the recovery of a DFS system.

Backups at the bank are used for complete IS/DFS system restoration. Backups are also extended to saving more than just digital data. Backup processes include the backup of IS/DFS system specifications and configurations, policies and procedures, equipment, and data centers.

Security Organization: The bank maintains a fairly safe circle of IS/DFS security practices. These include; User Authentication-all employees within and without a bank uses one or a combination of the following; Something he/she knows (a password or PIN), Something he/she has (a card or token), Something he/she is (a unique physical characteristic).

Application Security: The bank employs both network and computer-based control of applications. Respondent #BOA09 had this to say: 'we do control applications on the network, by allowing or denying the network connections required for the applications to communicate.'

Computer Security: The bank is using best practices to secure both Windows and Unix systems alike as described by Respondent #BOA04: 'we are doing our best to reduce the attack surfaces, run security software and antiviruses, apply vendor security updates, perform strong authentication, and control administrator privileges. However, out of the box, Windows contains many vulnerabilities that leave it open to attack, but we are trying our best to reduce those vulnerabilities in a number of ways. Whether a server or a workstation, the approach is the same'.

Network Security: The bank uses a combination of security mechanisms to secure its network including using routers and switches to increase the security of the network, Virtual Private Networks (VPN), unified threat management platforms (firewalls combined with network antivirus, web filtering, IPsec, and other network-oriented security functions). The bank however does not perform application network communication control, advanced wireless network hardening practices and this is found to be a serious security concern.

Storage Security: One of the primary concern of network security is to protect assets that reside on the network and the most significant of those assets is data. The bank boast of a modern and complex Storage Area Network (SAN) with built in

security capabilities. Separation of duties is however found to be lacking within the storage infrastructure of the bank.

Database Security: Many of the security-related best practices have been deployed by the bank to secure database systems including network-level security, physical security, and using server-related best practices. However, there are additional considerations that should be taken into account when securing databases.

Physical Security: The bank carries out a number of measures to ensure the physical security of IS/DFS infrastructure including; classification of assets which is the process of identifying physical assets and assigning criticality and value to them in order to develop concise controls and procedures that protect them effectively, building access control systems, mantraps at the entrance, locks, bugler-proof doors and file cabinets, laptop locks and docking stations, controlled access to data centers, wiring closets, and network rooms, building and employee IDs, biometrics, security guards, physical intrusion detection (e.g. Closed-Circuit Television-CCTV, alarms).

The bank is integrating old legacy systems with modern solutions in an endeavor to modernize their systems. This however, has been a huge hassle for the bank in the process of seeking to improve DFS. One of the challenges is that some of the modern cloud and other SaaS solutions are incompatible with the older legacy systems. This means that in order for the systems administrator incorporate new tools and programs, extensive custom code is required to make it work. This has resulted to the emergence of data silos at the bank, whereby different departments across the bank cannot freely access the data they need.

Talent and Training: The bank employs a reasonable number of talented IS/IT employees with an average of 5-10 years of work experience. However, the IT/IS department at the bank is suffering from gaps in critical skills areas such as cybersecurity, cloud computing and DevOps.

Banking Industry Practitioners

Ugandan banks functions in a dynamic operating environment marked by rising customer expectations, a constantly changing economic landscape, widening scope and intensity of industry regulation. It is leveraging less of technological innovation geared towards IS/DFS systems risk management, while at the same time staying less vigilant against evolving IS/DFS systems risks.

For the last few decades, the global technology industry navigated talent supply challenges quite effectively. At the beginning, Ugandan banks attracted science, technology, and engineering talent from around the globe to work in its tech departments but this has since changed.

4.1.3. Summary

The respondents in the interviews raised valuable and important points both anticipated and expected through directly answering questions, and through presenting views in open and closed-ended questions and focused group discussions. The various categories obtained included issues directly addressing the concept of DFS delivery channels and models and DFS risks and risk management approaches.

The way most of the obtained views were inter-related suggests the richness of the topic of discussion, and acted as a pointer to possible future research in a qualitative method. The findings presented, interpreted, deliberated upon and theoretically contextualized in this chapter signify an attempt not only to reinforce ideas picked from the DFS and risk management literature but to unequivocally extend those ideas and bridge gaps in knowledge that would assist DFS providers, policy makers and practitioners in engaging in an innovative but yet risk aware DFS delivery.

4.2. Artifact Design

The framework design work was started by setting initial requirements which acted as guidelines for finding different theories in literature, especially about DFS and risk management. The findings from literature review were combined with practical/field experiences and study findings of the researcher and as a result of this combination, the Framework was designed.

4.2.1. Framework Structure

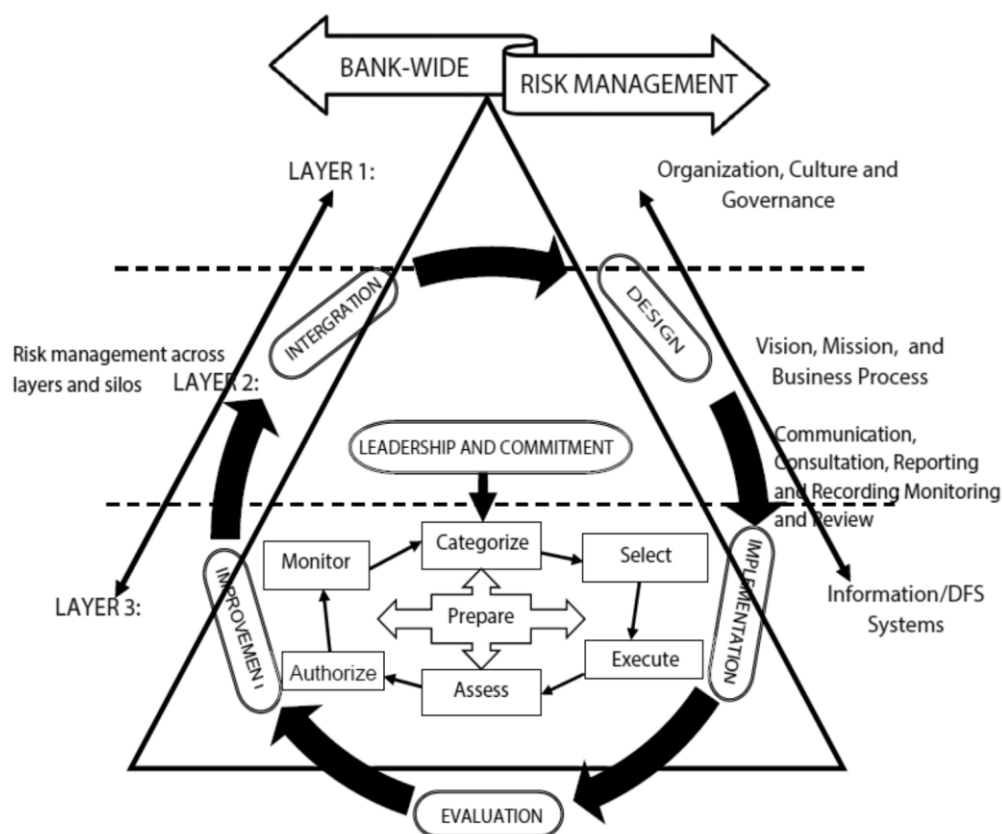


Figure 2: E-Risk Management Framework for DFS in banks

4.2.2. Framework components, process and contents

The framework adopts the ISO 31000:2018 framework design with a particular emphasis on Information/DFS Systems risk management incorporated with modification from NIST 2018 RMF. The framework works across three layers of the bank; Layer 1: Organization, culture, and governance, Layer 2: Vision, mission, and business process, and Layer 3: Information/DFS systems. The framework consists of six (6) major components: Leadership and commitment, Integration, Design, Implementation, Evaluation, and Improvement with seven (7) other steps (sub-components) focused on managing Information/DFS systems risk in banks; which are: Prepare (Process Initiation); Categorize; Select; Execute (Implement); Assess; Authorize; and Monitor.

4.2.2.1 DFS e-Risk Management Framework layers

Layer 1: Organization, Culture, and Governance: There should be adequate independence, accountability and segregation of duties involved in the oversight and management of DFS risks and the existing organization structure should allow for a bank-wide view of DFS risk management.

Layer 2: Vision, Mission, and Business process: Managing DFS risk in banks is a complex undertaking that requires the involvement of the entire bank. It should start from senior leaders providing the strategic vision and top-level goals and objectives for the bank, to mid-level leaders planning, executing, and managing DFS projects, to individuals developing, implementing, operating, and maintaining the Information/DFS systems supporting the bank's missions and business functions.

Layer 3: Information/DFS Systems: There should be a robust process in place to assess and monitor Information/DFS systems risk even at third party service providers. The questions to ask here include: 1) Is the Information/DFS Systems infrastructure appropriate given the DFS growth strategy and complexity of the DFS investments and type of DFS risks? 2) Are there adequate controls to guarantee DFS risk and finance data completeness, integrity and accuracy?

4.2.2.2 DFS e-Risk Management Framework components

- Leadership and commitment: Mandate and commitment from the Board is critically important and it needs to be continuous and high-profile. Unless this mandate and commitment are forthcoming, the DFS risk management initiative will be unsuccessful.
- Integration: This framework component includes; Determining management accountability and oversight roles and responsibilities; and Ensuring DFS risk management is part of, and not separate from, all aspects of the bank.
- Design: This component includes; Understanding the bank and its internal and external context; Articulating DFS risk management commitment and allocating resources; and Establishing communication and consultation arrangements.

- **Implementation:** This component includes; Developing an appropriate implementation plan including deadlines; Identifying where, when and how different types of decisions are made, and by whom; and Modifying the applicable decision-making processes where necessary.
- **Evaluation:** This component includes the following activities; Measuring the Framework performance against its purpose, implementation and behaviours; and Determining whether the Framework remains suitable to support achievement of objectives.
- **Improvement:** This component includes the following activities; Continually monitoring and adapting the Framework to address external and internal changes; Taking actions to improve the value of DFS risk management; and Improving the suitability, adequacy and effectiveness of the DFS RMF.

4.2.2.3 *Information/DFS Systems risk management steps (sub-components)*

The framework features the following steps (sub-components), incorporated from NIST 2018 RMF as part of the overall bank-wide risk framework—focused on Information/DFS Systems risk management:

- Prepare to execute the Information/DFS system RMF from an organization and a system-level perspective by establishing a context and priorities for managing security and privacy risk.
- Categorize the Information/DFS system and the information processed, stored, and transmitted by the Information/DFS system based on an analysis of the impact of loss.
- Select an initial set of controls for the Information/DFS system and tailor the controls as needed to reduce DFS risk to an acceptable level based on an assessment of DFS risk.
- Execute/Implement the controls and describe how the controls are employed within the Information/DFS system and its environment of operation.
- Assess the controls to determine if the controls are implemented correctly, operating as intended, and producing the desired outcomes with respect to satisfying, for example, the security and privacy requirements.
- Authorize the Information/DFS system or common controls based on a determination that the DFS risk to bank operations and assets, individuals, and other organizations is acceptable.
- Monitor the Information/DFS system and the associated controls on an ongoing basis to include assessing control effectiveness, documenting changes to the Information/DFS system and environment of operation, conducting DFS risk assessments and impact analyses, and reporting the security and privacy posture of the Information/DFS system.

4.2.3. Framework Implementation Plan

To successfully implement the DFS e-Risk Management Framework, the initiative should be an on-going process on a continuous basis.

No.	Activity	Tools and Techniques
1. Planning—Implementing		
1.1	Identify intended benefits of the DFS RMF/initiative and gain board/executive level support	• DFS risk appetite • Corporate governance
1.2	Plan the scope of the DFS RMF/initiative and develop common language of DFS risk	• DFS RMF sophistication • Upside of DFS risk • Stakeholder expectations
1.3	Establish the DFS risk management strategy, roles, and responsibilities	• DFS risk management policy • DFS risk architecture • Level of risk maturity
2. Implementing—Measuring		
2.1	Adopt a suitable DFS risk assessment procedures and an agreed DFS risk classification system	• DFS risk protocols • DFS risk management guidelines • DFS risk classification systems • DFS risk description
2.2	Establish DFS risk significance benchmarks and undertake DFS risk assessments	• Benchmark tests of significance • DFS risk register
2.3	Determine DFS risk appetite and risk tolerance levels and evaluate the existing controls	• DFS risk appetite • DFS risk matrix • Loss control
3. Measuring—Learning		
3.1	Ensure cost-effectiveness of existing controls and introduce improvements	• DFS risk improvement plans • Reaction planning
3.2	Embed DFS risk-aware culture and align DFS risk management with other management tasks	• Control environment • Resource allocation • DFS risk communications • DFS Delivery/Business model

4. Learning—Planning		
4.1	Monitor and review DFS risk performance indicators (KPIs) to measure RMF contribution	• Audit plan • Sources of DFS risk assurance
4.2	Report DFS risk performance in line with legal and other obligations and monitor improvement	• DFS risk reporting

Table 3: DFS E-Risk Management Framework Implementation Plan

5. Conclusion

DFS have enormous potential to drive financial inclusion in low resource countries, but it's success will depend on having an appropriate risk management and regulatory framework that does not stifle innovation, as well as strong commitment, communication, support, and coordination from other partners and regulatory bodies. The rapid technology evolution comes with risks, and requires that Ugandan banks, partners and regulators stay in constant communication in order to assess the risks of each DFS product/service. The study identified a number of unmet requirement/gaps that demonstrate highly, the need for a DFS e-risk management framework in banks in particular and financial institutions in general.

Risk management in banks in this digital age is becoming more complicated than ever as security technology – including methods to evade it are gaining in sophistication. There is need for digital risk assessment to be put first by Ugandan banks and they should also reinforce an updated DFS risk management practices because this will ensure that all customer data is encrypted, private, and appropriately secured. As government and regulatory bodies are also becoming more aware of the risks of DFS and other digital operations at banks, regulations and compliance requirements must increase concurrently and banks should be held to a higher standard for maintaining security of DFS systems.

Banks in Uganda have not developed her own comprehensive DFS risk management reports and are relying on other related reports to monitor some risks that are directly linked to DFS. They also don't employ a comprehensive approach to DFS risk management, seldom integrating DFS risk management strategies in all areas of operations and in the organizational (bank) culture. There are also a number of unmet requirements/gaps in the way the security of DFS systems at the bank are managed. A set of framework design requirements/criteria were identified on the onset and two existing and commonly used RMFs (ISO and NIST) were reviewed and deemed applicable in designing a DFS RMF.

Finally, this framework addresses the needs of Ugandan banks. The banks may need to adopt and integrate all or parts of the framework. This framework should help to convince banks of the importance of institutionalized and integrated DFS risk management, but it is up to the bank to create the links between the various levels of operations and lines of authority. This study therefore furthers our knowledge of how DFS risk management can be implemented in banks.

6. Recommendations

The bank should consider the impact of change, innovation in technology and access to technology when providing: a) New DFS; b) Amending DFS; c) Curtailing DFS due to the adoption of technological solutions and efficiency driving measures, and; d) Training for employees administering DFS.

IT spend at this bank should be carefully balanced across three critical areas: customer expectations/services, cybersecurity and internal process.

The bank need to constantly refresh the talent pool. As made in numerous observations and studies, it is found that high-performing risk functions commonly depend on a high-performing IT and data infrastructure—for example, a central “data lake/repository” with harmonized definitions, architecture and clear data governance. There is unquestionable evidence that points that building the right mix of talent is equally important.

The bank should enhance and “reinforce” risk reporting especially for DFS risk. Better risk reporting is needed because of the ever-broader and cross-boundary regulation, and the need to adjust to market developments which require rapid, fact-based decision making. Paramount, is the recommendation for replacing paper-based reports with for example interactive tablet and mobile-based solutions that offer information in real time and enable users to do root-cause analyses. This would enable the bank to make better decisions faster, robustly and to identify potential risks more quickly as well.

In the process of managing short-term risks and priorities, risk management in the bank has to also focus on emerging risks which include; Industry disruption due to technologies, Availability of data, Industry disruption to new entrants, Integrity of data and data destruction, IT obsolescence, Model risk, Geopolitical risk, and Environmental risk or climate change. These risks may be “new kids on the block”, previously less thought of or known but are increasing, and will definitely require more analysis, consideration and care.

The bank should build a strong risk-management culture. The activities of detection, assessment, and mitigation of DFS risk must become part and parcel of the daily activities of all the bank employees no matter the position and not only those in risk functions and senior management. With the continuous automation and more sophisticated and complex analytical and technical capabilities, human intervention is more than required to ensure appropriate and ethical application and deployment of risk management tools, technologies, policy and procedures.

DFS risk and risk management at this bank need to become a board-level concern. The Chief Risk Officer (CRO) need to establish ways of regularly monitoring DFS risks and providing an informed view to the bank and its management. In particular, the board at the bank need to be made aware of DFS risks and regularly updated on new developments and trends. DFS risk assessments should involve input from technology experts and other stakeholders across the bank; the bank need to set up a DFS working group that meets regularly. The CRO need to get closer to IT decision-making and establish strong links with their information security colleagues/department.

The bank need transformative new technology to address the ever-increasing complexity around managing risk and regulatory requirements. Some of the Important things the bank leaders must consider along the way are: preparing to implement changes without the need to complete a broad system rebuild, employing smarter software for risk management (Risk Monitoring and Management Information Systems—RMIS) and programs that are easily adaptable, and eliminating silos of data that currently exist between various systems in the financial environments. Advanced technologies such as big data analytics, service-based IT architectures, Artificial Intelligence (AI), and machine learning can help the bank harness the vast amounts of data at their fingertips to identify risks and opportunities with more precision, while responding more quickly to stakeholder demands. Risk management in these banks must keep pace with technology-driven change, and take the front seat in helping the bank to achieve digital ambitions.

The bank should regularly check its IT security. The ubiquity of digital technology in banking makes security a much bigger issue. With the constant and “break neck” speed of technology update/change in banks, the “ground-breaking” technology can become a liability if for example it leaks customer data or is hacked. The banks need to periodically and constantly review their security software and security policies. Fraud-detection and analytics technology has proven to be very helpful. It can help prevent intruders from breaching the bank’s perimeter network and highlight and expose suspicious transactions at an early stage.

7. Suggestions for Future Research

The following suggestions for further/future research address contemporary trends in DFS risk management in the Ugandan banking industry and the insights gained herein.

One outstanding limitation is that this study focuses heavily on bank employees. It has not explored deeply other parties that may constrain and/or influence DFS risk management in banks. Future researchers could take into account other parties' interests; For example, the interests of the telecom industry, non-bank payment institutions, credit intermediation platforms, FinTechs, and BigTechs, etc. in the future of DFS risk management in banks.

Finally, further study is recommended into the expanding role of Ugandan banks as DFS providers in securing DFS and systems. This could for example include whether there are acceptable sensible limits to tasks given and what role a bank can play in enhancing cooperation in the security chain between other stakeholders in DFS risk management such as manufacturers of ICT/FinTech products, BigTech, Telecoms, and providers of ICT services and concurrently asking the “mammoth” question; does the current definition of a bank as a DFS provider match the reality of work asked and tasked?

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Venezuelan Scientific Journals in Scopus: Production and Impact 2000-2020

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Abstract

The historical behavior of Venezuelan journals indexed in Scopus from 2000 to 2020, their visibility and impact were studied. The data were obtained from the Scimago Journals and Country Rank portal and were a number of journals, published papers, impact factor (SJR) and quartile of location. The historical behavior of each variable was analyzed using sequential time series models to establish whether the behavior has been random or whether it follows a defined trend. It was found that both the number of journals and the number of published papers follow definite trends and SJR behaves randomly. The decrease in the number of journals may be influenced by the critical socioeconomic situation of the country; however, the number of papers has increased over time and the SJR has remained in a narrow range, meaning that most journals fall between the Q3 and Q4 quartile.

Keywords: Venezuelan journals, historical behavior, impact, visibility

1. Introduction

Scientific production has become a priority for most countries in the world, especially for developing countries. In the last 20 years, scientific production in Latin America and the Caribbean, as in other regions of the world, has been influenced by the development of the Internet, with scientific journals moving from the printed format to coexist in digital format, and by the development of the open access movement, which promotes the publication of scientific articles without economic, technological, or legal barriers, in accordance with the Budapest Declaration, which has had a positive impact on most of the countries in the region [1].

The increase in the scientific production of countries has been related, in recent decades, to emerging economies, which has seen an expansion of productive activities at different levels, especially in the science, technology, and innovation sectors [2]. In the case of Venezuela, its scientific production ranked it number 5 in Latin America in 2000 according to the SJR ranking, surpassed only by Brazil, Argentina, Mexico,

and Chile. However, as a result of the country's economic situation, which has led to a hyperinflationary process [3], in addition to the degradation of the university system and research centers, scientific production has fallen significantly, reaching position 9 in 2016 and position 10 in the SJR ranking by 2020.

Venezuelan scientific production has also been negatively influenced by the decrease in the number of teachers and researchers, who have emigrated to other countries, many of whom have dedicated themselves to activities other than research and those who are doing so, produce scientific papers with institutional affiliations in other countries. It is estimated that, by the end of 2020, Venezuela has lost 2,630 scientific researchers, with different levels of expertise and coming from the entire spectrum of knowledge; from laboratory technicians to law graduates, to full professors or emeritus professors [4]. The number of researchers who have emigrated represents slightly more than 16% of the national research force, taking as a reference the 15,394 active researchers registered in the country for the period under analysis. The scientific production of those who have migrated represents 26% of the production of all researchers in the country. 26% of what is produced by all Venezuelan scientists and technologists [5].

The problem of the decrease in Venezuelan scientific production has been the subject of previous studies mainly due to the brain drain [6]. Likewise, the relationship between the emigration of researchers in Venezuela and overall scientific productivity has been analyzed [4]. Similarly, research has been conducted on the support to Venezuelan scientists, academics, and professionals in exile, refugees, and at risk [7]. Similarly, it has been reported in recent studies that in the period 1960-2014, 14% of the scientific community emigrated, corresponding to 1783 researchers, who are responsible for 31% of Venezuelan scientific production [8].

The negative effect of the migration of scientists has not only been on the country's scientific production but has also been manifested in the number of scientific journals published in the country, their production, and their impact. Therefore, the present research aims to analyze the behavior of the number of Venezuelan journals, their scientific production, and their impact in the period 2000 - 2020.

2. Materials and methods

2.1. Data collection

The data necessary to carry out the research were obtained from the Scimago Journal and Country Rank portal (www.scimagojr.com). It was filtered by country to obtain the data for Venezuela and each year from 2000 to 2020. All the data were downloaded to then choose those necessary for the research, which were: Number of journals, Published documents, SJR, Best quartile, and Number of journals by area of knowledge. The indicators analyzed in the study are described in Table 1.

Indicator	Codification	Description
Journals	Journals	Number of journals indexed in Scopus for each year analyzed.
Documents	Documents	Total number of papers published by the journals in each year analyzed.
SJR	SJR	Impact Factor according to Scopus average obtained for each year of study.
Best quartile	Q	Best quartile location of the journals for each year studied.
Knowledge area	KA	Specific knowledge area where the journals are located according to the Scopus database classification.

Table 1. Description of the bibliometric indicators used in the study.

2.2. Data processing

To analyze the behavior of the number of journals, the production of scientific papers and the impact factor (SJR) with respect to time, a time-series analysis with a randomization test [9], was performed to analyze the trend of the data and whether they follow a random behavior or, on the contrary, behave according to a defined trend. The results will be presented graphically and in tables.

A time-series consists of a sequential set of numerical data taken at equispaced time intervals, usually over some time data were taken at equispaced time intervals, usually over some time or space of time or space. Models available include moving averages, random walks, various types of exponential smoother, trend models, and parametric models trend models, and parametric ARIMA models [10]. For the selection of the time-series trend model, the criterion used was the Mean Absolute Percentage Error (MAPE), the best-trend model being the one with the lowest MAPE. All analyses were performed using Statgraphics Centurion XVII statistical software.

3. Results and discussions

From the data collected, Table 2 shows the number of journals per year and the number of journals that were placed in each quartile according to the SJR.

A progressive increase in the number of indexed journals was observed between 2000 and 2010, indicating a decade of growth in the quality of Venezuelan journals. From 2011 onwards, the number of journals decreased until 2020. This decrease was mainly because some journals ceased to circulate, i.e., they did not continue publishing, and others were discontinued from Scopus due to non-compliance with the minimum requirements demanded by the indexer, but they are still active, although they are no longer indexed in Scopus. The most recent cases of discontinued journals are observed in 2020 where the two journals located in the WQ column (without quartile) were removed from the database, these were the journal *Opción* and the journal *Utopía y Praxis*; both in the areas of Social Sciences and Arts and Humanities.

Year	Journals	Q1	Q2	Q2	Q4	WQ
2000	12	1	3	3	5	0
2001	13	0	1	7	4	1
2002	15	0	2	4	7	2
2003	17	0	2	5	8	2
2004	18	0	1	6	10	1
2005	18	0	2	6	9	1
2006	19	0	1	4	13	1
2007	25	0	1	6	10	8
2008	39	0	1	9	15	14
2009	42	0	1	9	28	4
2010	43	0	1	14	27	1
2011	43	0	1	17	25	0
2012	42	0	1	19	21	1
2013	40	0	0	19	20	1
2014	40	0	0	11	29	0
2015	40	0	1	14	25	0
2016	39	0	0	17	21	1
2017	40	0	0	12	27	1
2018	39	0	1	7	31	0
2019	37	0	3	11	23	0
2020	31	0	1	6	22	2

Table 2. Number of Venezuelan journals indexed in Scopus between 2000 and 2020 and quartiles.

Despite the decrease in the number of journals in the last decade, there is still a positive difference concerning the year 2000 of 19 journals, which indicates that Venezuelan scientific publications still represent 3.5% of the total number of journals in Latin America and the Caribbean. This is only surpassed by countries with a research tradition such as Brazil (44.6%), Colombia (13.0%), Mexico (12.8%), Chile (12.6%) and Argentina (7.5%) and surpassing countries that are in a stable economic situation and considered to be among the fastest-growing in the region, such as Peru (1.5%), Costa Rica (0.7%) and Ecuador (0.3%). This shows that even with the migration of scientists, Venezuela will continue to maintain by 2020 an important number of journals where scientific articles are published not only in the country but also in other parts of the world. This is even more relevant if we consider that the number of LAC journals indexed in Scopus has been increasing in recent years [11].

Regarding the placement of Venezuelan journals in quartiles, in 2000 the only journal in Q1 was *Interciencia* (Multidisciplinary). In the rest of the study period, the

maximum location of the journals was in Q2, reaching 3 journals in that quartile in 2019 and one in 2020. The largest number of journals were located in the Q3 and Q4 quartiles, which shows that in the last 20 years the impact of Venezuelan journals indexed in Scopus has been medium-low. This behavior is not exclusive to Venezuelan journals, but is a trend observed in LAC journals [1] and was reported in the case of Peru with a greater number of journals between the Q3 - Q4 quartiles [12].

3.1. Journal trends

To analyze the historical trend of the number of Venezuelan journals between 2000 and 2020 different sequential time series models were applied and the one that obtained the lowest MAPE was the ARIMA (2,0,0) model with a value of 6.32% with a p-value < 0.05 and an estimated standard deviation of 3.29 (Figure 1). According to these results, the historical behavior of the number of journals fits a sequential autoregressive integrated moving average autoregressive model with the quadratic autoregressive term [13].

The randomization analysis showed that the applied test (Box-Pierce) based on the sum of squares of the autocorrelation coefficients yielded a p-value = $0.000 < 0.05$, which indicates that the hypothesis that the trend of Venezuelan journals has a random historical behavior is rejected [14], thus proving that the number of Venezuelan journals indexed in Scopus between the years 2000 and 2020 has behaved following a pattern, which has been influenced by the country's internal socio-economic problems since the situation of the Venezuelan science has reported a significant decline in the production of knowledge mainly by its state universities, which has systematically influenced its scientific journals [15].

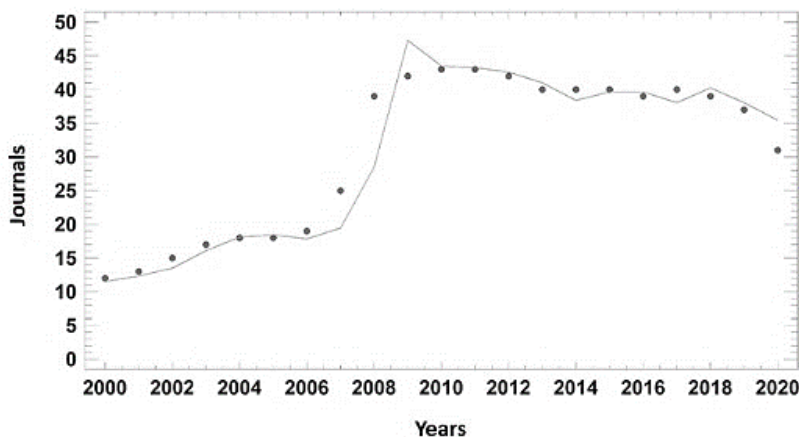


Figure 1. The behavior of the number of Venezuelan journals between 2000 and 2020 according to the ARIMA model.

3.2. Documents trends

The analysis of the historical behavior of the documents published by Venezuelan journals between 2000 and 2020 can be seen in Figure 2. Regarding this variable, it was observed that even when the number of journals decreased from 2010, the number of documents published remained practically constant from this year until 2014, from which a progressive increase was observed with a maximum peak in 2017 and then a decrease until 2020. Despite the decrease in the number of documents published by Venezuelan journals between 2017 and 2020, there is still a higher production than at the beginning of the study period and even higher than the production in the years when there was a greater number of indexed journals.

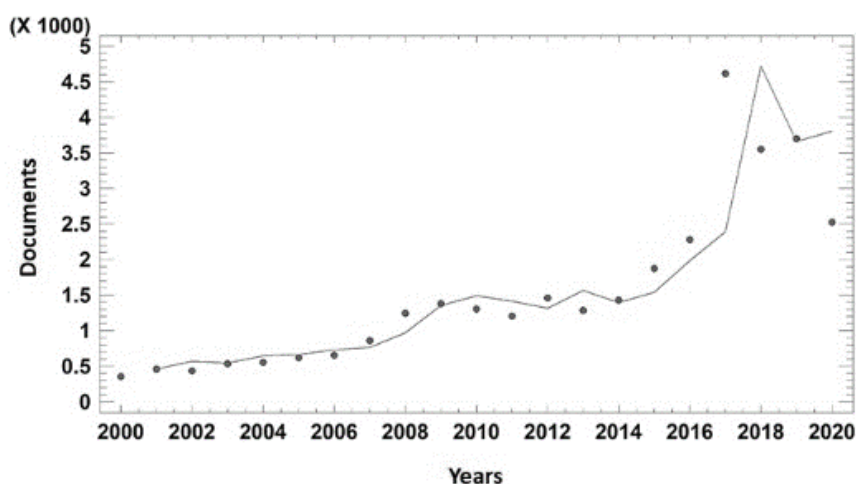


Figure 2. The behavior of papers published by Venezuelan journals between 2000 and 2020 according to the Random walk with drift model.

The analysis by sequential time series showed a trend adjusted to a Random walk model with drift = 108.65, with a MAPE = 16.64%. This model assumes that the best prediction is given by the last possible data value plus a drift constant up or down. The behavior of published papers with a fit to a random walk model, even if between 2016 and 2016 a stable trend with a slight slope that caused the increase in production is observed, may be influenced by the sharp rise and subsequent fall in production between 2017 and 2020. The above led to the randomness analysis of the historical series, which resulted in the Box-Pierce test in a $p\text{-value} = 0.0006 < 0.05$ indicating that the series is not random, but on the contrary follows a behavior dependent on the determinants on the number of papers published by the journals.

The publication of Venezuelan scientific journals remained stable during most of the study period, despite the deterioration of university institutions and research centers in the country, as well as the slowdown of research stimulus programs [16]. Similarly, the relevance of including socio-political analytical dimensions has been highlighted when considering studies on the behavior of science in Venezuela as part

of new methodologies of analysis for the understanding of this phenomenon in the country [17].

On the other hand, the high production of Venezuelan journals between 2017 and 2019 compared to previous years was determined by some journals that published an excessive number of papers, with questionable editorial processes, such as the case of the journal *Espacios* that published 1959 papers in 2017 and 1683 papers in 2018 which led to its discontinuation in 2019 and definitive removal from Scopus. This is a situation that can also be attributed as a consequence of the Venezuelan socioeconomic situation, since journals such as the aforementioned one were dedicated to publishing papers without scientific rigor, just for a publication fee, which turned it into a simple business.

3.3. Impact factor trends

The historical behavior of the average impact factor of Venezuelan journals between 2000 and 2020 according to the Scopus SJR is shown in Figure 3. This impact indicator was adjusted to a two-term Simple Moving Average model, mainly due to the observed variability, with a maximum value of 0.150 in 2013 and a minimum of 0.121 in 2009.

The analysis of the randomness of the variable through the Box-Pierce method indicated that the SJR of Venezuelan journals behaved randomly between the years 2000 and 2020 with a $p\text{-value} = 0.7030 > 0.05$. This reveals that the impact of the journals has not followed a stable trend, but on the contrary has behaved randomly, so that the importance of the published papers may vary in each year, depending on the quality and relevancy of publishing documents.

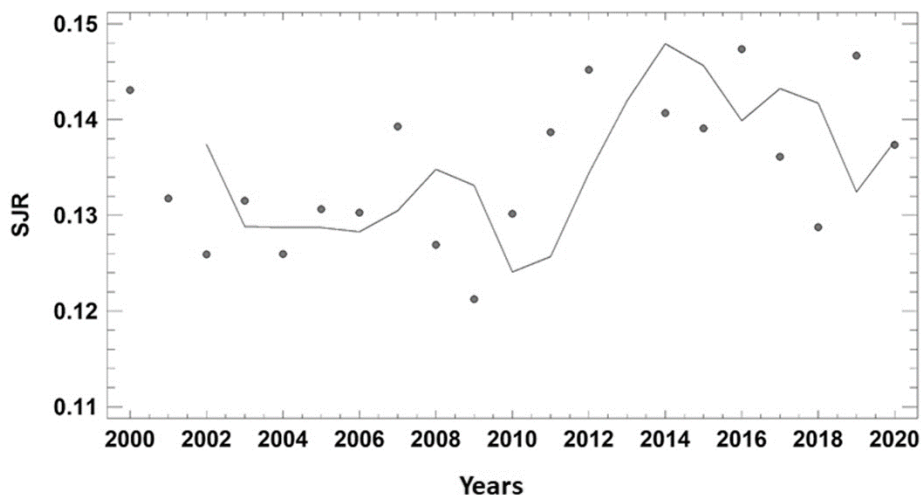


Figure 3. The behavior of SJR of Venezuelan journals between 2000 and 2020 according to the 2-term Simple Moving Average model

The impact factor varies each year and in some areas of knowledge more than in others, that is why important variations are observed in specific periods, such as a fall between 2000 and 2002, then a relatively stable variation between 2003 and 2006, and later increase and fall again between 2007 and 2009. Between 2009 and 2012 occurred the largest increase and then fluctuate between 2013 and 2020. The variations in the annual average impact factor are due in part to the fact that the papers are not immediately cited, but rather that the true impact can be observed in an average of 2 years after publication [18].

3.4. Trend of journals by area of knowledge

A review of the evolution of the number of journals per year according to the area of knowledge showed that the largest number of journals indexed in Scopus are in the areas of Arts and Humanities, Agriculture and Biological, Social Sciences and Medicine (Figure 4).

These areas of knowledge showed a higher number of journals between the years 2007 and 2018, from this year they suffered a decrease but remain as the areas with the highest number of journals. By the end of the period, the highest number of journals corresponds to Social Sciences and Medicine with 10 and 11, respectively.

In the rest of the areas of knowledge, the number of Venezuelan journals has been low throughout the study period (<4) with some journals being excluded from Scopus towards the end of the period, as in the case of environmental sciences. This indicates that although the number of journals has decreased, the areas of knowledge have been maintained over time, some with greater presence than others.

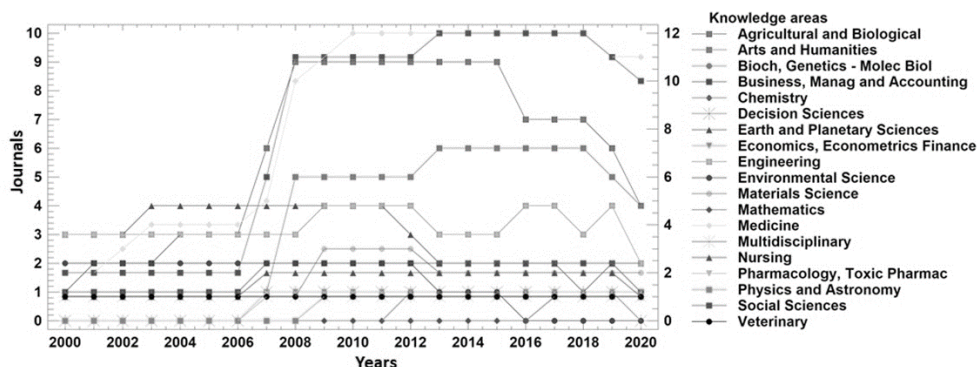


Figure 4. Number of Venezuelan journals by area of knowledge between 2000 and 2020

Venezuelan scientific diffusion based on its scientific journals is still maintained, although these journals, being mostly associated with public universities, have suffered significantly due to the budgetary deficiencies resulting from the government's misguided economic policies [19], which is why Venezuela is still the sixth country in the number of journals indexed in Scopus for the year 2020.

In specific areas of knowledge such as natural resources and engineering, it has been shown that socioeconomic indicators such as public spending on research and development, the number of researchers, spending on education, and GDP are determinants in the number of journals in Latin American countries [11], [20], which may also influence the historical behavior of journals in other areas of knowledge, as observed.

4. Conclusions

Despite the problems generated by the socio-economic and political situation affecting Venezuela, which have led to a decrease in scientific production, the loss of researchers who have emigrated to other countries, and the critical conditions in which public universities find themselves, which have generated a decrease in the number of scientific journals indexed in Scopus, the country remains as the sixth in the Latin American and Caribbean region in the number of indexed journals with 31 for the year 2020, which indicates a degree of commitment of universities and editorial teams to keep alive these means of scientific dissemination par excellence.

It was observed that the number of Venezuelan journals indexed in Scopus has had a non-random historical behavior between the years 2000 and 2020, so it is concluded that both the increase shown between the years 2006 and 2011 and the tendency to decrease from 2012 have not occurred randomly, but have been behaviors influenced by the critical situation through which the country has gone through during the entire study period. Accordingly, the temporal sequential trend model to which the behavior of the number of journals was adjusted can be a predictive tool for future years, especially because there is no improvement in the conditions affecting journals, at least in the short term.

Regarding the number of documents published by Venezuelan journals indexed in Scopus between 2000 and 2020, the historical behavior showed a trend of a sustained non-random increase so that even when the number of journals decreased, the number of published documents continued to increase. This leads to the conclusion that Venezuelan journals have maintained a certain level of prestige as a means of scientific divulgation, and that authors have continued to rely on them to publish their articles. At the end of the period, there was a greater variation in the number of articles published in Venezuelan journals, as a result of excess publications by some journals with dubious editorial processes that were discontinued by Scopus, resulting in a decrease by the year 2020, returning to stabilize the historical trend.

The average annual impact factors (SJR) between the study years had a narrow range between 0.121 and 0.150, with historical behavior fitted to a 2-term Simple Moving Average model. From the above, it is concluded that the impact of the documents published by Venezuelan journals between 2000 and 2020 has been low, which is also based on the fact that most of the journals were located between the Q3 and Q4 quartile, i.e. the middle-low quartile.

In general, it is concluded that the Venezuelan journals indexed in Scopus between 2000 and 2020 have been influenced by the socioeconomic and political situation that the country is going through, which has caused them to have a tendency

to decrease, although the publication of documents is on an upward trend and the impact factor remains within a stable range. The above merits a continuity in the deeper study of how the situation in Venezuela is going through is affecting the bibliometric indicators of its journals in comparison with those of other countries whose socioeconomic and political situation is more stable, since Venezuela continues to maintain an important presence of journals indexed in Scopus in Latin America and the Caribbean.

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Identifying Organizational Factors Effective Knowledge Concealment in Scientific Contexts (Case Study: Islamic Azad University of Khorasan Razavi)

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Abstract

This study aims to investigate the organizational factors affecting knowledge concealment in scientific contexts. This study has taken a mixed approach to identify these factors, so what makes it unique is the pluralism of data collection methods. Also, using the "Delphi" method, a conceptual model of organizational factors affecting knowledge concealment in scientific contexts is presented. The statistical sample included 314 employees of the Islamic Azad University of Khorasan Razavi who were selected through the random sampling method. They filled knowledge concealment questionnaire by Demirkasimoglu (2016) and a scholar-made questionnaire. Data were analyzed using the structural equation method (SEM) in AMOS software. Findings revealed that the coefficient correlation of organizational culture, reward system, organizational structure, organizational support, organizational justice, quality of work-life, and leadership style with knowledge concealment was -0.62, -0.27, -0.49, -1.30, -0.77, -0.39, and -0.88, respectively. The results indicate that organizational factors have an inverse and significant relationship with knowledge concealment.

Keywords: Organizational Factors, Knowledge Concealment, Islamic Azad University of Khorasan Razavi.

1. Introduction

Although many variables involved in knowledge sharing have been studied, the factors affecting knowledge concealment have not been specifically addressed. It is

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very important to investigate the existence of deliberate efforts by an organization's staff to hide knowledge and its roots in the organization. Since organizations do not own the intellectual property of their employees, they cannot force them to transfer knowledge to other members [1].

Despite the designed efforts to increase knowledge transfer at the organizational level, little success has been achieved. Therefore, no accurate statistics of knowledge concealment is mentioned in domestic research; However, studies on hiding organizational knowledge and examining the effect of social norms on knowledge concealment in organizations, as well as providing a background model for knowledge concealment in software companies, indicate the existence of this phenomena in Iranian organizations [2], [3], [4].

Failure or relative success of field research projects shows that poor staff communication at the operational level, weak teamwork skills, the competitiveness of organizations with similar foreign organizations in terms of expertise and multifunctional knowledge lead to the process of knowledge concealment in Iranian organizations [4].

Despite efforts to transfer knowledge in organizations, many challenges are unsolved. In many cases, even when organizations take measures to facilitate knowledge transfer, employees are not motivated to share their knowledge [5]. On the one hand, concealing knowledge may have positive causes and consequences and may be done solely to prevent hurting the other party's feelings or to keep secrets, or to protect the interests of a third party. So, knowledge concealment is not always a negative behavior [6]. On the other hand, achieving sustainable competitive advantage needs specific attention to the current knowledge, how to use it effectively, and creating a structure for using new [7]. Some organizational factors also pave the way for the establishment of knowledge management [8].

Given the importance of sharing knowledge in organizations, this research seeks to identify organizational factors affecting knowledge concealment in scientific contexts.

2. Literature Review

Scholars and academics have different perspectives on knowledge management and they propose various technology-based solutions and practical instructions [9]. The most important goal of applying knowledge management in different types of institutions is to adapt quickly to environmental changes to improve organizational efficiency and profitability. As a result, knowledge management refers to how knowledge is created, disseminated, and used in the organization [10].

Knowledge management improves universities' competitiveness by using new knowledge to reduce costs, increase speed, and meet customer needs [11].

Knowledge concealment refers to the deliberate attempt of some individuals to conceal knowledge or not revealing it to an asking person [3]. Albeit, knowledge concealment focuses on the state in which specific knowledge is sought by an individual. For example, a person may request a copy of a report and his/her colleague

refuses to provide it, arguing that the report is confidential. In this example, the required knowledge is not provided, although there was no deception [12].

Knowledge concealment is examined in the interpersonal state since individuals are the main way of knowledge transfer in organizations. Also, people's attitudes toward knowledge – the effect of reputation and a sense of individual ownership on knowledge – are among factors ignored concerning knowledge concealment [13].

Organizational factors in the present study include organizational culture, reward system, organizational structure, organizational support, organizational justice, quality of work-life and leadership style, each of which is briefly stated.

Organizational culture is a phenomenon in the organization while all the employees agree that an invisible hand leads them to a kind of invisible behavior. Perceiving the components of organizational culture, and how it is created and sustained helps to justify the staff's behaviors [14].

The reward system refers to the provision of a pleasant outcome for the desired behavior to increase the likelihood of its recurrence [15]. Rezaieen (1989) defines organizational structure as a system of relationships, informally formed and formally approved, that governs the activities of individuals who are interdependent to achieve common goals [16].

Organizational support is define as an essential component of mutual relationships related to organizational commitment, and studies suggest a positive strong relationship between perceived organizational support and staff's organizational commitments [17].

Organizational justice points to the staff's perceptions of fair or unfair organizational treatment [18].

Quality of work life is the staff's reaction to their jobs, especially its consequences for job satisfaction and mental health [19].

Leadership is a kind of behavior and the physical manifestation of a relationship. Leadership as a process refers to influencing without force to guide and coordinate activities of a group, and as an attribute, it means a set of characteristics.

Therefore, the role of organizational factors including organizational culture, reward system, organizational structure, organizational support, organizational justice, quality of work-life and leadership style affect knowledge concealment [20].

3. Research Background

The study of Xu et al. showed that workplace isolation was positively associated with evasive knowledge concealment. In addition, a hypothesized three-way interaction including workplace isolation, negativity, and moral separation was justified by knowledge concealment [21].

The results of Bari et al manifested that knowledge concealment and concealment through vague games had a significant negative relationship with team creativity. However, logical concealment did not significantly affect team creativity [22].

Belshack et al concluded that Machiavellian employees help to reduce beneficial behaviors, and increase knowledge concealment and emotional manipulation, but only when moral leadership is absent. Under highly ethical leadership, unfavorable

organizational behaviors in Machiavelli employees do not increase. However, cross-design prevents conclusions about the direction of causality. Findings from the study showed that ethical leadership (as a potential solution to Machiavelli staff's misbehaviors) and from a practical perspective, leads to more investment [23].

King and Marks found that managerial support, specifically managerial oversight, were important predictors of goals of individual knowledge sharing [24].

Bordia et al, reported that knowledge concealment helped to observe implicit norms in an organization [25].

Safari concluded that perceived organizational policies and knowledge concealment were significantly related to staff's creativity concerning the moderating role of the staff's professional commitments [26].

Golmohammadisanji confirmed that strengthening the organizational culture greatly reduced knowledge concealment and exclusiveness of individual and organizational knowledge [27].

Dargahi and Dastafkan found that in many cases, even when there were appropriate facilities for knowledge sharing in organizations, employees were reluctant to cooperate. On the other hand, hiding knowledge can lead to reduced productivity and even reduced profits in organizations, especially health care organizations and especially clinical laboratories [1].

Kamraie and Hassanzadeh manifested that knowledge concealment occurred within organizations and sometimes employees hide their knowledge and do not share it. Knowledge concealment in organizations may have various causes and destructive consequences such as reduced productivity and profit. Therefore, identifying the causes of knowledge concealment and finding solutions to eliminate them is vital [28].

Therefore, this study was performed to examine these hypotheses:

Hypothesis:H1= There is a significant relationship between organizational culture and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H2= There is a significant relationship between the reward system and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H3= There is a significant relationship between organizational structure and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H4= There is a significant relationship between organizational support and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H5= There is a significant relationship between organizational justice and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H6= There is a significant relationship between quality of work-life and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

Hypothesis:H7= There is a significant relationship between leadership style and knowledge concealment in the Islamic Azad University of Khorasan Razavi.

According to the research background and its goal, the conceptual model of analyzing organizational factors affecting knowledge concealment in scientific contexts, which is based on library studies and experts' opinions (Delphi), is designed in the form of Figure 1.

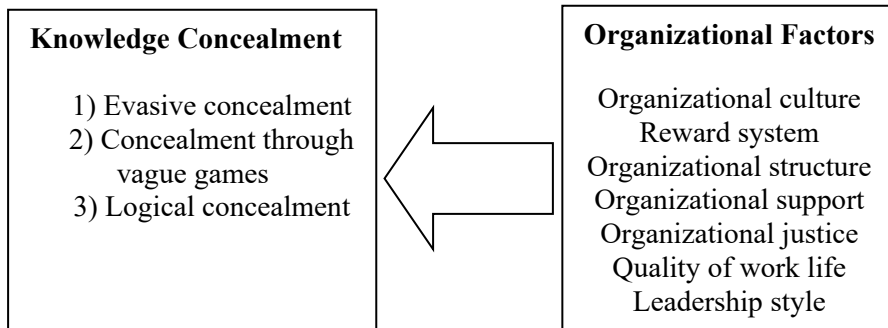


Figure 1. Conceptual Model of Research

4. Methodology

This is exploratory mixed research. Mixed research is performed by combining two sets of quantitative and qualitative methods and provides more evidence for a better understanding of phenomena since it is not constrained by the limitations of the two methods [29]. Therefore, first, a qualitative approach was used to identify organizational factors affecting the concealment of knowledge in scientific contexts, and then, using the Delphi method, the initial model was approved by the research experts.

4.1. Data Collection Method

To select variables of knowledge concealment, first, the components and dimensions were investigated through library studies (referring to written documents including books, magazines, etc.). Simultaneously with identifying the components and dimensions of each variable, expert interviews with relevant experts (including professors and experts aware of the subject of human resource management) were arranged. Expert interviews are mostly semi-structured and help the interviewer learn a variety of facts from the interviewee, and provide the interviewee with an opportunity to express his/her ideas without being influenced by the interviewer. The expert interview was conducted for two purposes: to present the extracted components and dimensions based on library studies to the experts and to ask their opinion about these components and dimensions, and to identify the components and dimensions not identified through library studies. Gain a better understanding of the variables to define them operationally, to extract metrics, and to classify them appropriately was another purpose of the expert interview. Then, to finalize the list of identified components, the process of surveying experts (including university professors and specialists in the field of human resource management) using the Delphi method was performed. To survey the experts, a special type of open and closed questionnaire was distributed.

4.2. Delphi Method

Delphi is a useful communication tool for a group of experts that makes it easy to formulate their opinions [30]. The first attempt to study the philosophy of the Delphi method was made by Helmer and Reicher on the epistemology of the classic article they published entitled "The False Sciences" [31]. The main hypothesis of this method is that experts have better ideas than what may happen in the future, so, contrary to a simple study, the validity and reliability of this method depends more on the expertise of the study group than the number of participants [32]. The basis of the Delphi method is that the opinion of the experts of any scientific field on the prediction of the future is the most authoritative; therefore, the validity of the Delphi method depends not on the number of participants but their scientific validity [33]. Participants in the Delphi method are between 5 to 20 experts. The minimum number of participants depends on how the research method is designed. In this method, a panel (group) of experts is formed and the members communicate with the supervision of the chairman. This internal communication is anonymous and the opinions, predictions, and inclinations are not attributed to their providers. This information is published without identifying the providers. The most important point in the Delphi method is to overcome the negative points in the conventional committees. In this regard, non-disclosure of identity, controlled feedback and statistics-based responses are the most important characteristics of Delphi [34].

Despite significant differences in performing the Delphi method, a Delphi research usually begins with a questionnaire designed by a small team and sent to a larger group of experts. Questionnaires are designed so that participants can understand the issue and express their reactions [35]. After completing the questionnaires, all the experts' answers are reviewed and summarized. At this stage, items not related to the study objectives are removed. Then, the summarized report is sent to the experts. Experts are allowed to change their answers based on the results, and the new results will be re-evaluated by experts in the second round. In this way, over time and as the work progresses, the views of the audience will adapt to the topic. This process continues until the desired consensus is reached [35].

4.3. Investigation of Organizational Factors Component Questionnaire

To find effective components in terms of the experts' ideas, the t-test was performed to compare the mean of opinions with the theoretical value (3.00). If the score of a component was higher than the theoretical value (3.00), that component would remain in the model. The results of this test for each of the variables are given in Table 1.

As Table 1 manifests the components of the organizational dimension have been approved by the experts (mean > 3). 314 employees of the Islamic Azad University of Khorasan Razavi were selected as the study sample through simple random sampling. Due to the infinity of the statistical population, Cochran's formula was used to determine the number of participants.

Component	M	SD	T	P	Result
Organizational culture	3/45	0/47	3.53	0.000	Accepted
Reward system	4.65	0.65	5.78	0.000	Accepted
Organizational structure	3.65	0.41	8.34	0.000	Accepted
Organizational support	3.87	0.74	6.09	0.000	Accepted
Organizational justice	4.64	0.70	4.20	0.000	Accepted
Quality of work life	4.13	0.61	8.57	0.000	Accepted
Leadership style	3.68	0.53	4.97	0.000	Accepted

Table 1. Results of the organizational factors component questionnaire

4.4. Measuring variables

The knowledge concealment variable was measured by the standard Dimirkasimoglu questionnaire (Demirkasimoglu, 2016) and organizational factors were measured by a scholar-made questionnaire. Before entering the questionnaire, the selected indicators were evaluated by 20 experts and finally, the agreed questionnaire was used to collect data.

4.5. Validity

The content validity of the questionnaire was confirmed by experts. In terms of the construct validity, the results showed that all indicators of the studied constructs have enough importance for measuring their constructs since the values of factor loads were higher than 0.4.

4.6. Reliability

To assess the reliability of the questionnaires, a pre-test was performed which indicated the appropriate and acceptable reliability of the assessment tool. Also, the reliability results of the research variables are presented in Table 2.

To test the hypotheses, the probability value of the model fitness in the significant state of parameters using structural equation modeling and path analysis was considered. Since the desired confidence level was 95%, a significant number at the 95% level in the range of 1.96 to -.196 was in the rejection area, and numbers outside this range were accepted. Finally, in AMOS software, the relationships between individual factors' variables with knowledge concealment were investigated.

Variable	Number of questions	Reliability
Organizational factors	33	0.931
Knowledge concealment	12	0.876

Table 2. Reliability of the studied variables

5. Results

5.1. Descriptive Statistics

The results of descriptive statistics in terms of gender showed that most respondents (N= 232, 65.16%) were male. The highest frequency distribution belonged to the age range of 41-50 years (N= 150, 47.77%). Most of the respondents (N= 174, 55.73%) had 11-19 years of work experience, had a master's degree (N = 40, 44.58%), and studied a major in human sciences (N = 165, 52.54%).

5.2. Variables' status

Regarding the skewness and kurtosis coefficients of the variables, their normality was investigated. In this assumption, the data were normal if their critical ratios were between 2.58 to -2.58. The results of examining the variables' normal distribution are shown in Table 3.

Variable	Skewness	Critical ratio	Kurtosis	Critical ratio
Organizational culture	-0.284	-2.705	0.052	0.248
Reward system	-0.245	-2.333	0.361	1.719
Organizational structure	-0.300	-2.857	-0.183	-0.871
Organizational support	-0.191	-1.819	-0.185	-0.881
Organizational justice	-0.222	-2.114	-0.117	-0.557
Quality of work life	-0.245	-2.333	0.211	1.005
Leadership style	-0.245	-2.333	0.361	1.719

Table 3. Results of examining the variables' normal distribution

Given Table 3, all the coefficients are between 2.85 to -2.85. Therefore, this assumption holds for all components of the factors affecting knowledge concealment. This means that parametric statistical tests (requiring normal distribution) could be used to examine the research questions.

5.3. Testing the research hypotheses

In this section, the method of data analysis - structural equation modeling with the help of AMOS software - is described and then the research hypotheses are tested. The hypotheses are examined by referring to Figure 2 and the results of the model fitness in Table 5. As mentioned, paths with a t-statistic greater than 1.96 or less than -1.96 are significant.

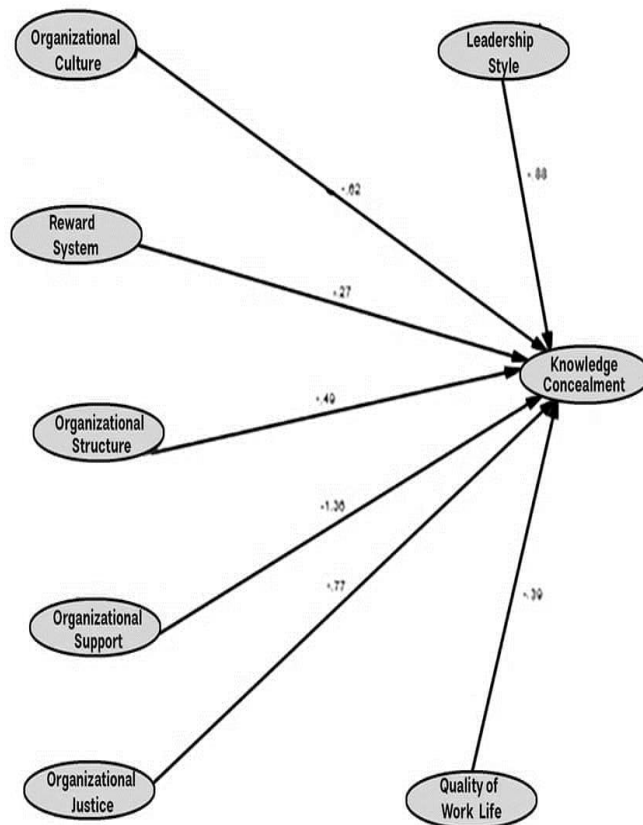


Figure 2. Factor coefficients and path coefficient of the suggested model in the standard mode

The general fitness index of the measurement models obtained by the confirmatory factor analysis is given in Table 4.

Index	Acceptable limit	Reported value
Root mean square error of approximation (RMSEA)	≤ 0.08	0.068
chi-square divided by degree of freedom (CMIN/DF)	≤ 5	2.438
Goodness of fit index (GFI)	≥ 0.9	0.965
Adjusted goodness of fit index (AGFI)	≥ 0.9	0.935
Comparative fit index (CFI)	≥ 0.9	0.813
Normalized fit index (NFI)	≥ 0.9	0.982
Tucker-Lewis index (TLI)	≥ 0.9	0.811
Incremental fit index (IFI)	≥ 0.9	0.892

Table 4. Fitness indexes of the suggested model

Table 4 shows that RMSEA = 0.068, CMIN/DF = 2.438, and GFI = 0.965. Results of Table 5 reveal a negative significant relationship between organizational factors and knowledge concealment ($p < 0.05$). Since the coefficients are negative, these relationships are inverse (decreasing). This means that improvement of the organizational factors' levels leads to a reduction of knowledge concealment. The results of the factor analysis for testing the hypotheses are reported in Table 5.

Hypothesis	Path coefficient	T	Result	Relationship direction
Organizational culture → Knowledge concealment	-0.62	-3.77	Accepted	Inverse
Reward system → Knowledge concealment	-0.27	-2.39	Accepted	Inverse
Organizational structure → Knowledge concealment	-0.49	-7.57	Accepted	Inverse
Organizational support → Knowledge concealment	-1.30	-8.95	Accepted	Inverse
Organizational justice → Knowledge concealment	-0.77	-2.86	Accepted	Inverse

Quality of life work →				Inverse
Knowledge concealment	-0.39	-3.58	Accepted	
Leadership style →				Inverse
Knowledge concealment	-0.88	-3.87	Accepted	

Table 5. Results of the factor analysis for testing the hypotheses

The significance value and effect of each of the model coefficients are given in Table 5. The results manifest that all coefficients related to knowledge concealment are significant with 95% confidence since their significance value is less than 0.05 and the t-statistic of all variables is higher than 1.96. As can be seen, the standard coefficient of the effect of organizational culture, reward system, organizational structure, organizational support, organizational justice, quality of work-life, and leadership style on knowledge concealment are -0.62, -0.27, -0.49, -1.30, -0.77, -0.39 and -0.88. This means that a unit of improvement in organizational culture, reward system, organizational structure, organizational support, organizational justice, quality of work-life, and leadership style reduces knowledge concealment as -0.62, -0.27, -0.49, -1.30, -0.77, -0.39 and -0.88, respectively.

6. Discussion and Conclusion

In this study, first, the effect of organizational factors on knowledge concealment through exploratory transactions and surveying experts was investigated, and then these factors were tested in a suggested model in the statistical population.

This finding was consistent with that of Belshack et al and Xu et al [23], [21]. In this regard, Belshack et al showed that Machiavellian employees help to reduce beneficial behaviors, and increase knowledge concealment and emotional manipulation, but only when moral leadership is absent. Under highly ethical leadership, unfavorable organizational behaviors in Machiavelli employees do not increase. However, cross-design prevents conclusions about the direction of causality. Findings from the study showed that ethical leadership (as a potential solution to Machiavelli staff's misbehaviors) and from a practical perspective, leads to more investment. Also Xu et al showed that workplace isolation was positively associated with evasive knowledge concealment. In addition, a hypothesized three-way interaction including workplace isolation, negativity, and moral separation was justified by knowledge concealment. Therefore, such an argument can be made that organizational culture had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. Organizational culture has recently entered the field of management knowledge and organizational behavior. Organizational culture, as a set of common beliefs and values, affects staff's behaviors and thoughts. It can be both a starting point for forwarding mobility, or an obstacle to progress, and is a fundamental area of change and transformation in the organization. Therefore, organizational culture reduces knowledge concealment.

Reward system had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. The result of this hypothesis is in line with that of Bari et al [22]. In this regard, Bari et al showed that manifested that knowledge concealment and concealment through vague games had a significant negative relationship with team creativity. However, logical concealment did not significantly affect team creativity. Therefore, such an argument can be made that reward system is an important part of human resources management. This system highly matters in organizations both in terms of employees' satisfaction and organizational effectiveness. Employees are not just looking for payment; they are looking for an organization with a sustainable future, a clear vision of its goals, and a defined way to reach them. While money is undoubtedly a serious component of the reward system, it is increasingly observed that hiring and retaining capable staff requires things beyond money. There are elements in the total reward system, each of which includes programs, activities, components, and dimensions that collectively determine the organization's strategy to attract, motivate and retain its staff. Elements represent the toolbox that an organization chooses to create value for both the organization and its employees. Therefore, performing the right reward system reduces knowledge concealment.

Organizational culture had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. King and Mark reported the same finding [24]. In this regard, King and Mark showed that managerial support, specifically managerial oversight, were important predictors of goals of individual knowledge sharing. Therefore, such an argument can be made that organizational structure is the main pillar of an organization that may significantly impact its performance. Proper organizational structure plays an important role in the improvement of organizational productivity, while accurate planning for any structure will ameliorate the performance of human resources. Each organization accepts a structure or form that is more compatible with its national culture. But when the organization is faced with conflicting environmental conditions, it may not adapt and chooses an inappropriate structure. Organizational structure and processes interact. Therefore, a dignified organizational structure weakens knowledge concealment.

Organizational support had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. Bordia et al concluded the same [25]. In this regard, Bordia et al showed that knowledge concealment helped to observe implicit norms in an organization. Therefore, such an argument can be made that if the organization cares about its staff's efforts and physical/mental health and helps them in coping with stressful situations, their organizational commitment will be strengthened. Therefore, a higher level of organizational support may be beneficial for knowledge concealment reduction.

Organizational justice had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. Safari formerly verified this finding [26]. In this regard, Safari showed that perceived organizational policies and knowledge concealment were significantly related to staff's creativity concerning the moderating role of the staff's professional commitments. Therefore, such an argument can be made that organizational justice is a mental construct in the

sense that what may be perceived as fair by a person may be perceived as unfair by another. Additionally, when justice is expanded socially, it makes employees more motivated to work and learn. When justice in the organization is observed in terms of resource allocation and reward/punishment system among employees, their capabilities progress, and knowledge concealment is reduced.

Quality of work-life had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. The result of this hypothesis is in line with that of Golmohammadisanji [27]. In this regard, Golmohammadisanji showed that strengthening the organizational culture greatly reduced knowledge concealment and exclusiveness of individual and organizational knowledge. Therefore, such an argument can be made that quality of work-life can be an important factor in encouraging ethical behaviors among managers and employees of the organization. This construct, which refers to employees' perception of the physical and psychological desirability of their work environment, requires collaborative efforts between managers and employees. The higher the quality of work-life, the weaker the knowledge concealment becomes.

Leadership style had a negative significant relationship with knowledge concealment in the Islamic Azad University of Khorasan Razavi. Dargahi and Dastafckan also believed in this idea [1]. In this regard, Dargahi and Dastafckan showed that in many cases, even when there were appropriate facilities for knowledge sharing in organizations, employees were reluctant to cooperate. On the other hand, hiding knowledge can lead to reduced productivity and even reduced profits in organizations, especially health care organizations and especially clinical laboratories. Therefore, such an argument can be made that managers who realize and embrace their unique leadership style are more effective than those who try to do everything right. Managers are multi-faceted heroes who respect their values, trust their instincts, build multiple relationships, and work based on conscientious principles.

In this regard, several suggestions are offered to the managers of the Islamic Azad University of Khorasan Razavi. They should provide the necessary training and skills to employees and use the results of performance evaluation to improve the culture of creativity, innovation, and productivity in the organization; Consider the careful evaluation of the employees' distinctive and surplus working activities as the basis of extraordinary rewards in the organization; Decrease the focus of decisions in the organization and give systematic freedom to employees, and appreciate their special extraordinary efforts; Accent the overall satisfaction of employees with their work environment; The workload of employees should be fair and balanced, and opportunities for professional growth and promotion should be provided; Any prejudice and discrimination in the organization should be winded up; Finally, supervised employees should be allowed to use their judgment in solving problems.

This research was limited to the employees of Islamic Azad University of Khorasan Razavi. It is suggested that more research be done in other government agencies in other countries in order to comparatively study the model in other companies and organizations and determine their differences. Also other researchers can refer to other organizations to identify several other influential factors in order to complete the present research model. Finally, given that there are different models of

knowledge concealment that each of them has different dimensions, so it is suggested that other researchers compare the relationship between each of the components of the model with each other and evaluate their effect using the existing models of knowledge concealment variable.

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Employing a Time Series Forecasting Model for Tourism Demand Using ANFIS

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Abstract

Forecasting the future trends is of utmost importance for managers and decision makers in different sectors. Scholars thus have introduced various techniques to the service industry aiming at employing a prediction model with ultimate accuracy and high efficiency. The literature proves that adaptive neuro-fuzzy inference systems (ANFIS) are the most efficiency models. However, the literature lacks reports on how ANFIS parameters may affect the accuracy of the system. Employing tourist arrival records to Cyprus between 2015 and 2019, this study has developed an ANFIS system to evaluate the accuracy performance of different prediction models with varied number of inputs and number or type of membership functions. Results show that the forecasting accuracy of a model with four inputs and four membership functions when the type of membership functions is Gaussian is relatively better than other models. In other words, it can be concluded that the forecast model with four inputs and four Gaussian membership functions is ultimate with the most accurate prediction record with reference to MAE, RMSE, and MAPE. The results of this study may be significant for senior managers and decision-makers of the tourism industry.

Keywords: Decision making, Time series, Forecasting, Fuzzy rule-based system, ANFIS

1. Introduction

Having control and plan is indispensable in decision-making for managers in different industries, including tourism. The backbone of controlling and planning is forecasting future trends. Tourism, because of the multiple benefits and advantages it provides, is one of the crucial industries invested heavily. Meantime, it is one of the fastest-growing industries today, and it adds to a country's overall growth and development. The growth of tourism in a country leads to increasing its commercial activity, creates thousands of jobs, and contributes to the country's brand value, image, and identity.

Forecasting the future demand provides important data for managers while making their decisions. Nonetheless, accuracy in forecasting is essential in making efficacious decisions. When it comes to the tourism industry, forecasting the future, especially the future flow of tourists, is of utmost significance. However, due to the special characteristics of tourism and a large number of effective factors, forecasting the demand with little error is not an easy job.

To succeed in today's highly competitive market, the government, public and private sectors, as well as all responsible authorities, should work in harmony. Authorities in both government and private sectors measure the success rates of their plans by comparing the current year's performance to the previous year's records. Consequently, scholars have proposed different forecasting methodologies and techniques.

One of those methods, time series forecasting, is very popular among scholars. Time series forecasting is the process of using past data to forecast future values. To create a forecasting model based on the time series method, earlier observations are collected, analyzed, and processed to determine future trends. Using this method, several models have been introduced; however, the research findings recommended that a combination of different models rather than employing a single model may result in more accurate predictions.

Classical time series models have been applied in various types of applications; however, they have some drawbacks. They cannot capture the structure of non-linear relationships due to the assumptions based only on linear relationships among time-lagged variables [1]. They fail to predict the problems with linguistic values [2], [3] and fail to have high accuracy in complex problems. They require a large amount of data, and they are time-consuming [4].

Being proposed by Zadeh [5], the fuzzy logic has been applied and used in different complex systems successfully. When making decisions, fuzzy set theory plays an essential role in coping with uncertainty. As a result, fuzzy sets have attracted increasing interest and attention in modern information technology, decision making, production technique, data analysis, pattern recognition, and diagnostics [6]–[9].

Song and Chissom are the pioneers of defining fuzzy time series using fuzzy logic theory [10]. Fuzzy time series methods are used in different areas since they are applicable with ambiguous and non-complete data [11]. They are capable to tackle the uncertainty that is inherited in collecting data. Applying fuzzy logic can increase the accuracy of the model [12], and there is no need for any assumptions such as linearity and normality [13]. In addition, they do not require data from a large sample, or normal and stationary distribution during the data collection phase [14]. The key feature of fuzzy logic, however, is that there is no systematic procedure for designing a fuzzy controller. Therefore, many hybrid techniques have been proposed for forecasting [15]–[17].

Artificial neural networks (ANNs) are frequently used for prediction and have been considered as a potentially effective technique for modeling complicated nonlinear systems [18]. Modeling a system using ANNs is sample-based learning which should be trained using a trained data set. After completing the learning process then the proper ANN model is obtained. Some advantages of ANNs are mentioned as (a) working with incomplete and insufficient data (b) sample-based learning (c) realizing machine learning (putting machine learning into practice) (d) having capability in classification, association, and pattern recognition [19].

Neuro-fuzzy systems are fuzzy systems that use the theory of ANNs to determine their properties (fuzzy sets and fuzzy rules) by processing data samples. They use the potential and advantages of both fuzzy logic and ANNs, by employing the ANNs'

mathematical properties in tuning rule-based fuzzy systems. In the development of neuro-fuzzy systems, a specific approach is the adaptive neuro-fuzzy inference system (ANFIS).

ANFIS is a hybrid method, developed by Jang [20] which combines the ANNs adaptive capability and the fuzzy logic qualitative approach. It combines an optimized premise membership function with a consequent equation, using the Takagi–Sugeno rule format. To have input-output pairs with a high degree of accuracy, ANFIS combines the advantage of learning an ANN and making use of a set of fuzzy IF-THEN rules with appropriate membership functions. It has been employed successfully in modeling complex systems [21] and nonlinear functions [22].

The effect of temperature and air velocity on drying time was investigated by using ANFIS. The results show that ANFIS is one of the fastest methods with high accuracy. In the ANFIS structure, the number of inputs is considered as three and three Gaussian membership for each input [23].

To predict rainfall, ANFIS, as an artificial intelligence application, has been employed. Rainfall prediction based on ANFIS time series appears promising, according to analyses of six-year rainfall data on a monthly basis. In the ANFIS structure, the number of inputs is considered as three and the membership functions are Trapezoid and Bell-shaped [24].

To construct a successful fuzzy inference system to forecast a launching service in tourism, ANFIS is applied [25]. The ANFIS model has two inputs and five membership functions for each input. The type of selected membership function for this model is Gaussian.

The literature lacks reports on the effect of ANFIS parameters (number of inputs and number or type of membership functions) on the efficacy and accuracy of the employed model in forecasting the number of tourists arriving at a specific location. This paper thus aims to analyze the accuracy rate of ANFIS systems in forecasting the flow of tourists to Cyprus when the number of inputs and number or type of membership functions varies. To do so, the monthly records of tourist arrivals to the country between January 2015 and December 2019 have been used and analyzed.

2. Preliminaries

Time series. It is defined as:

$$X_t = G_q(X_{t-1}, X_{t-2}, \dots, X_{t-p}) \quad (1)$$

In Eqn. (1) G_q is any nonlinear function, the values of variable $X(t)$ in periods $t-1, t-2, \dots, t-p$ of time series are represented by $X_{t-1}, X_{t-2}, \dots, X_{t-p}$. A forecast value of the variable X for the period t is shown by $X(t)$. We need to find such a function $G(\cdot)$ and input number p to fulfill the condition.

$$\phi = \sum_{i=1}^n (X_i^p(t) - X_i^e(t))^2 \rightarrow \min \quad (2)$$

Where $X_i^p(t)$ is a forecast value at a time t is based on the obtained model, and $X_i^e(t)$ is an experimental value of a variable [15].

Fuzzy time series. Let $U(t) \subset R^1$ be the universal set, where $R^1 \subset \mathbb{R}$, i.e., R^1 is a subset of real numbers, on $f_{k(t)}$ which is fuzzy set with $k = 1, 2, 3, \dots$ and $t = \dots, 0, 1, 2, \dots$. The fuzzy time series on the set $U(t)$ is denoted by $F(t) = \{f_k(t)\}_{k \in I}$.

Fuzzy rule-based system. The expansion of the classical method of a rule-based system that is generally based on IF-THEN rules is a fuzzy rule-based system. The conditional statements have the form “IF C (condition) THEN R (restriction)” which is characterized by membership functions.

Takagi–Sugeno–Kang (TSK) type fuzzy rule-based system. The core of the TSK type fuzzy rule-based system is a set of IF-THEN rules that is shown by R_j with fuzzy implications and first-order functional consequence parts. A common rule R_j in the TSK type fuzzy rule-based system is defined as follows:

$$(R_j) : IF x_1 is A_{1j} \wedge x_2 is A_{2j} \wedge \dots \wedge x_i is A_{ij} \\ THEN y_j = \alpha_{ij}x_i + \alpha_{(i-1)j}x_{i-1} + \dots + \alpha_{1j}x_1 + \alpha_{0j} \quad j = 1 \dots, J. \quad (3)$$

where a fuzzy subset that is subscribed by the input variable named x_i for the j th rule is represented by A_{ij} . A fuzzy conjunction operator and the number of fuzzy rules are shown by $\wedge$ and j , respectively. Each rule in Eqn. (3) is premised on $x^T = (x_1, x_2, \dots, x_i)$ which is the input vector and maps the fuzzy sets in the input space $A_j \subset R_i$ to a y_j .

3. Adaptive Neuro-Fuzzy Inference System: Architecture and algorithm

An adaptive neuro-fuzzy inference system (ANFIS) is a neural network approach that is based on TSK type fuzzy rule-based system to find the solution for function approximation problems [20],[26]. ANFIS constructs a fuzzy inference system based on a given input-output where the parameters of membership function can be modified by applying the hybrid learning algorithm. The ANFIS forms the distribution of membership functions optimally by setting out the mapping relation between the input and output pairs. The strengths of both fuzzy logic and artificial neural networks are combined in ANFIS. It not only completes ANNs' computation power and the low-level learning with fuzzy systems it also brings the high-level IF-THEN rules to ANNs [27]. Such a system makes the ANFIS modeling more systematic which is also less reliant on the knowledge of experts. To construct an ANFIS, five layers are used where each layer is made up of several nodes. The nodes are described by the node function. The nodes in the previous layers provide the inputs for the current layers. To show the architecture of the ANFIS, a common fuzzy rule set with two fuzzy IF-THEN rules is considered. The IF-THEN rules are based on a first-order Sugeno model stated as follows:

$$(R_1): IF x is \tilde{A}_1 \wedge y is \tilde{B}_1 THEN f_1(x, y) = p_1x + q_1y + r_1 \\ (R_2): IF x is \tilde{A}_2 \wedge y is \tilde{B}_2 THEN f_2(x, y) = p_2x + q_2y + r_2$$

where $\tilde{A}_i$ and $\tilde{B}_i$ ($i = 1,2$) are the fuzzy sets for the inputs x and y of ANFIS, respectively. The output of the system is represented by $f_i(x, y)$ which is the first-order polynomial; p_i , q_i , and r_i are the parameters of $f_i(x, y)$ where ($i = 1,2$). The architecture of typical ANFIS to implement the rules (R_1) and (R_2) has five layers including two different nodes such as adaptive nodes, shown by squares, and fixed nodes shown by circles as demonstrated in Figure 1. In the system, adaptive nodes represent the parameter sets that can be adjustable whereas fixed nodes show the parameter sets that are fixed.

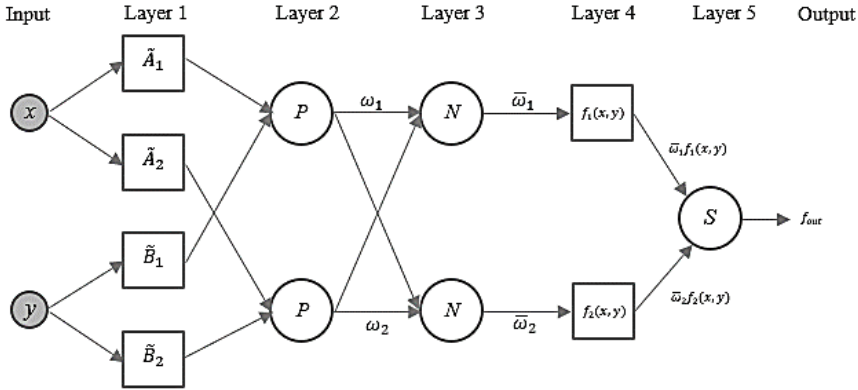


Figure 1. ANFIS architecture [20]

- i. Layer 1: All nodes in the first layer of ANFIS are adaptive nodes. The outputs of this layer as shown by $O_{1,i}$ are the membership grades of the inputs, which are as follows:

$$O_{1,i} = \mu_{\tilde{A}_i}(x), \quad i = 1,2 \quad (4)$$

$$O_{1,i} = \mu_{\tilde{B}_{i-2}}(y), \quad i = 3,4 \quad (5)$$

where x and y are inputs, $\mu_{\tilde{A}_i}(x)$ and $\mu_{\tilde{B}_i}(y)$ are the membership functions of the fuzzy sets $\tilde{A}_i$ and $\tilde{B}_i$, respectively.

- ii. Layer 2: All nodes in the second layer of ANFIS are fixed nodes. In Figure 1, they are marked with P to show the Product's operator. The outputs of this layer as shown by $O_{2,i}$ represent the firing strength of a rule which are as follows:

$$O_{2,i} = \omega_i = \mu_{\tilde{A}_i}(x)\mu_{\tilde{B}_i}(y), \quad i = 1,2 \quad (6)$$

- iii. Layer 3: All nodes in the third layer of ANFIS are also fixed nodes. In Figure 1, they are marked with N . The outputs $O_{3,i}$ are called normalized firing strength.

$$O_{3,i} = \bar{\omega}_i = \frac{\omega_i}{\sum_{i=1}^2 \omega_i} = \frac{\omega_i}{\omega_1 + \omega_2}, \quad i = 1, 2 \quad (7)$$

- iv. Layer 4: All nodes in the fourth layer of ANFIS are adaptive nodes. The outputs of this layer as shown by $O_{4,i}$ are given by

$$O_{4,i} = \bar{\omega}_i f_i(x, y) = \bar{\omega}_i (p_i x + q_i y + r_i), \quad i = 1, 2 \quad (8)$$

where p_i , q_i , and r_i are consequent parameters. The output is the multiplication of the normalized firing strength and a first-order polynomial as shown by $\bar{\omega}_i$ and $f_i(x, y)$, respectively.

- v. Layer 5: The final layer has a single fixed node which is also called output node and is labeled with S in Figure 1. The output $O_{5,i}$ is computed as follows:

$$O_{5,i} = f_{out} = \sum_{i=1}^2 \bar{\omega}_i f_i(x, y) = \frac{\sum_{i=1}^2 \omega_i f_i(x, y)}{\sum_{i=1}^2 \omega_i}, \quad i = 1, 2 \quad (9)$$

The ANFIS is trained based on supervised learning. ANFIS has two adaptive layers in the first and fourth layers. The first layer has modifiable parameters which are related to the membership functions. In the fourth layer, it has modifiable parameters of the first-order polynomial. To make the output of the ANFIS matched with the training data, the learning algorithm of this architecture adjusts all the modifiable parameters. The learning procedure has two steps known as a hybrid learning algorithm. In step 1, the premise parameters are kept without any changes. Node outputs go forward till the fourth layer and the least square method identifies the consequent parameters. In step 2, the consequent parameters are kept without any changes. The error signals propagate (transmit) backward. To update the premise parameters, a gradient descent method is applied. The hybrid learning algorithm in more detail can be found in [20].

4. Methodology

Using the software Matlab, the computation of the data for the ANFIS was employed. The training algorithms of ANFIS, including the least-squares method and the gradient method, were set in Fuzzy Inference System Editor (FIS Editor) in Matlab software. This study includes the following stages:

1. In the first stage, data input stage, input sets, and corresponding outputs were formed by grouping the time series. Each input was made of a set with n -tuple with the form $(F_{i-1}, F_{i-2}, \dots, F_{i-n})$ and the output as F_i . The used structure was as follows:

$$f: (F_{i-1}, F_{i-2}, \dots, F_{i-n}) \rightarrow F_i \quad (10)$$

In the Eqn. (10), F_i represents the number of tourist arrivals in the i th month.

2. For each input, the number of membership functions and the type of membership functions had to be assigned. The Gaussian membership function (GMF) was used in this study due to its smoothness and concise notation.

$$\text{Gaussian}(u; c, \sigma) = \mu_{\tilde{A}(x)} = e^{\frac{-(c-x)^2}{2\sigma^2}} \quad (11)$$

where c is the center of the fuzzy set $\tilde{A}$ and σ is its width.

3. In the third stage, a fuzzy inference system was generated. To find the forecast value based on the given current inputs, Sugeno fuzzy inference system (also referred to as TSK type fuzzy rule-based system) was selected.
4. ANFIS training function in the Matlab fuzzy toolbox was employed for the training of the input data. This procedure has been performed automatically and as a result, an array of training errors was gained.
5. In the last stage, an ANFIS model with a forecasting function has been derived for output forecasting.

5. Numerical Example and Results

Cyprus, as a small country with limited industrial income but numerous natural and manmade attractions has paid significance to the advancement of its tourism industry against its rivals. This island with a population smaller than two million is one of the neighboring countries to the Mediterranean Sea favored by many regional and international tourists [28]. In addition, the geographical location of Cyprus at the gateway of three continents, Asia, Africa, and Europe, has given it a unique advantage. Considering all these, the country's government has employed policies aiming at boosting tourism resulting in economic recovery. The success of those policies is reflected in the tourism sector which is considered as one of the active sectors of the country.

This study aimed to develop an ANFIS to forecast the monthly number of tourist arrivals in Cyprus with high accuracy and low prediction error. The monthly number of tourist arrivals in Cyprus during 2015-2019 was employed as the data set. This data set has been collected and published by the Cyprus Ministry of Finance [29]. Figure 2 illustrates the monthly number of tourist arrivals in Cyprus from January 2015 to December 2019 and sketches based on the collected data.

For the first stage in section 4, a different number of inputs as $x=2$, $x=3$, and $x=4$ was selected. In the second stage in section 4, for each input different number of membership functions were applied as $MFs=2$, $MFs=3$, $MFs=4$, and $MFs=5$. There are various types of membership functions but the most commonly used ones are Gaussian, Bell-shaped, Triangular, and Trapezoidal membership functions. The Gaussian membership function was suggested in this study due to its smoothness and concise notation, furthermore, it uses only two parameters. Also, the Gaussian membership functions have the advantage of being smooth and nonzero at all points [30],[31]. After deciding about the number of inputs and membership functions for each input, ANFIS was applied to extract the TSK-type fuzzy rule-based system.

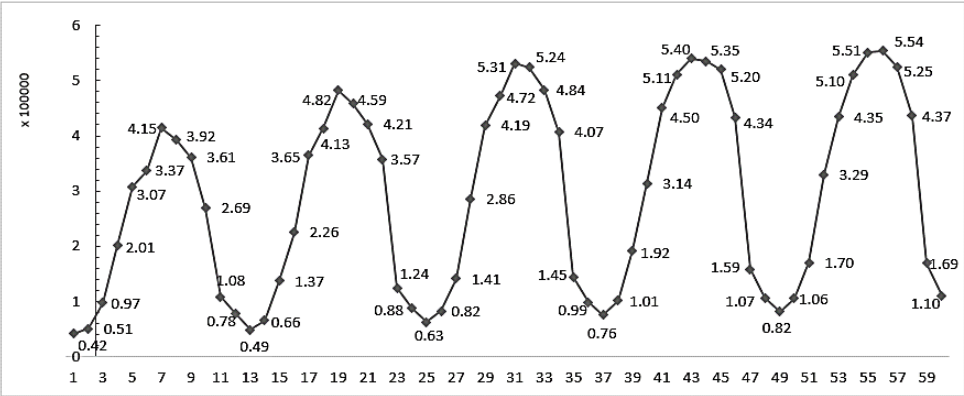


Figure 2. The monthly number of tourist arrivals in Cyprus from January 2015 to December 2019.

In Appendix A, Triangular, Trapezoidal, and Bell-shaped membership functions are defined and their effects on the accuracy of the models were tested. In developing a forecasting model, the selection of the number of inputs and the number of membership functions, and the type of membership functions for each input may affect the accuracy of the system significantly, which has been tested in this study.

By employing different number of inputs and membership functions, twelve models were designed and analyzed. The data set which includes the monthly number of tourist arrivals in Cyprus over 60 months was divided into the training data set (70%) and testing data set (30%) following other studies [32-34]. The training datasets were used to build the models, and the testing datasets were used to validate the models. The models were calibrated using the training data set by modifying the membership function parameters to better match the results. Testing data was used to check the accuracy of each model.

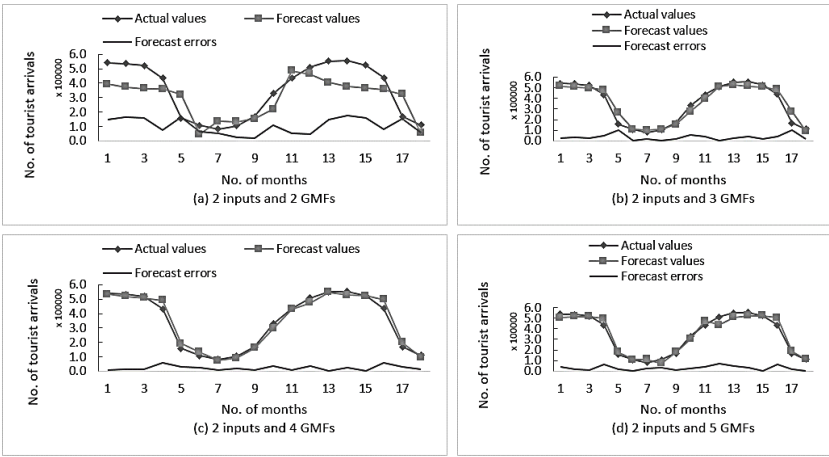


Figure 3. Forecasting results of ANFIS models using testing data with inputs $x=2$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

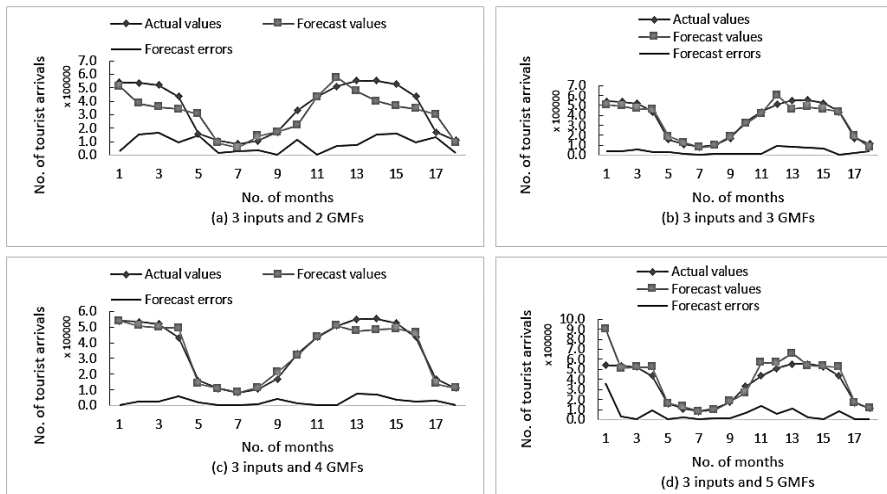


Figure 4. Forecasting results of ANFIS models using testing data with inputs $x=3$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

The efficiency and accuracy of each model were calculated based on three different common metrics for measuring the forecast accuracy. The performances of each model were tabulated and compared in Table 1, Table A1, Table A2, and Table A3.

Figure 3 illustrates the forecasting results of ANFIS models using testing data with inputs $x=2$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

Figure 4 illustrates the forecasting results of ANFIS models using testing data with inputs $x=3$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

Figure 5 illustrates the forecasting results of ANFIS models using testing data with inputs $x=4$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

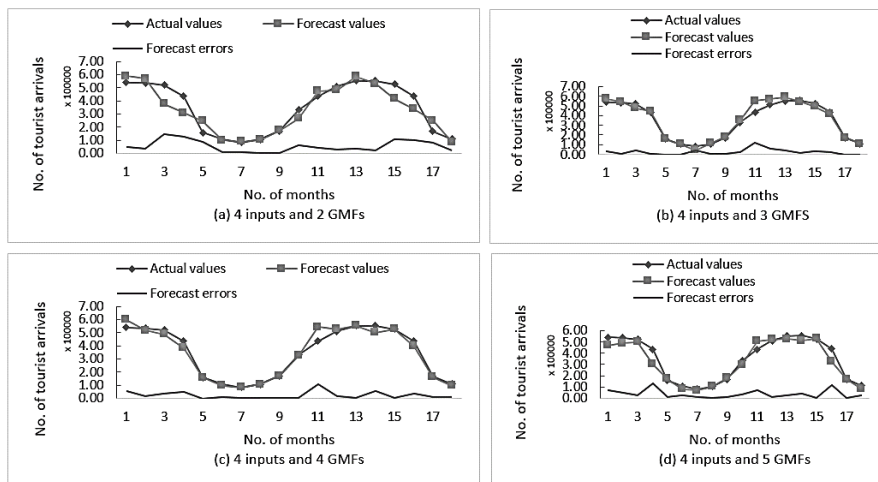


Figure 5. Forecasting results of ANFIS models using testing data with inputs $x=4$ and Gaussian membership functions $GMFs=2, 3, 4, 5$.

As shown in part (a) of Figures 3, 4, and 5, models with inputs $x=2$, $x=3$, and $x=4$ respectively, when the number of membership functions was $GMFs=2$, the models could not capture the trends of the data efficiently. Therefore, we could not have a desirable output with low forecasting errors and high accuracy.

However, as shown in Figure 4-(c) the model with $x=3$ and $GMFs=4$, and Figure 5-(c), the model with $x=4$ and $GMFs=4$ could capture the trends of the data efficiently. Thus selecting the number of membership functions $GMFs=4$ could reduce the forecasting error and increase the forecasting accuracy significantly. Gaussian membership function plot and homogeneous fuzzy partitions where $GMFs=4$ is illustrated in Figure 6.

As shown in Figures 3, 4, and 5 part (d) when $GMFs=5$ regardless of the number of inputs, the accuracy rate of the forecasting models dropped markedly.

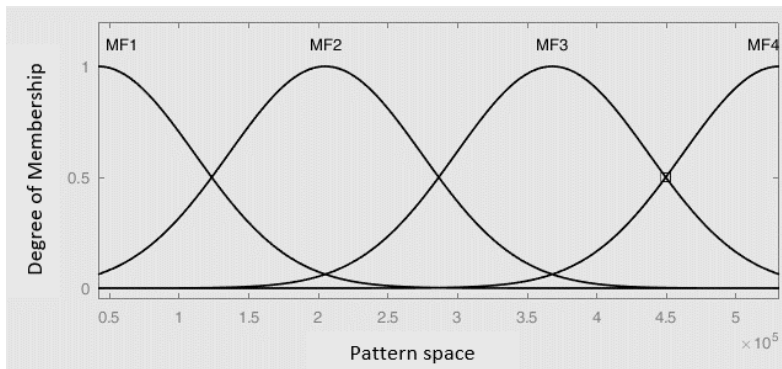


Figure 6. Gaussian membership function plot and homogeneous fuzzy partitions where $MFs=4$.

The tradeoffs between speed and accuracy, or good generalization and over-fitting, must be considered while determining the size of the membership function. It takes longer to train and generate predictions for a larger number of membership functions. In the ANFIS model with m number of inputs and n number of membership functions for each input, there are totally n^m rules produced. Therefore, the number of rules will increase exponentially by increasing the number of inputs and membership functions which decrease the time complexity of the model significantly.

The accuracy of each forecasting model was measured by applying the mean absolute error (MAE), the root mean square error (RMSE), and the mean absolute percentage error (MAPE). The lowest value of MAD, RMSE, and MAPE shows the desired system.

The formula of MAE is as follows:

$$MAE = \frac{1}{N} \sum_{k=1}^N |Y_k^p - Y_k^e| \quad (12)$$

The formula of RMSE is as follows:

$$\text{RMSE} = \sqrt{\frac{1}{N} \sum_{k=1}^N (Y_k^p - Y_k^e)^2} \quad (13)$$

The formula of MAPE is as follows:

$$\text{MAPE} = 100 \times \frac{1}{N} \sum_{k=1}^N \frac{|Y_k^p - Y_k^e|}{Y_k^e} \quad (14)$$

where N is the number of data used in the testing data set, Y_k^p and Y_k^e represent the predicted and actual (experimental) values of the k th data, respectively.

Table 1 summarizes the parameters and comparison of forecasting models' accuracy in terms of MAE, RMSE, and MAPE(%) of testing data and the parameters of each model.

Programming Language					MATLAB R2015							
No. Inputs	2				3				4			
No. Gaussian MFs	2	3	4	5	2	3	4	5	2	3	4	5
ANFIS architecture	2-2	3-3	4-4	5-5	2-2-2	3-3-3	4-4-4	5-5-5	2-2-2-2	3-3-3-3	4-4-4-4	5-5-5-5
No. Rules	4	9	16	25	8	27	64	125	16	81	256	625
MAE	1.03E+05	5.37E+04	2.53E+04	2.89E+04	8.23E+04	3.47E+04	2.20E+04	3.73E+04	5.53E+04	2.43E+04	1.50E+04	3.57E+04
RMSE	1.16E+05	6.88E+04	3.66E+04	3.78E+04	1.01E+05	4.48E+04	3.42E+04	5.24E+04	9.06E+04	3.64E+04	2.78E+04	4.52E+04
MAPE (%)	37.09	14.29	9.18	10.12	27.81	11.26	7.31	13.05	17.03	8.06	4.18	11.45
Ranking	12	9	4	5	11	6	2	8	10	3	1	7

Table 1. Parameters and comparison of the forecasting models when MFs type is Gaussian

As it is evident in Table 1, the desired model is the one with 4 inputs ($x=4$) and 4 membership functions ($GMFs=4$) with the value of MAE equals to 1.50E+04, the value of RMSE equals to 2.78E+04, and the value of MAPE equals to 4.18%.

6. Conclusion

The development and examination of accurate forecasting methods are important topics of continuing interest and research. This study developed twelve adaptive neuro-fuzzy inference systems to reveal the effect of different parameters on the accuracy of the model. A comparative analysis of different models, $x=2, 3, 4$ and $MFs=2, 3, 4, 5$, shows that there is a significant positive correlation between the number of inputs, number of membership functions, and the type of membership functions on the forecasting accuracy rate of the models. When the number of inputs is $x=2, x=3$, or $x=4$ and the number of Gaussian membership functions is $GMFs=2$, the accuracy of the model is not reliable. However, the superiority of the model with $x=4$ and $GMFs=4$ is evident in terms of the overall forecasting error with the lowest error of $MAE=1.50E+04$, $RMSE=2.78E+04$, and $MAPE=4.18\%$. It needs to be

highlighted that the results of this study show that when $GMFs=5$, the forecasting accuracy will be hindered. Therefore, it can be concluded that the model with 4 inputs $x=4$ and 4 Gaussian membership functions $GMFs=4$ offers a promising alternative for forecasting the number of tourist arrivals. Meantime, the results confirm the usefulness of ANFIS as a forecasting method for tourism demand. Therefore, ANFIS models seem to be applicable for the solution of real-world problems.

Appendix A.

Fuzzy triangular membership function: A triangular fuzzy number is defined by a triplet $\tilde{a} = (a, b, c)$. The membership function $\mu_{\tilde{a}}(x)$ of $\tilde{a}$ is given by

$$\mu_{\tilde{a}}(x; a, b, c) = \begin{cases} 0; & x \leq a \\ \frac{x-a}{b-a}; & a < x \leq b \\ \frac{c-x}{c-b}; & b < x < c \\ 0, & x \geq c \end{cases} \quad (A1)$$

Fuzzy trapezoidal membership function: A trapezoidal fuzzy number is defined by $\tilde{a} = (a, b, c, d)$. The membership function $\mu_{\tilde{a}}(x)$ of $\tilde{a}$ is given by

$$\mu_{\tilde{a}}(x; a, b, c, d) = \begin{cases} 0; & x \leq a \\ \frac{x-a}{b-a}; & a < x \leq b \\ 1; & b \leq x \leq c \\ \frac{d-x}{d-c}; & c < x < d \\ 0; & x \geq d \end{cases} \quad (A2)$$

Bell-shaped membership function: A bell-shaped membership function is given by the expression

$$\mu_{\tilde{a}}(x; a, b, c) = \frac{1}{1 + \left| \frac{x-c}{a} \right|^{2b}} \quad (A3)$$

where the parameter b is usually positive and defines the shape of the curve on either side of the central plateau, the parameter a shows the width of the curve and the parameter c shows the center of the curve.

Programming Language					MATLAB R2015							
No. Inputs	2				3				4			
No. Triangular MFs	2	3	4	5	2	3	4	5	2	3	4	5
ANFIS architecture	2-2	3-3	4-4	5-5	2-2-2	3-3-3	4-4-4	5-5-5	2-2-2-2	3-3-3-3	4-4-4-4	5-5-5-5
No. Rules	4	9	16	25	8	27	64	125	16	81	256	625
MAE	6.46E+04	3.51E+04	1.05E+05	4.82E+04	6.17E+04	3.66E+04	1.18E+05	4.14E+04	5.31E+04	3.08E+04	2.88E+04	4.96E+04
RMSE	8.46E+04	4.50E+04	2.53E+05	6.60E+04	7.89E+04	4.36E+04	2.45E+05	5.53E+04	6.83E+04	4.34E+04	3.32E+04	6.16E+04
MAPE (%)	30.28	14.49	83.00	22.39	24.20	14.99	82.36	15.96	23.67	13.91	13.49	20.47

Table A1. Parameters and comparison of the forecasting models when MFs type is Triangular

Programming Language					MATLAB R2015							
No. Inputs	2				3				4			
No. Trapezoidal MFs	2	3	4	5	2	3	4	5	2	3	4	5
ANFIS architecture	2-2	3-3	4-4	5-5	2-2-2	3-3-3	4-4-4	5-5-5	2-2-2-2	3-3-3-3	4-4-4-4	5-5-5-5
No. Rules	4	9	16	25	8	27	64	125	16	81	256	625
MAE	1.10E+05	6.38E+04	5.32E+04	5.04E+04	1.04E+05	5.14E+04	7.93E+04	5.61E+04	8.32E+04	5.47E+04	3.41E+04	7.24E+04
RMSE	1.32E+05	8.18E+04	8.66E+04	6.09E+04	1.23E+05	6.30E+04	1.13E+05	8.18E+04	1.28E+05	7.33E+04	4.08E+04	1.06E+05
MAPE (%)	45.64	26.59	20.97	15.64	40.24	20.65	27.20	22.37	30.91	21.62	12.72	22.66

Table A2. Parameters and comparison of the forecasting models when MFs type is Trapezoidal

Programming Language					MATLAB R2015							
No. Inputs	2				3				4			
No. Bell-shaped MFs	2	3	4	5	2	3	4	5	2	3	4	5
ANFIS architecture	2-2	3-3	4-4	5-5	2-2-2	3-3-3	4-4-4	5-5-5	2-2-2-2	3-3-3-3	4-4-4-4	5-5-5-5
No. Rules	4	9	16	25	8	27	64	125	16	81	256	625
MAE	9.05E+04	4.43E+04	2.92E+05	5.75E+04	7.93E+04	3.27E+05	5.77E+04	7.45E+04	5.10E+04	4.31E+04	3.90E+04	6.39E+04
RMSE	1.14E+05	6.05E+04	7.91E+05	7.36E+04	1.06E+05	6.85E+05	7.39E+04	9.56E+04	6.86E+04	6.23E+04	4.68E+04	8.13E+04
MAPE (%)	39.98	20.06	40.20	25.98	32.86	49.75	29.90	31.50	23.82	18.01	12.26	28.16

Table A3. Parameters and comparison of the forecasting models when MFs type is Bell-shaped

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Strategic Development of a National Pre-tertiary Learning Analytics System

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Abstract

This paper elaborates the design of a National Learning Analytics (LA) and Educational Data Mining System for pre-tertiary education in Croatia. The described approach consists of the following five phases: 1) objectives setting, 2) user needs analysis, 3) data availability analysis, 4) dashboards pre-design and 5) validation of functionalities. There is an evident research gap, as well as the lack of practical examples about the development of a Learning Analytics System (LAS) for pre-tertiary education on the national and/or regional level. Therefore, this research aims to make a scientific contribution by filling the recognized gap, but also contribute to solving the practical issues of national schools' LAS development. To increase the usability of an LAS, the involvement of all end users is essential. In the described case, six main user groups were identified: 10-18 years old students, teachers, school management and support staff, regional and national authorities responsible for education, strategic bodies and researchers and, finally, project partners that work on system development. For each of them, separate dashboard functionalities have been designed through several rounds of consultations. Consultations with users started with focus groups and panels, to brainstorm the most important issues they would like to answer in order to enhance learning and teaching. Between the two rounds of consultation, there was an evaluation phase of the relevance of the gathered questions. Finally, targeted users provided feedback on the pre-production functionalities of each dashboard and validated them. In this process, several challenges were detected, including data gathering and protection, ethical issues and interpretation of results for students who are underage, and continuous adjustments to the users' needs.

Keywords: Learning analytics, Learning analytics system, Pre-tertiary education, Needs analysis, Dashboard

1. Introduction

This paper presents the design of a National Learning Analytics (LA) and Educational Data Mining pre-production system for the pre-tertiary educational sector in Croatia, with a special emphasis on the methodology of gathering and validating user's needs. The methodology and the approach presented in this paper have been developed in the scope of the project entitled „E-schools: Establishing a System for Developing Digitally Mature Schools (pilot project)“ (E-schools) (CARNet, 2018). The project is due to run from 2014 to 2022 with a budget of EUR 180 million, with 85% of funding coming from EU funds and 15% from national and local budgets. The coordinating body of the project is the Croatian Academic and Research Network – CARNet, and the University of Zagreb, Faculty of Organization and Informatics (FOI) is one of the project partners. The overall goal of the “E-schools” pilot project (2016-2018) is to establish a system for the development of digitally mature schools and to evaluate the application of information and communications technologies (ICT) in the educational and operational processes of 150 schools in the Republic of Croatia [2]. One of the project results is the development of an LA and Educational Data Mining System as a comprehensive and overarching system for pre-tertiary education in Croatia and that process will be elaborated in this paper. FOI, as a project partner, is responsible for the research and design of the scope and functionalities of the Learning Analytics System (LAS).

First, this introductory chapter shortly describes pre-tertiary education in Croatia, to sketch the educational environment that the LAS has to serve and help to enhance. The Croatian educational system consists of [16]: preschool, primary, secondary and higher education. Primary education is mandatory and free for all children aged six to fifteen and consists of four years of lower and four years of upper primary education. Secondary education is optional in Croatia, although there is a strong movement to make it compulsory, and the great majority of young people (85%) enter secondary education. There are different types of secondary education: grammar schools, vocational schools and art schools. Secondary schools run for 3 or 4 years and students finish them at the age of 18 (the age of the majority). Therefore, the LAS developed within the scope of this project will serve underage students.

According to the Croatian Bureau of Statistics data [3] for the school year 2015/2016, there were 2 806 schools (2 055 primary and 751 secondary schools) and the total of 498 510 students in Croatia. Within the project “E-schools”, 150 schools were included in the pilot project phase from 2016 until 2018, but in the full rollout of the project foreseen to last until the end of 2022, all schools are included.

Higher education activities are carried out by higher education institutions (HEIs) (universities, faculties and art academies, polytechnics and colleges) and a prerequisite for admission is the state exam (matura). Since 2005, all study programs have been aligned with the requirements of the Bologna Process.

In 2014, based on the state analysis of the educational sector in Croatia, the Croatian Parliament adopted the Strategy for Education, Science and Technology, supporting five sectors: 1) early childhood and preschool, primary and secondary

education, 2) higher education, 3) adult education, 4) lifelong learning and 5) science and technology [15].

If we compare the digital development of Croatia with the EU, the results are as follows. Less than 10% of primary school students in Croatia are classified as ‘digitally-supportive’ and, on average, 26 students share one computer in Croatian schools, which means that, in both categories, they are lagging behind their EU peers [9].

Further, according to the results of the OECD’s Teaching and Learning International Survey [19], in 2014, 96.8% of teachers in lower secondary schools participated in some kind of trainings and 58.2% of them were trained specifically within ICT, settling Croatia at the top end compared to other EU countries. On the other hand, the proportion of teachers who used ICT in teaching was 23.5%, which is below the EU average of 34%. Finally, the proportion of teachers assigning different tasks to students based on their individual needs was above the EU average (51.2% compared to 46%).

Therefore, the “E-schools” project has had a very important role to be a ground-breaking initiative for the comprehensive digitalisation of the infrastructure, teaching and administration processes in schools in Croatia. Besides that, the project has had the role to support schools to take more autonomy and to be accountable for their development, while the LAS can particularly support those endeavours by providing school management with necessary data and analyses. This was especially important when project started since, according to the OECD index [18], school autonomy over resources allocation and over curricula in Croatia was below the OECD average. Further, schools need instruments for benchmarking. In primary schools, students are supposed to attend their neighbourhood schools, while enrolment in secondary schools depends on the admission criteria based on the student’s achievements in primary school. In Croatia, over 98% of students attend public schools. The process of admission to higher education is based on *numerus clausus* and its competitiveness is based on the students’ results on the state exam (*matura*). As a consequence, competition between schools is stronger on the secondary school level, especially between “elite” grammar-type schools.

To conclude, in Croatia, an LAS is essential to support students and teachers to enhance learning and teaching outcomes, schools to embrace more autonomy and national authorities to set, monitor and evaluate the strategic development of the whole pre-tertiary system.

In accordance with the presented issues regarding the school system in Croatia and taking into account the project aims, research questions are defined as follows: 1) What are the main national goals in the development of the LAS?, 2) What are the needs of LA user groups in pre-tertiary education? and 3) Which are the identified risks at the educational system level?

2. State of the art

This chapter gives a short overview of the literature on: 1) research that suggest frameworks for the introduction of LA and educational data mining (EDM) in a

standardized way (how to start?), 2) the application of frameworks in an education system and, finally, 3) the visualization of the analytics on the dashboard.

The information overload and the growing quantity of “Big Data” induced new opportunities for their use in different sectors. In education (formal and informal), there are two different but also closely related approaches: LA and EDM. According to [20] “LA and EDM constitute an ecosystem of methods and techniques (in general procedures) that successively gather, process, report and act on machine-readable data on an ongoing basis in order to advance the educational environment and reflect on learning processes” (p. 49) but they differ in their origins, techniques, fields of emphasis and types of discovery. The authors emphasise that “LA adopts a holistic framework, seeking to understand systems in their full complexity” and “EDM adopts a reductionistic viewpoint by analyzing individual components, seeking for new patterns in data and modifying respective algorithms.” (p. 50) Finally, LA is mainly about students and their contexts, while EDM is related to decision making at different levels in an education system.

Authors in [4] stated that a small number of institutions had been able to implement large-scale LA programs with a demonstrable impact on their teaching and learning outcomes. Further, authors in [10][31] also researched the implementation of LA and stated that there is still a lack of systematic and large-scale implementation of LA in higher education, although funding opportunities for LA research and activities have increased.

The benefits of the implementation of LA are recognized, but the adoption of LA at the institutional level is complex and challenging. Authors [4] the challenges that should be considered during the LA adoption: 1) the importance of committed and informed leadership, 2) organizational culture recognized as a key mediator of LA implementation – shared, willing and receptive appreciation of LA potential; 3) staff and institutional capacity - the ability of staff to effectively “link” pedagogy and analytics; 4) strategy – a clear vision and purpose of LA through the development of policy and procedures.

Further, [32] developed the SHEILA framework (Supporting Higher Education to Integrate Learning Analytics), a policy development framework that supports systematic, sustainable and responsible adoption of LA at an institutional level, built using the RAPID Outcome Mapping Approach (ROMA). The SHEILA framework consists of a comprehensive list of adoption actions, relevant challenges and policy prompts, framed in six ROMA dimensions (Dimension 1: Map Political Context, Dimension 2: Identify Key Stakeholders, Dimension 3: Identify Desired Behaviour Changes, Dimension 4: Develop Engagement Strategy, Dimension 5: Analyze Internal Capacity to Effect Change, Dimension 6: Establish Monitoring and Learning Frameworks).

Authors in [26] presented a mix-method study using a group concept mapping (GCM) approach that was conducted with LA experts to explore the essential features of LA policy in HEIs in contribution to the development of the framework. The study identified six clusters of features that an LA policy should include, provided ratings based on the ease of implementation and importance for each of the six themes, and offered suggestions to HEIs on how they could proceed with the development of LA

policies. The six clusters identified in the study are: (1) privacy & transparency, (2) roles & responsibilities (of all stakeholders), (3) objectives of LA (student and teacher support), (4) risks & challenges, (5) data management, and (6) research & data analysis.

A framework for setting up LA services in support of educational practice and student guidance, in quality assurance, curriculum development and in improving teacher's effectiveness and efficiency based on six critical dimensions of LA is presented in [11]. The stated six dimensions of the proposed LA framework are: stakeholders (student, teachers, students, other), objectives (reflection, prediction), data (open, protected), instruments (technology, algorithm, theories, other), external constraints (conventions, norms) and internal limitations (competences, acceptance). The authors' conviction is that only the consideration of all six dimensions in the design process can lead to optimal exploitation of LA. Additionally, [11] stated that there are some problem areas that influence the acceptance and the impact of LA such as data ownership and openness, ethical use and danger of abuse, as well as the demand for new key competences to interpret and act on LA results. Ethical issues and dilemmas related to LA were also discussed in [28]. Authors proposed six principles as a framework for considerations to guide HEIs to address ethical issues in LA and challenges in context-dependent and appropriate ways.

Further, based on the results of the Group Concept Mapping study conducted with experts from the field of LA, [25] proposed a framework of quality indicators for LA. The proposed framework includes the following five criteria and quality indicators: Objectives, Learning Support, Learning Measures and Output, Data Aspects and Organizational Aspects. The aim of the proposed framework is to provide a means to capture evidence for the impact of LA on educational practices in a standardized manner.

In order to ensure the use of educational data for LA in an acceptable and compliant way, and to overcome the fears connected to data aggregation and processing, in their paper [7] described an instrument for educational institutions to demystify the ethics and privacy discussions on LA. The developed eight-point checklist named DELICATE (included points are Determination, Explain, Legitimate, Involve, Consent, Anonymize, Technical, External) can be applied by researchers, policy makers and institutional managers and institutional managers to facilitate trusted implementation of LA.

The above-mentioned research [11] was used by authors [21] and applied to a primary school classroom. The case study illustrated that legal and ethical issues related to data control and data ownership can become the main issues to solve when applying an LA approach to a primary school context. Additionally, in their paper [24] contextualized the goal of the PILARES project (Smart Learning Analytics Platform to Enhance Performance in Secondary Education) in the wider panorama of LA, with references to the situation in the Spanish context. The authors stated that one of the most pressing concerns within the educational system in the Spanish context is a high rate of school leaving with a lower secondary education or less. Additionally, they identified motivation as a key factor influencing achievement and the improvement of the quality of learning, which can be influenced by schools and teachers through early

intervention and adapting the learning path to the student's needs. Finally, the authors considered the implementation of LA as a promising way that can timely provide teachers with the information needed to early detect motivation issues.

The necessity for the introduction of LA in primary education is recognized by [8] who address the question of how LA can be helpful at the course level, i. e. for learning math in primary education. Their starting point was the expectation to improve the diagnostics of some problems with the multiplication table and multi-digit multiplications and the results show that automated precise testing and feedback can be seen as an individual assistance and an effort to achieve an effective learning process.

Further, [33] designed and developed an early version of an LA Dashboard based on the review and comparison of nine developed applications against a group of criteria (1) intended goals and target users, 2) data-extraction and mining, 3) visualization and 4) evaluation) and based on preliminary investigation on the need for such tools. After conducting the usability test and refining the dashboard, 73 college students participated in a pilot test of the first version of the dashboard. The perceived usefulness of the developed dashboard was low. According to the authors' opinion, the reason for such a result was the descriptive nature of the dashboard. They think that providing the prediction of students' final scores and sending signals to students would significantly improve the dashboard's usefulness and power.

Finally, even though there is a great number of LA studies published until 2020, there are very few that deal with pre-tertiary education and especially with the development of the national-level LAS. Most of the current studies have been performed on the individual school level. Therefore, there have been limited benchmarking possibilities for designing the pre-tertiary LA national system for the "E-schools" project in Croatia.

3. Design science methodology for the development of the LAS for the pre-tertiary education system in Croatia

Within the „E-schools“ pilot project, the design for the development of the LAS for pre-tertiary education was prepared. The approach consisted of the following phases: 1) setting of overall objectives and vision, 2) user needs analysis, 3) data availability analysis, 4) dashboards development, including setting aims for each dashboard and designing dashboard functionalities, followed by 5) user evaluation of the dashboard design and functionalities example. These phases are explained in more detail in [5]. It is important to stress that users have been consulted three times: once in phase 2 and twice in phase 5. Hence, the results of the performed needs analysis presented later in the text served as a basis for defining dashboard functionalities for the identified user groups.

The proposed five phases of the LAS development follow the research steps which can be found within the design science paradigm for information systems, including: 1) awareness of a problem/identifying a new need (literature review and user groups identification), 2) defining the scope (focus groups with the recognized user groups and literature review), 3) designing dashboards, 4) evaluating the

dashboards and 5) reflecting the evolution [35][14]. The design science research is a common paradigm for the design of information systems focused on designing and evaluating innovative artefacts to solve complex problems from the real-world domain, considering the rigor, evident in research methods, and relevance, evident in the societal importance of the studied problem [13][1]. In this case, the relevance is evident in the recognized need for the development of a national LAS in Croatia and the involvement of all the end users' groups in the pre-design of dashboard functionalities. On the other hand, the rigor is evident from the provided state of the art related to the LAS development and the basis for certain steps in the LAS development in the findings from the scientific literature.

Moreover, the steps according to the design science paradigm also follow the logic of strategic planning, as they cover all the steps of the Deming PCDA (Plan-Do-Check-Act) cycle, which is characteristic for strategic planning. The planning phase includes identification of different user groups' needs, the implementation phase is evident in the dashboards design, the evaluation phase is focused on the user evaluation of the design dashboards, while ideas for further research indicate the need to reflect the evolution of the designed dashboards and improve them to the form of the final LAS that will be applied in schools in Croatia (Fig. 1).

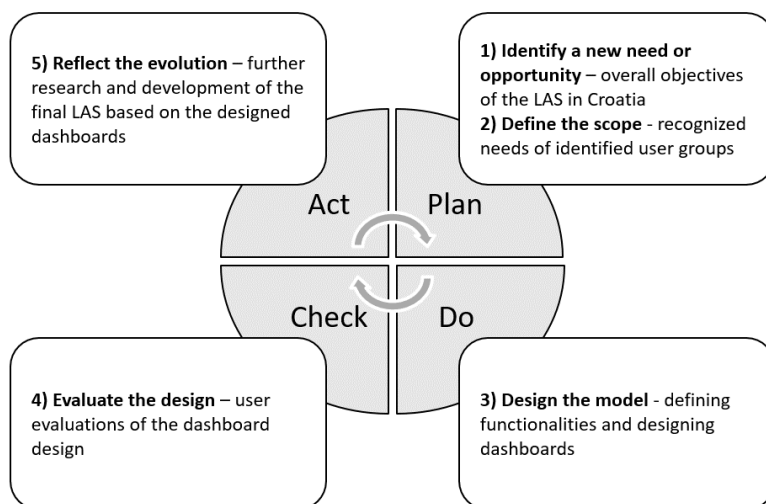


Figure 1. Connections between the strategic planning steps and the steps of the national LAS development according to the design science paradigm

3.1. Identify a new need or opportunity (overall objective and vision)

In the project preparation phase and the process of adoption of the Strategy for Education, Science and Technology (2014), all the stakeholders in pre-tertiary education participated and the overall goals related to the development of the LAS had been discussed and recognized. As it is argued in the Introduction of this paper, the national LAS in Croatia is essential to support students and teachers in enhancing

learning and teaching outcomes, schools to embrace more autonomy and national authorities to set, monitor and evaluate achievements planned in the Strategy for Education, Science and Technology. It means that a comprehensive system has to be developed considering LA and EDM approaches, to cover all available data sources, i.e. the Repository of Digital Learning Resources, National Data Repositories about students, teachers and schools on the national level as well as to analyse the risks that can arise, but also the virtual learning environment (VLE) Learning Management System (LMS). This elaboration of the situation on the national level provides an answer to the first step of design science research – awareness of the problem, which is further elaborated with the identification of the users' needs.

3.2. Define the scope via needs analysis

As presented in [5] the methodology for the needs analysis for the LAS in pre-tertiary education was developed and implemented in Croatia. In this respect, successful acceptance of LAS, it is of crucial importance that the development of LA takes a bottom-up approach focused on the interests of the students as the main driving force [11].

The main user groups were identified by the following simple analysis. Users were divided based on two dimensions: 1) in school/out of school and 2) involved in pedagogical/administrative processes. As a result, six target groups of users, for which the LA system has to provide useful data, information and analysis, were identified. These are: 1) Students (pupils) and their parents, 2) Teachers, 3) School management and support (principal/pedagogue/psychologist), 4) Local and national education authorities (School founders/the Ministry/Agencies for Quality Assurance), 5) Policy-making bodies and researchers and 6) Project partners within the "E-schools" project.

For all the six groups there were focus groups, panels and interviews organized in order to encourage users to identify the key questions to which they would like the LAS to provide answers, regardless of whether such answers are possible at the moment. In that manner, 168 questions were collected. Afterwards, the analysis of the collected questions was conducted, that included the identification of the most important, redundant and unclear questions as well as the questions that are impossible to be answered due to the technology state of the art or the availability of data. The final list included 131 questions grouped as relevant for different user groups (students and parents - 48, teachers - 90, school management - 52, school founders/the Ministry/agencies - 87, policy bodies and researchers - 60, project partners - 29).

Besides that, a questionnaire was formulated in order to detect the relevance of items collected in the previous stage. Users were asked to indicate whether an answer to a question is relevant to their learning, teaching and work, on a 5-point Likert-type scale, in order to assess the relevance for the inclusion of a certain question in the LA system. In that phase, 262 fully completed questionnaires from all target groups were received (students - 116, teachers - 39, school principals/pedagogues/psychologists - 32, local and national authorities - 50, policy bodies and researchers - 21, project partners - 4), along with some qualitative comments and recommendations.

The presented needs analysis contributes to the first step of the design science methodology: identify a new need or opportunity.

Further, the quantitative and qualitative data analysis and prioritization of items was conducted based on the questionnaire results. The description of the most highly ranked interests (according to users' responses to the questionnaire) of every target group are given in Table 1. The presented list of the most important interests contributes to phase 2, define the scope of design science research as further dashboard design is focused around these interests.

	Interest
Students and parents	• comparison of the student's achieved competences and competences required on the labour market • comparison of student's achievement and the preconditions for enrolment to secondary school/higher education • teachers' performance (survey results, students' course grades in previous school years, average grade on the course (historical overview)) • risks students have in achieving their goals • how a student can improve his/her performance • impact of various factors on student achievement (such as family social status, school equipment and design, working atmosphere, school practice, teamwork, absence from school, time spent on independent work) and • impact of various factors on the acquisition of competences (e.g. attending elective courses on digital competences).
Teachers	• their performance (survey results, students' grades, historical overview) • talented students and students who need additional support • students' achievement in continuing their education • students' learning activities • impact of various factors on students' activities (e.g. teaching methods, learning methods, evaluation methods) • impact of various factors on student success (e.g. time spent on homework, teachers' success in previous education) • recommendations for professional development to improve teaching performance
School management and support	• student performance and progress in school (difference between input and output competences) • teacher's performance and progress • talented students and students with special educational needs • feedback on student success in further education or in a chosen career • impact of various factors on student success and motivation (e.g. equipment, design, working atmosphere, teacher's professional development, teaching timetable, socio-economic status of students)
Local and national	• students who need additional support (talented students, students at risk, students with disabilities) • feedback on students' success in further education or in chosen

education authorities	- careers - students' evaluation of teachers' performance - impact of various factors on student success/learning outcomes (practice outside school, teachers' professional development, field education and internship, school equipment, design, working atmosphere, socio-economic status of students)
Policy bodies and researchers	- identification of teaching, learning and evaluation methods that increase students' activity in learning - use of problem solving or inquiry-based learning approaches - evidence that students' assessment is based on achievement of intended learning outcomes - form and content of lifelong learning for teachers to increase their performance - support for students who need additional support (talented students, students at risk, students with disabilities) - students that achieved preconditions for enrolment to higher educational levels
Project partners	- impact of various factors on student success/learning outcomes (reminders on students' obligations, formative evaluation, use of ICT and digital learning materials, school equipment, ...) - impact of various factors on teacher's performance - the most popular digital educational materials in digital repository and LMS - impact of computerization of business, administrative and educational processes on school results - the school digital maturity level

Table 1: Highly ranked interests of every target group

Although the analysis of the available data sources is not in the scope of this paper, it is important to emphasize that it was a very demanding process due to the fragmentation and incompleteness of databases, data ownership issues, interoperability challenges, ethical concerns and integration of data collected online and in physical school environments. The complexity of the inclusion of data from different databases in terms of user identification, ethics and privacy is also mentioned in [20].

Altogether 11 potential data sources were identified: e-Dnevnik, e-Matica, the repository of Digital Educational Content, the CARNET survey system, the Classroom Management System (CMS), the Learning Management System (LMS), the Learning Record Store (LRS), Yammer, network logs, the database of schools' digital maturity assessment, the database with an overview of teachers' education and professional development. As those are not in compliance, there is a challenge to integrate and interconnect data. As stated in [22], since students' learning activities increasingly include resources out of the LMS, focusing the analysis on the LMS provides an incomplete view, so it is important that the LAS includes all the relevant data sources. In Croatian schools, most of the teaching and learning activities are face-to-face in classrooms and just recent developments due to the curricula reform (2018-

2020) and the COVID-19 pandemic involved the use of an LMS, learning repositories and other online tools and that have implications on data gathering in the first phase of the project until 2018. The curricular reform provided the preconditions for an agile and successful response to the COVID-19 crisis [30]. Moreover, at the onset of the pandemic, a series of guidelines was prepared at the national level in order to support schools in the rapid shift to digital distance education; more details are available in the Action Plan on Digital Education [17].

Besides that, there is one even more important data protection issue, which is dealing with the data of young people that are mostly underage.

3.3. Dashboards design

The third step according to the design science for the development of the LAS for pre-tertiary education is designing dashboards for identified target users. According to [29] the dashboard is the sense-making component of the LAS, presenting visualized data to assist individuals in making decisions about teaching and learning. According to the performed review of nine developed dashboards presented in [33], previously developed dashboards can be generally divided into three types: dashboards for 1) teachers, 2) both teachers and students and 3) students only. According to the conducted needs analysis of different end-user groups, it can be claimed that the comprehensive implementation of the LA country-wide in Croatia can give added value not only to students and educators, but also to other identified user groups within the project. Therefore, based on the results of the performed needs analysis and the available data sources, six types of dashboards were designed – one for each of the identified user groups. This phase consisted of two steps: 1) defining dashboard aims for each of the identified user target groups and 2) defining dashboard functionalities.

The overall objective of LA is to support learning and teaching and that has been followed by the LAS development. Besides that, there have been additional needs deriving from other user groups that involved data mining based on mostly the same datasets as for the basic LAS aimed for students and teachers. Still, the needs of students and teachers are given the highest priority in the design process and reflected in the goals for each dashboard. Table 2 presents the aims of dashboards for each of user groups identified by “E-schools” project partners based on the overall project objectives as well as on the results of the focus groups and panel discussions with potential users.

Finally, when the aims of dashboards for each target group of users were defined, it was possible to proceed with the third phase according to the design science approach, design of the dashboard. First, the pre-production examples of dashboards for all six user groups were designed. There are four dashboards presented here: for students, teachers, school management and local, as well as national, authorities responsible for the education system.

The dashboards described here are based on the needs analysis and available data sources, and represent current plans for the development of the final LAS functionalities. At the moment, it cannot be claimed that the same design will be implemented in the production phase, but these specifications became a part of the

tender documentation. There are several key principles applied in tendering the production development of all dashboards and the whole LAS:

- 1) Students are the main beneficiaries of the LAS.
- 2) Protection of students' and teachers' personal data takes precedence over functionality development.
- 3) Students' and teachers' personal data should be available only on the school level, while on higher levels, in principal aggregated data should be used.
- 4) The LAS uses existing data and only exceptionally and justifiably independent data collection particularly for LAS.
- 5) The LAS should be open for upgrading and further development and should apply the interoperability principles.
- 6) The LAS dashboards should allow personalization for of users from all target groups.
- 7) The LAS must be scalable because in several years it should serve around half a million students, 50 000 teachers and several thousand other users.

The design of the dashboard for students was initially presented in [6], while this paper further describes dashboards for end user groups.

Target users	Aims of dashboards
Students and parents	Data collection, data analysis and visualization adjusted to students in order to achieve better educational results (learning outcomes) and to raise their motivation for learning and learning self-regulation.
Teachers	Equip a teacher with information, analysis and recommendations as well as communication tools allowing her/him to better support students in a learning process and to improve his/her teaching performance.
School management and support	Continuously providing school management (principals) and support (deputies/pedagogues/ psychologists) with information about the quality and efficiency of the educational process at school, students' and teachers' needs and possibilities for improvement in order to ensure for every student the best possible conditions and support for successful learning and holistic personal development and enhance the quality of the educational process.
Local and national education authorities	Continuously providing local and national authorities with information about the quality of educational process, system efficiency, investment needs and educational, financial, personnel, etc. interventions in the system or any part of it, in order to ensure for every student the best possible conditions and support for successful learning and holistic personal development and enhance the quality of educational process.
Policy bodies and researchers	Continuously providing policy bodies with information on the state of the educational process at schools, implementation of strategies at the level of pre-tertiary education system in Croatia in order to assure quality, pedagogically justified and relevant education and equity for all students.
Project partners	Monitoring the introduction of digitally mature schools' concepts in pre-tertiary education system in Croatia and their impact on the achievement of goals from relevant strategies.

Table 2: Aims of dashboards for target users

3.3.1. Dashboard for students

The dashboard for students is very essential and fundamental because it answers the most important questions coming from students and it provides a starting platform for generating all other dashboards. The dashboard for students is shown in Table 3. Students have a central place to grasp all information about themselves, their teachers and school, including a personal development space and a parent corner. “Me” area consists of three parts: awareness and reflection, predictions and interventions. Students can see all the elements of progress on two levels: aggregated for all courses and separately for each course. Students will have insight into some basic information about teachers (CVs), but teachers can also allow students to see some extras, such as their hobby details, favourite teaching resources etc. Further, students and parents can get data about the school and compare it with similar schools in Croatia. A testing of a simple early warning system (predictions) based on elements such as grades, absence and teachers’ warnings was also planned. Two-way communication between students and teachers and pedagogical and psychological support at school is planned in Interventions. In the scope of that, students can ask for help, get advices, receive tasks etc. Furthermore, students can set some educational goals for themselves and then trace their achievements by the use of gap analysis or obtaining badges (Personal development part). There is also the Survey module that can be used to ask students to assess or evaluate a school and teachers, but also their own motivation, attitudes and needs. Students’ participation in the survey will be on a voluntary basis and results can be used just on an aggregated level by teachers, authorities and researchers. Student have unlimited access to their results and to see how they are used. Finally, the design was checked according to the DELICATE eight-point checklist [7].

3.3.2. Dashboard for teacher

Detecting problems in the learning process is a way to improve educational systems and provide feedback at the right time and in line with the situation [23] [34].

In order to provide students with timely and adequate support during their educational process and to detect problem zones in due time, teachers should be aware of students’ behaviour and needs. Accordingly, the dashboard should allow them easy monitoring of students’ progress, activities, obligations and networking with other students.

As already mentioned, teachers are allowed to see the majority of personal data and analytics for all their students (all elements presented in Table 3, except for Success Planner, Interventions and Learning more on the individual level), but the dashboard also provides a teacher additional analytical elements: successful and less successful students, class overview, comparison of success in different subjects if a teacher is a class headmaster etc.

3.3.3. Dashboard for school management and support

The school management and support was planned to have a possibility to see analytics for each course, for each class and for each student, including all dashboard elements

presented in Table 3 (except for Interventions, Success Planner and Learning more). Additionally, it was planned that school principals are also regularly provided with information such as:

- a list of successful classes/students according to different factors, such as the highest average grade, the highest average grade per subject, results of student competitions, the lowest absence rate;
- a list of less successful classes/students according to different factors, such as the lowest average grade, the lowest average grade per subject, the highest absence rate. This element indicates potential risks for students and requests timely interventions from teacher/pedagogue/psychologist.

It was planned that the school management would have the possibility to see analytics for each teacher (results of students' survey on teachers' performance, comparison of teachers according to different factors, teachers' trainings) and for other data with teacher consent (teachers' networks, interventions, competency testing).

Regarding the school, the school management and support services can see additional information such as:

- according to which criteria the school deviates compared to other schools in town, county and similar schools on the national level
- what is the status of the school regarding different factors (number of students, number of students per teacher, students' grade)
- the results of all performed data analyses related to the school
- the recommendations and proposed interventions for the school from local and national education authorities
- statistical reports about the educational system on the national level.

3.3.4. *Dashboard for local and national education authorities*

Local and national education authorities are provided with data and analyses about schools, students and teachers based on aggregated data and only exceptionally on individual level (by consent or by legal obligation). Analytics are planned separately for primary schools and for secondary schools on the town level, county level and national level. The dashboard for local and national education authorities provides a quick overview of successful and less successful schools based on the selected criteria as well as the overview of schools that need support for different reasons. Additionally, the dashboard allows following up the achievement of indicators for the strategic goals defined within national strategies. For instance: the number of students per teacher at school, the number of teaching assistants per student with disabilities at school, schools that have a high rate of drop out, teachers' participation in trainings and professional development, the number of active projects at school, the level of teachers' digital competences, the level of schools' digital maturity, the proportion of minorities at school etc. Finally, local and national education authorities are also provided with analyses performed on data from founders of schools (sample description, methods, results) and statistical data in form of a report.

On	Aim	Element	Description
Me	Reflections	Success and progress	A review of student success and progress – overall student grade average, grade average per subject, obtained badges. A review of student grades for the previous school year.
		Me and others	Comparison with other students in the classroom (statistically aggregated), in the school and students from other “similar” schools, according to different factors (e.g. average grade, students’ activities, absence rate).
		My network	Students’ positions according to centrality measures in different networks (e.g. teamwork, informal communication, sharing documents, activities in different systems such as an LMS, forum activities, group membership etc.).
		My obligations	Students’ past, current and future activities, such as homework, tests, self-assessment, essay presentations etc.)
		Attendance	Students’ presence in the classroom (justified and unjustified absences).
	Predictions	How am I doing?	An early warning system. A review of possible risks that could threaten student success (e.g. too many negative grades, too many absences from school, teachers’ warnings).
	Interventions	My needs	Allows students to request help from a teacher/pedagogue/psychologist.
		Tasks and recommendations	A review of tasks and recommendations assigned by a teacher to a student (e.g., attending supplementary classes).
My teachers		Info point about teachers	Information about teachers, such as results of students’ evaluation of teachers’ work, teachers’ professional development, students’ results in competitions in a subject, students’ average grade, teachers’ networking, cooperation with other teachers, project activities etc.).
My school		School particularities	A review of factors according to which a school is positioned as the best in the city, county, country (e.g., results in the national students’ competition in Mathematics).
		Comparison with other schools	School status according to different factors (e.g., student success, teacher performance, external evaluation etc.)
Additional	Personal development	Success Planner	Allows students to define their educational goals, the desired overall average grade, an average grade per subject, the maximal number of absences, the student discipline grade, conditions for enrolment in high school/HEI. At the system level, students get motivational messages and badges depending on their current success and progress and set plans.

	Parental involvement	Parents Corner	Allows insight for parents into possibilities for consultations with teachers, parents' meetings with a headmaster and Parents Council meetings.
	Learning more	Survey module	Allows teachers, schools or authorities to survey students on their learning, motivation and needs, to create better teaching and supporting strategies.

Table 3: Elements of the dashboard for students

3.4. Evaluation of dashboards design

The created dashboards were presented to 160 participants of all user groups in September 2016, followed by discussions in smaller groups, with the purpose of gathering additional inputs from users. Finally, 102 written evaluations, with a rather favourable final evaluation (4.3 out of 5), and numerous suggestions and concerns were collected and considered when designing dashboard examples. The collected user evaluations present a contribution to step 4, evaluate the dashboard of the design science research.

4. Discussion

4.1. Basic functionalities

In Croatia, the national LAS has been planned to have a rather wide grasp, from supporting students and teachers in enhancing learning and teaching outcomes, schools to embrace more autonomy, and national authorities to set, monitor and evaluate the strategic development. Having that in mind, all the user groups have a wide range of information and analyses available. There are many similarities between the user groups in their needs and wishes. Although from different aspects, all the user groups focus on students' success, students' problems, e. g. potential risks and their needs, special educational needs, which gives the impression that students really are at the very centre of the whole LAS development. There is also a considerable interest for various predictions. But some of the questions they posed were very complex (e.g., students: Am I on a good track to be employable?) and there are no available data sets to support predictions so far. Bearing in mind that the LAS provides great help in discovering hidden information and patterns from raw data collected from educational environments [27][34], throughout the process of dashboard design, an emphasis was put on providing user groups with data relevant for their area of activity, being realistic about the availability and reliability of certain data sets. However, based on the performed literature review and needs analysis, several issues came up as the ones that should be given a special attention. Therefore, except for the presented dashboards, three additional modules were proposed within the LAS architecture: Consent System, System for Warning and Intervention and Success Planner.

4.1.1. Privacy, data control, data ownership - Consent System

As evident from the performed research review, legal and ethical issues related to data control and data ownership can become the main problem in the process of an LAS implementation.

In order to facilitate trusted implementation of LA [7][22] and considering that the largest user group of the LAS is underage, we planned the Consent System as a part of the LAS. The Consent System, concerning the Consent and Anonymise points of the DELICATE checklist [7], allow users to see how their personal data have been used (what data, for what purpose, on which locations they are stored and what systems use them). The Consent System also allows users to give or refuse their consent to use personal data for a specific purpose (users can give a permission for using all personal data, only a particular set of personal data or only anonymized data).

4.1.2. Prediction-System for Warning and Intervention

Motivated by the potential and opportunities offered by LA, especially in the field of students' success prediction, the System for Warning and Interventions has been planned as a supporting module to the LAS. This system serves students, to improve their learning processes and results, to complete certain parts of their learning processes, as well as educators, to provide individualized guidance in students' educational processes. Prediction elements are incorporated in several functionalities, such as How am I doing?.

Some authors [33] stated that the "descriptive dashboard" they developed was not recognized as significantly usable from the students' aspect. Probably, some of the problems derive from the fact that students do not know how to interpret presented data and therefore do not consider a dashboard as a helpful tool. Otherwise, the personalized motivational messages planned within the LAS in Croatia should guide students in their learning processes. Except on the system level, teachers can also consult and guide students through their learning processes. Teachers do not have time to interpret educational events immediately and in detail, since in the classroom they have to observe and react to many different events at once [12][36]. Bearing this in mind, the prediction elements incorporated in this system play an important role in providing timely and adequate support to students in semi-automatic ways.

As for the further development, a careful process of data interpretation as well as the education scenarios shall be further designed to give students and teachers possibilities to use the information meaningfully.

4.1.3. Success Planner

The final system that supports the LAS is the Success Planner. The Success Planner is foreseen as embedded in the LAS and aims to encourage students' reflection on their learning goals, desired success and competences they want to acquire, i.e. to develop their metacognition skills and approaches. In that way, the Success Planner provides students with the sense of where they are, where they can be and how to get there in an early phase of their educational process.

4.2. Interpretation of the results

Finally, a short discussion of the potential hazards related to the implementation of the LAS is provided. A potential danger of using educational datasets for the purpose of LA stems from a possible misinterpretation of LA results presented within a dashboard. As stated in [11], a data analysis could have dramatic (and unwanted) consequences if not used with the necessary care. Concerning the fact that this system, together with regular upgrades, is foreseen to be used by half a million of underage students, this issue should be taken very seriously. The correct interpretation of data presented within a dashboard provides a basis for conclusions and decision-making, which follow the analytics process. This implies the development of skills and competencies for all LAS users.

Besides that, the LAS can provide school management with the necessary data and analyses to support their decision-making processes, and consequently support schools to be more independent and take responsibility for their development. To support all the users in maximizing the benefits of the LAS implementation, use scenarios are developed.

5. Limitations of research

Due to financial and time constraints, there are several limitations of the needs analysis research and the results can therefore be biased. Some of the functionalities planned for the dashboards will probably not appear in other national environments because all the participants in the needs analysis are from Croatia. Further, even though the representatives of all user groups and around 500 participants have been involved in the consultations and evaluations, the research sample was not representative. In order to incorporate broader perspectives, the analysis included research studies and practitioners' references as well as experiences of the international experts engaged to work with the national teams within the "E-schools" project.

6. Further research

Regarding LA for pre-tertiary education, there are still many gaps in contemporary research and numerous possibilities for further research. From the technology and LA methods point of view, there is no big difference between tertiary and pre-tertiary education, but from the pedagogical and methodological point of view, there are much more difficult challenges in pre-tertiary education, starting with ethical issues, aggregation of classroom data with online data, to interpretation of LA results and justification of their use. For future research, the idea is to analyse pedagogical scenarios for the use of dashboards, such as interpretation of data for all target groups, ways of using the Success Planner in the classroom, preparing reports on student success for parents' meetings and how to get badges. Further work should also consider broad research of how, why and when some information or visualization can be delivered to students, but also how to protect students from the misuse of information. Finally, if something can be prepared from the technological point of

view, it should not necessarily be given to users without a clear goal and a confirmation that it is not harmful.

Here, it is important to emphasize the last phase within the design science research, Reflect evolution, which implies a need for the presentation of the system evolution to the appropriate audience and collecting inputs for further improvements. In the context of this research, that is accomplished through presentation at conferences and workshops, in publications, etc.

Additionally, further research should be related to: 1) specific challenges of institutional adoption at the pre-tertiary level; 2) students' and teachers' data literacy necessary for meaningful data interpretation and 3) ethical and pedagogical issues related to the institutional adoption of LA.

7. Conclusions

The majority of the existing research on LA has been done in the last decade and its value is unquestionable. However, the vast majority of the research concerns higher education settings, without any extensive research on the application of a LAS in pre-tertiary education. Moreover, no national LASs on the level of primary or secondary education in practice have been identified. Therefore, the objective of designing the pre-production National LA and Educational Data Mining System as a comprehensive and overarching information system for pre-tertiary education in Croatia within the "E-schools" project has been demanding and complex.

At the very beginning, this paper clearly defined the objective of the LAS, with the primary focus on improving students' learning and motivation, but also supporting schools in accountability and national authorities in setting, monitoring and evaluating the strategic goals. After that, six target user groups (stakeholders) were identified: students (pupils), teachers, school management and support, regional and national authorities responsible for education, strategic bodies and researchers and, finally, project partners working on system development. The main requirements from the six main groups of users are to support student success, to allow identification of students at risk based on different factors (such as negative grades, too many absences, low rate of engagement in the course), to allow educators to friendly monitor students' success, progress, needs and provide timely interventions to prevent students' failure. In the development of functionalities and dashboards for the six identified user groups, special attention was given to the needs and opinion of users. Based on that, six examples of dashboards were designed, including the description of main functionalities and the associated methods. Besides the data analysis part of the system, there is also the Consent System, giving students and teachers the possibility to control the use of their personal data, the System for Warning and Intervention, helping students and teachers to deal with risks, as well as the Success Planner, that enables the development of students' metacognitive skills.

There are several issues which have to be considered with special care, such as data collection, control and preventions, the analysis of usability (and harmfulness of the presented information and analyses. Furthermore, students, teachers and other users should be trained to interpret the analysis results and other information available

via the dashboards. Finally, the whole process of production of the LAS and the implementation of that system should be closely monitored and evaluated.

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Exploring Students' Perspective of a Platform for Digital Competence Acquisition in Schools

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Abstract

This study aims to evaluate the ways that the actual usage of a platform for digital competence acquisition, evaluation and certification contributes to satisfaction and perceived success of students in primary and secondary schools. A cross-sectional survey was implemented online to collect 1725 students' answers in six European countries. The analysis of collected data was carried out by employing Pearson correlation, Partial least squares structural equation modelling (PLS-SEM) and Importance-performance map analysis (IPMA). Findings indicated that the usage of such a platform has greater effects on the impacts than on students' satisfaction. Detailed analysis of correlations revealed that students' decision on whether they will use the platform in the future greatly depends on how it contributes to the success of their learning processes. Results also suggest that teachers are seen as an inevitable part of such a process and are mandatory to achieve the full potential of the platform.

Keywords: User satisfaction, net impacts, system use, Delone and Mclean information systems success model, digital competence, importance-performance map analysis

1. Introduction

Today, a young person needs to acquire a set of digital skills most commonly represented as digital competence (DC) to be able to enter the labour market without the risk of exclusion. The literature review has shown that the best solution for students to acquire DC is to integrate them into the formal educational curriculum [1], [2]. This is further supported by [3]–[6] who suggest that education and evaluation of DC should be started from the earliest age of students and promoted throughout the

curriculum. That way, schools could timely identify the lack of a specific DC and intervene with a certain plan of development. However, very few studies have been reported to deal with the evaluation of DC at any level of education, especially in primary and secondary education. A three-year longitudinal study [7] concluded that digital skills do not develop equally over the years of education, e.g. creating information skills has been developing most slowly.

With that respect, an EU funded research project CRISS has been established to develop an online platform (hereinafter referred to as CRISS DC platform) for DC acquisition, evaluation and certification in primary and secondary schools. The platform is based on a newly developed framework [8] that decomposes DC into five areas and twelve sub-competences. Each sub-competence is composed of a set of performance criteria that translate the sub-competences into more specific elements of what a student should be able to demonstrate. Teachers are responsible to plan the learning, providing feedback and evaluating activities and tasks that relate to an individual sub-competence. The activities and tasks are retrieved by the CRISS repository and teachers can apply them with or without further adaptations. The students should conduct the activities by performing one or more tasks and generate evidence to prove the acquisition of a specific sub-competence. The evaluation of digital (sub-)competence is also performed through the CRISS DC platform with two types of interventions: human and technological. Human interventions are carried out by teachers and students using tools like Rubrics, Check Lists, Scales, etc., that are automatically generated by the CRISS DC platform and customized by teachers. The technological intervention is executed by the platform automatically which is set to track the students while working in their assigned activities and to collect relevant information i.e., the indicators of the evidence evaluation. The CRISS DC platform as such has been piloted in six European countries (Spain, Sweden, Croatia, Greece, Romania and Italy) for several months during the school year 2018/2019 with a targeted population of students over 9 years of age.

The main aim of this study is to investigate how the actual use of such a platform contributes to satisfaction and perceived success of students in primary and secondary schools.

2. Research Focus

Although recent research findings [9], [10] suggest that teachers are the main drivers for the incorporation of DC evaluation and certification into curricula, students are the ones who need to benefit from that process. In that sense, educational systems face a significant challenge to provide their users with an effective learning experience. Outcomes of interaction are most visible after extensive time and effort invested in learning on behalf of students. Therefore, it is up to a system to provide students with an engaging experience to achieve sustainability goals.

Studies have found that students who are satisfied with the system will use it more frequently [11]. Furthermore, students that could successfully interact with each other and had various ways of learning evaluations within the system were more satisfied [12]. Students' perception of content structure, functionalities and navigation will also

impact their satisfaction and use. The system success will be a result of students' perceived benefits and attitudes towards the system. With that respect, the following hypotheses are proposed (see Figure 1):

H1. System use has a positive effect on User satisfaction.

H2. System use has a positive effect on Net impacts.

H3. User satisfaction has a positive effect on Net impacts.

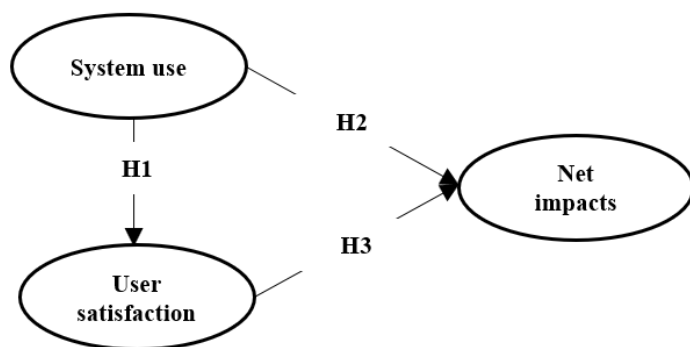


Figure 1. Hypothesized model

Overall, this study is focused to contribute to future academic research and advancement in the field of DC platform development.

3. Method

This section describes the research participants who have actively used the CRISS DC platform during the implementation of the CRISS project. The procedure of data collection, which was performed online in primary and secondary schools, is also described. Data was collected with the survey that is based on the well-known DeLone and McLean Information Systems Success Model. Survey items were adapted to primary and secondary school students and translated into the official languages of the countries where it was administered.

3.1. Participants and Data Collection

Students from primary and secondary schools were selected as they were active users of the CRISS DC platform for at least one month. It is assumed that those students had sufficient time to get familiar with the platform to properly assess it.

The total number of students enrolled in the CRISS DC platform during the school year 2018/2019 was 7543. Of these, 1725 students (47% boys and 53% girls) aged from 9 to 20 years ($M = 14.91$; $SD = 1.83$) participated in the research between May and September 2019. Seventy-one percent of them attended secondary and 29% primary schools located in six European countries. Most students were from Croatia

(41.6%), then from Spain (26.7%), Greece (12.3%), Italy (4.8%), Romania (6.7%) and Sweden (7.8%).

Data collection was conducted using an online survey which was administered by teachers during the class to clarify possible doubts of students in certain questions and to achieve the highest response rate possible on behalf of this study's authors. Teachers were instructed to explain briefly to students the purpose of filling out the survey and to ask them to carefully read questions. The participation of students was voluntary and anonymous. The survey was distributed with LimeSurvey online tool that was set not to collect personal data or track IP addresses.

For this research, the judgement sampling approach was based on the selection of teachers with whom continuous communication was established during the project and who were believed to survey students during their classes. The response rate was 22.9% which is in line with the findings that showed that the average response rate in online surveys ranges between 20% and 47% [13].

3.2. Research Instrument

To assess and identify the most relevant variables of students' satisfaction, use and impacts of the CRISS DC platform we used three constructs from the DeLone and McLean Information Systems Success Model revised in 2016 [14]. The first construct, User satisfaction measures users' level of satisfaction with reports, platform, and support services. The second construct, System use measures the feedback on using the capabilities of the CRISS DC platform. The third construct, Net impacts measures the extent to which the platform contributes to the success of users. User satisfaction, System use and Net impacts are measured with five, eight and twelve items, respectively.

The instrument development phase was conducted by following the recommendations of several prominent scholars [15]–[17]. We started with the operationalization of research constructs based on the existing measures and modified it with a set of new target-specific measures. Content validity was ensured, besides using an extensive literature review, by using focus groups that involved experts in the field of pedagogy, e-learning, assessment, and teaching methodology. The final measurement instrument (see Table 1) was translated into all target languages of students. Students could record their answers on a five-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The survey aimed to examine students' satisfaction, their use of the platform, and their success during the acquisition and evaluation of DC.

Code	Items – SYSTEM USE
SU1	I would like to use the CRISS platform again in the future
SU2	I have all the necessary equipment to use the CRISS platform (e.g. computer/tablet/mobile phone, internet connection).
SU3	I use the CRISS platform to organize and publish my work (ePortfolio).
SU4	I use the CRISS platform to work with other students (teamwork).
SU5	I use the CRISS platform features to tag my work (e.g. homework, seminar, project, images, videos, etc.).

SU6	I use the CRISS platform to see my progress and achievements (grades, badges, etc.).
SU7	I use the CRISS platform to see the progress of other students.
SU8	I use the CRISS platform to communicate with my teacher(s).
Code	Items – USER SATISFACTION
US1	I like using the CRISS platform
US2	I find the CRISS platform useful for my learning
US3	I think it is interesting to use the CRISS platform
US4	I feel confident using the CRISS platform
US5	I am satisfied with the CRISS platform possibilities
Code	Items – NET IMPACTS
NI1	The tasks in the CRISS platform enable me to be creative in solving them (ingenious, original).
NI2	The CRISS platform makes my learning easier.
NI3	The CRISS platform helps me to see my progress.
NI4	Seeing my progress helps me to improve my learning.
NI5	Earning badges motivates me.
NI6	The CRISS platform helps me to develop new skills (making presentations, sharing my work, finding information on the Internet, online communication ...).
NI7	Within the CRISS platform I easily understand how my work is being assessed.
NI8	I get feedback from my teacher more quickly with the CRISS platform.
NI9	The CRISS platform enabled me to show my work in a more attractive way(s) (e.g. my presentations are more visible and organized/my videos can be accessed easily/I can use portably to show my different works...).
NI10	The CRISS platform enables me to participate in my assessment (i.e. self-assessment, my comments to the teacher).
NI11	The time spent on activities has been useful to learn.
NI12	When I work in the CRISS platform, I realise the process I follow to solve the tasks.
<i>Notes.</i> Answers on a five-point Likert-type scale (1 – Strongly disagree; 2 – Disagree; 3 – Uncertain; 4 – Agree; 5 – Strongly agree; NA – not applicable).	

Table 1. Survey instrument

4. Results

Descriptive statistics and correlations between variables were calculated using R [18]. Additionally, data were examined using the partial least squares structural equation modelling (PLS-SEM) in SmartPLS 3 [19]. This multivariate analysis is suitable for theory building, providing causal explanations and when there are concerns about data distribution [20].

In that sense, the psychometric properties of constructs in the outer (measurement) model were analysed, and relationships between three proposed latent variables were observed in the inner (structural) model. The significance of relationships was assessed using bootstrapping of 5000 samples and a critical t-value of 1.96 for $p < 0.01$.

Finally, the importance-performance map analysis (IPMA) was used to bring more insight into the impact of exogenous constructs on the target construct (Net impacts) in the model.

4.1. Descriptive Statistics and Pearson's Correlation

The analysis of collected data showed that most students were between 14 and 17 years old (80.5%). Only 2% of students reported being older than that. During the school year 2018/2019, students used the CRISS DC platform every day (1.9%), almost every day (9.9%), at least once a week, but not every day (47.3%), at least once a month, but not every week (25.3%) and never or almost never (15.5%). Their experience of using the system outside school, but also the use frequency of other digital technologies for learning is shown in Table 2.

The mean values at construct levels are 2.79 ($SD=1.55$) for System use, 2.71 ($SD=1.48$) for User satisfaction and 2.80 ($SD=1.52$) for Net impacts. As expected, the median value for all three question categories is 3.00 which indicates the mostly uncertain perception of system use, satisfaction and its impact.

Possible answers	a. (%)	b. (%)	c. (%)	d. (%)
Never or almost never	46.9	7.9	6.8	36.6
At least once a month, but not every week	20.6	19.1	19.2	16.8
At least once a week, but not every day	26.8	35.1	27.7	17.6
Almost every day	4.9	23.9	28.2	14.4
Every day	0.8	14.1	18.1	16.6
a. Use of CRISS platform outside the school timing. b. I use digital technologies in school related to schoolwork (e.g. assignments, communication with other students or communication with teachers). c. I use digital technologies at home related to schoolwork (e.g. assignments, communication with other students or communication with teachers). d. I use digital technologies outside the school for learning that is not related to school (e.g. robotics or computer classes).				

Table 2. Descriptive statistics of use frequency ($N = 1725$)

Table 3 displays a summary of the mean and standard deviation of students' responses for each item. Furthermore, survey responses "5 - strongly agree" and "4 - agree" are combined within column "Agree", column "Neutral" represents all "3 - uncertain" answers while "1 - strongly disagree" and "2 - disagree" are combined within column "Disagree".

Items	Mean (Std. dev)	Agree (%)	Neutral (%)	Disagree (%)
SU1	2.41 (1.47)	467 (27%)	334 (19%)	924 (54%)
SU2	3.96 (1.33)	1311 (76%)	176 (10%)	238 (14%)
SU3	2.86 (1.53)	728 (42%)	345 (20%)	652 (38%)
SU4	3.10 (1.48)	877 (51%)	290 (17%)	558 (32%)
SU5	2.65 (1.49)	586 (34%)	397 (23%)	741 (43%)
SU6	2.74 (1.50)	664 (38%)	329 (19%)	732 (42%)
SU7	2.30 (1.47)	428 (25%)	303 (18%)	994 (58%)
SU8	2.33 (1.39)	415 (24%)	337 (20%)	973 (56%)
US1	2.47 (1.48)	514 (30%)	343 (20%)	868 (50%)

US2	2.75 (1.45)	643 (37%)	352 (20%)	730 (42%)
US3	2.73 (1.50)	635 (37%)	340 (20%)	750 (43%)
US4	2.76 (1.50)	655 (38%)	352 (20%)	718 (42%)
US5	2.84 (1.47)	683 (40%)	359 (21%)	683 (40%)
NI1	2.95 (1.44)	721 (42%)	399 (23%)	605 (35%)
NI2	2.61 (1.43)	528 (31%)	424 (25%)	773 (45%)
NI3	2.81 (1.49)	683 (40%)	365 (21%)	677 (39%)
NI4	2.91 (1.52)	732 (42%)	367 (21%)	626 (36%)
NI5	2.46 (1.66)	560 (32%)	353 (20%)	812 (47%)
NI6	3.02 (1.49)	783 (45%)	381 (22%)	561 (33%)
NI7	2.94 (1.52)	753 (44%)	352 (20%)	620 (36%)
NI8	2.67 (1.55)	627 (36%)	363 (21%)	735 (43%)
NI9	2.82 (1.54)	678 (39%)	399 (23%)	648 (38%)
NI10	2.7 (1.52)	618 (36%)	429 (25%)	677 (39%)
NI11	2.83 (1.52)	695 (40%)	361 (21%)	669 (39%)
NI12	2.93 (1.50)	755 (44%)	346 (20%)	624 (36%)

Table 3. Aggregated survey response of students ($N = 1725$)

The mean of answers for System use fluctuates from 2.30 (SU7) to 3.96 (SU2). The highest standard deviation was reported for item SU3 (1.53) regarding the organization and publication of students' work via ePortfolio. In the satisfaction category, item US5 has the highest mean value of 2.84 and US3 the lowest (2.73).

Items NI6, NI1, NI7 and NI12 have the highest mean values of 3.02, 2.95, 2.94 and 2.93, respectively. The lowest mean value is reported for NI3 (2.81). Although, there are many items that students disagree with, here we will single out items with a higher percentage of positive responses – SU2, SU3, SU4, NI1, NI3, NI4, NI6, NI7, NI9, NI11 and NI12.

The Pearson correlation coefficient is calculated for variables across three constructs and results are interpreted according to Evans [21]: 0.00 - 0.19 (very weak), 0.20 - 0.39 (weak), 0.40 - 0.59 (moderate), 0.60 - 0.79 (strong) or 0.80 - 1.0 (very strong). The significance of correlations among the variables is tested at $p < 0.01$.

In Table 4, there is a very strong and significant relationship between SU1 and US1 ($r=0.86$; $p < 0.01$) indicating that students who like to use the platform would like to use it in the future as well. Variable SU2 has weak, although significant relationships ($p < 0.01$) with all the other satisfaction variables. Although the correlation between SU1 and US3 is fairly large, it is not significant ($p > 0.05$), so there is a high chance this relationship does not exist in the population. All other relationships in Table 4 are moderate to strong and significant ($p < 0.01$).

	US1	US2	US3	US4	US5
SU1	0.86	0.76	0.80**	0.67	0.74
SU2	0.26	0.32	0.30	0.34	0.34
SU3	0.60	0.63	0.64	0.58	0.63
SU4	0.48	0.53	0.51	0.47	0.53

SU5	0.58	0.60	0.60	0.54	0.62
SU6	0.66	0.66	0.67	0.60	0.68
SU7	0.60	0.60	0.60	0.54	0.60
SU8	0.62	0.63	0.60	0.54	0.60

Notes. All correlations are significant at the 0.01 level (2-tailed); **except between the variables SU1 and US3. Bold correlations are considered 'strong' or 'very strong'.

Table 4. Correlations between System use (SU) and User satisfaction (US)

In Table 5 there are numerous moderate to strong and significant relationships (r between 0.40 and 0.79; $p < 0.01$). Variable SU2 has only one moderate and significant relationship with the NI1, while all others are weak (r between 0.29 and 0.39), but significant.

	SU1	SU2	SU3	SU4	SU5	SU6	SU7	SU8
NI1	0.71	0.41	0.67	0.56	0.64	0.69	0.61	0.59
NI2	0.74	0.30	0.63	0.55	0.65	0.71	0.65	0.67
NI3	0.70	0.35	0.65	0.56	0.68	0.75	0.64	0.65
NI4	0.67	0.30	0.61	0.48	0.61	0.68	0.59	0.60
NI5	0.68	0.29	0.59	0.49	0.63	0.68	0.62	0.60
NI6	0.67	0.39	0.62	0.54	0.62	0.67	0.58	0.58
NI7	0.64	0.39	0.61	0.51	0.59	0.65	0.59	0.56
NI8	0.65	0.31	0.60	0.51	0.60	0.66	0.59	0.61
NI9	0.72	0.36	0.66	0.57	0.66	0.72	0.67	0.64
NI10	0.68	0.34	0.65	0.54	0.65	0.70	0.65	0.64
NI11	0.75	0.31	0.63	0.54	0.62	0.71	0.64	0.64
NI12	0.71	0.39	0.64	0.55	0.61	0.68	0.62	0.63

Notes. All correlations are significant at the 0.01 level (2-tailed). Bold correlations are considered 'strong' or 'very strong'.

Table 5. Correlations between System use (SU) and Net impacts (NI)

4.2. Measurement Models

PLS-SEM is adopted in this study to estimate the reliability and validity of obtained data as shown in Table 6. In a measurement model, almost all loadings were above acceptable 0.70 which suggests that the construct explains more than 50 percent of the variance of a given indicator [20]. The exception was indicator SU2 with the loading of 0.39 which is dropped from further analysis. Internal consistency reliability of each latent variable is measured in terms of Cronbach's Alpha (CA) and Composite Reliability (CR). The results of latent variables were higher than 0.70 in both cases which is a preferred cut-off for reliability [20]. The convergent validity was estimated with Average Variance Extracted (AVE) which should be above 0.50 to be acceptable [22]. In this study, the AVEs ranged from 0.57 to 0.76 showing that the most variance is captured by User satisfaction indicators.

To ensure the discriminant validity of the measurement models, the Heterotrait-Monotrait criterion (HTMT) was applied [23] and shown in Table 7. The HTMT criterion indicates that all variables are distinctively different at 0.90 as a targeted limit

acceptable. All values are below the determined threshold beside User satisfaction which is on the borderline with the value of 0.90 and therefore the bootstrapping procedure was taken as suggested by Hair et al. [22]. The re-assessment showed that the HTMT confidence intervals (97,5%) do not contain the value of one which would indicate the lack of discriminant validity. By that, we can conclude that the variables are appropriately distinctive from one another, and discriminant validity is established.

Latent Variable	Indicator	Loading	Internal Consistency Reliability		Convergent validity
			CA	CR	AVE
System use	SU1	0.75	0.88	0.90	0.57
	SU3	0.75			
	SU4	0.70			
	SU5	0.75			
	SU6	0.81			
	SU7	0.77			
	SU8	0.76			
User satisfaction	US1	0.88	0.92	0.94	0.76
	US2	0.88			
	US3	0.90			
	US4	0.82			
	US5	0.88			
Net impacts	NI1	0.81	0.95	0.95	0.63
	NI2	0.84			
	NI3	0.84			
	NI4	0.76			
	NI5	0.74			
	NI6	0.80			
	NI7	0.77			
	NI8	0.75			
	NI9	0.80			
	NI10	0.79			
	NI11	0.84			
	NI12	0.81			

Table 6. Convergent validity and reliability.

Variables	Net impacts	System use	User satisfaction
Net impacts			
System use	0.89		
User satisfaction	0.90	0.85	

Table 7. Discriminant validity following HTMT.

4.3. Structural Model

The structural model represents (inner) relationships among constructs [24]. First, the predictor constructs, System use and User satisfaction, were examined for the Variance Inflation Factor (VIF). Results in Table 8 have not found any collinearity issues given that the cut-off value of three has not been exceeded [22].

Variables	Net impacts	System use	User satisfaction
System use	2.51		1.00
User satisfaction	2.51		

Table 8. Inner VIF values.

Next, the coefficient of determination for endogenous variables (R^2) and their predictive relevance (Q^2) were estimated to interpret the explanatory power and predictive accuracy of the structural model [20].

The R^2 of 0.67, 0.33 and 0.19 are considered substantial, moderate and weak, respectively [25]. Table 9 shows acceptable R^2 values meaning that 78 percent of the variance in Net impacts is explained by System use and User satisfaction, while 60 percent of the variance in User satisfaction is explained solely by System use. Regarding Q^2 in Table 9, the cut-off values of 0, 0.25 and 0.5 explain a small, medium, and large predictive accuracy of the paths in the model [20]. Obtained results suggest medium predictive relevance of exogenous constructs on the associated endogenous constructs.

The effect size (f^2) of 0.02 signifies a small effect, 0.15 a medium effect, and 0.35 a large effect [22]. Table 10 shows that System use on Net impacts has a medium effect, while User satisfaction has a large one. However, the largest effect has System use on User satisfaction.

The structural model with results shown in Table 11 and Figure 2 is significant for all three hypothesized paths with a p-value less than 0.01.

Variables	R^2	Results	Q^2	Results
Net impacts	0.78	Substantial	0.49	Medium
User satisfaction	0.60	Moderate	0.46	

Table 9. R^2 and Q^2 of endogenous latent variables.

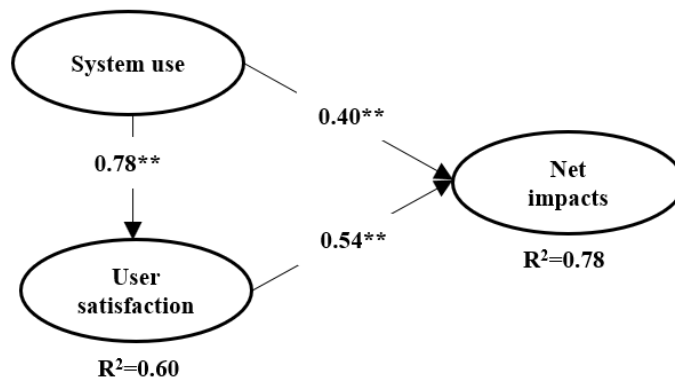
Variables	Net impacts	System use	User satisfaction
System use	0.29		1.51
User satisfaction	0.52		

Table 10. The f^2 effect sizes.

Hypothesized path	Standardized coefficients (β) ^a	SD ^b	t-values ^c	p-values ^d	Result
H1. System use $\rightarrow$ User satisfaction	0.78**	0.01	68.82	0.00	Supported
H2. System use $\rightarrow$ Net impacts	0.40**	0.02	16.41	0.00	Supported
H3. User satisfaction $\rightarrow$ Net impacts	0.54**	0.02	22.19	0.00	Supported

Notes. ^a Bootstrapping(c) with 5,000 samples (two-tailed test); ^b Standard deviation (SD); ^c $t > 1.96$ (sig. level=5%); ^d ** $p < 0.01$.

Table 11. Summary of the structural model and hypotheses testing

Figure 2. Structural model (** $p < 0.01$)

4.4. Importance-Performance Map Analysis

To complement PLS-SEM results and reported path coefficients, we have used the importance-performance map analysis (IPMA) [22]. Additionally, it helped to explain the impact of exogenous constructs, namely – System use and User satisfaction, on the target construct, Net impacts.

Table 12 revealed that System use has a stronger total effect (a sum value of indirect and direct effects) over the Net impacts than User satisfaction. However, their performance values are the same. Figure 3 shows an importance-performance map divided into four quadrants which are determined according to Streukens et al. [26].

The mean value for the x-axis (importance) is 0.50, while the value of 50 is a midpoint of the 0-100 range for the y-axis (performance). The first quadrant comprises System use and that is interpreted as ‘keep up the good work’. However, User satisfaction is in the middle of the first and fourth quadrant which is labelled as ‘possible overkill’. Nevertheless, both predecessors have lower performance, but the

System use would have priority over User satisfaction for improvement because of its high importance for Net impacts.

Predecessor construct	Importance (Total effects)	Performance
System use	0.92	54
User satisfaction	0.50	54

Table 12. Summary of the IPMA for Net Impacts.

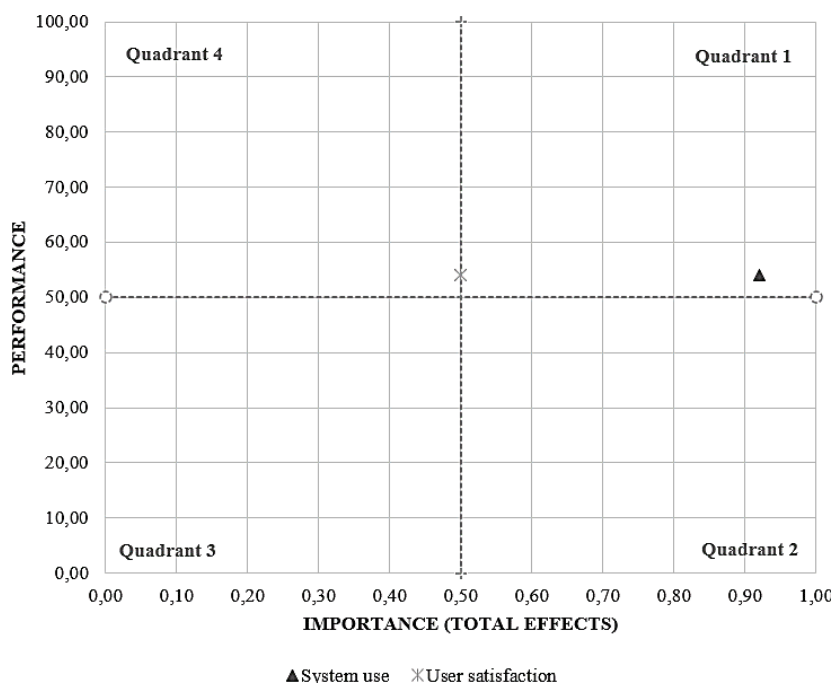


Figure 3. Importance-performance map of predecessor constructs

5. Discussion

Research results indicated that students were in general satisfied with the platform possibilities. They have mostly used the platform for teamwork purposes, and less to track the progress of their peers which may be one of the proofs that they are not as competitive as it is naturally assumed. Students recognized that the CRISS DC platform can help them to develop new skills such as making presentations, sharing their work, finding information on the Internet, communicating online, etc. Moreover, they claim it helped them to be more creative in solving the tasks. On the other hand, students did not seem to be especially motivated by earning badges within the platform. This can be due to different implementations of a digital competence acquisition across schools. Some schools only implemented one sub-competence

scenario to try out the platform, so students and teachers might have not seen the real purpose of badges which was to efficiently track the progress across a variety of sub-competences. However, the digital competence acquisition and the platform are intended to be used throughout several grades/years which means that the final digital competence certificate could be earned throughout one, two or even three years within the formal curriculum, depending on the subjects in which DC assessment is integrated, number of scenarios, etc.

All these results consistently support the fact that a lot of research is needed in the field of implementing digital competences in the education of primary and secondary school students, as well as the tools that would support it.

Using Pearson's correlation when observing the relationship between students' use of the CRISS DC platform and their satisfaction, we did not find a statistical significance between students' decision to continue using the platform again in the future and whether they consider it to be interesting to use. On the other hand, their decision would be impacted by whether they like using the platform, found it useful for learning or feeling confident and satisfied while using it. Also, they would use ePortfolio for organizing and publishing their work because they have found it interesting. Furthermore, they can use the CRISS DC platform to tag their work and this seems like a satisfactory possibility. Overall, the platform gives them proper feedback which they like, consider useful, interesting and it boosts their confidence. It is interesting to observe that seeing the progress of their peers did not have a significant impact on their confidence which is in line with the previously stated findings on student competitiveness. The same conclusion is derived for their communication with teachers – it did not boost their confidence.

The correlation analysis of students' use of the CRISS DC platform and its impact on their work again confirmed some major findings such as the need to creatively express themselves and get proper feedback for it. Furthermore, students' decision to reuse the platform in the future would be impacted by all twelve listed net impacts, but the strongest ones are listed here: usefulness of spending time on the platform, easier learning, more attractive way of presenting solved tasks, insight into the process of solving the tasks, and others. Results confirmed that a possibility of tracking progress and achievements within the CRISS DC platform is making students' learning easier. Knowledge of what they have achieved in real-time gives them a sense of useful utilized time. Findings also confirmed the significant relationship between communication with teachers via the platform and students' easier learning.

Overall, students perceived the platform helpful in developing new skills and they could easily understand how their work is being assessed. Furthermore, they were able to be more creative in solving the tasks. On the other hand, students less considered earning badges as essential to their motivation to use the platform.

6. Conclusion

This investigated the relationship between user satisfaction, system use and net impacts of cloud-based infrastructure for acquisition, evaluation and certification of digital competence in primary and secondary education focusing on students'

perspectives. According to our knowledge, the CRISS DC platform is the first attempt to create a comprehensive, cloud-based solution for digital competence acquisition, evaluation and certification in Europe, and to pilot such a solution within a formal curriculum of primary and secondary schools in six European countries.

The PLS-SEM analysis found the proposed model to be reliable and valid for the assessment of students' satisfaction, their use of the CRISS DC platform and their success. All hypothesized relationships were statistically significant supporting the proposed model.

It can be concluded that student confidence is a result of being able to check self-progress and achievements in real-time. It can also impact their decision to use the system again in the future. Whether they have the necessary equipment to use the platform will not affect their satisfaction because most of them have optimal requirements at school. The use of educational platforms can be improved if students consider it useful for their learning and if it has satisfactory possibilities. Future studies should analyse which possibilities students liked the most and practitioners could implement it as a baseline in future platforms.

Students' decision on whether they will use the system in the future greatly depends on how the platform contributes to the success of their learning processes, and not their direct satisfaction.

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A Mobile Based Pharmacy Store Location-aware System

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Abstract

This paper presents a formulated mobile-based location-awareness model that was implemented into a Location-awareness System (L-aS hereafter) for finding the pharmacy location where prescribed drugs and their prices are available for sale. The scenario that inspired the model formulation was formalized using the unified modeling language. The model was implemented within the android studio integrated development environment with the L-aS database created through SQL lite database. The system was tested using user experience based testing technique. Based on core system performance testing, the system demonstrated a normal response time, resource utilization (i.e. storage and memory usage), and data use potentials of 414.6ms, 4.964mb and 1.9116 kb/secs, and 3.0296mb respectively. Therefore, the system performed well under ordinary conditions as an android application running on small memory devices. The study concluded that the developed mobile based pharmacy store location-aware system was useful to provide information to purchase prescribed drugs especially in perplexed situation(s).

Keywords: Location-aware system, location-based services haversine algorithm, performance evaluation, user experience, ICT

1. Introduction

The contribution of Information and Communication Technology (ICT) to human development in the modern world is unquantifiable. ICT has tremendously improved the ability of man to use environmental elements to influence what happens around them positively. In real-time, it is now possible to use ICT to make informed decisions that can avert danger and improve the quality of human life [1, 2]. As of now, the health sector has benefited immensely from ICT's use to assist in decision-making

processes [51, 52]. During emergencies, medical doctors would usually prescribe drugs for quick intervention in patients' health. The de facto standard is to get the drug from the hospital's pharmacy [6, 14]. Patients will need to get the drug from a retail pharmacy store outside the hospital complex when this is not the case. A severe challenge emerges if the prescribed drugs are not readily available nearby. The only option is for patients to transverse several pharmacy stores without guaranteeing the availability of such drugs. This challenge may appear quite simple. However, this could often be cumbersome and energy-sapping for many patients if they have to go far to get the drug right at that moment in time. Cases of this nature are widespread in developing countries, often leading to morbidity [3, 4].

It is often the case to find patients with terminal diseases such as hypertension, diabetes, cancer, etc that for the rest of their life require the regular use of medications being victims of the circumstances thus described. Patients' health condition in this situation often develop complications when the drug(s) they need per time is either not available or when available; they are just hard to get. It could be disastrous - a consequence no one wishes to have - when patients have limited or no access to medication(s). This unavoidable constraint can result in premature death. The Internet - an ICT based solution-oriented technology, has been shown to improve healthcare accessibility and delivery to even remote areas seamlessly. However, in developing countries like Nigeria, it has not been explored to mitigate the challenge of uncertainty in seeking prescribed drugs, particularly in the case of an emergency. The growing and unprecedentedly large number of ICT-Internet savvy individuals (e.g., in Nigeria [22]) makes it overarching to embrace ICT-based solutions to mitigate uncertainty at the point of making a critical life decision, which must be right. It is no gainsaying that the citizens' standard of living of any nation on earth could improve through ICT-Internet-based technologies. These technologies are retrofittable with immense disruptive potentials to improve things [53]. As the world enters the post-COVID-19 Era, it is imperative, and now a matter of urgency, to seek ICT-based solutions to maintain social distancing and reduce physical contact.

This paper, therefore, considering the potentials of using ICT to benefit humans, formulated a model with computational properties that precisely determines the location of a pharmaceutical store. Information about the prices of drugs and the distance from where a patient is to the pharmacy store where prescribed drugs can be found and bought can be known by using the implemented system. This ICT-based solution could help users reduce the number of physical contacts they make before locating the exact pharmacy where drug purchases can be made. The possibility of using ICT based solutions to guide users in an uncertain situation has been reported in the literature [24]. However, the possibility of making less physical contact, which the new normal arising from the post-COVID 19 era demands [51] when using the reported system, was not addressed. This paper is structured as follows with the related literature found in Section 2, and the theoretical framework and conceptual model design presented in Section 3. The paper's methodology, result and analysis, and conclusion are in Sections 4, 5, and 6.

2. Related Literature

2.1. Location Aware System, Wireless Application Protocol, and Services

The literature is replete with studies on location awareness with a particular focus on wireless application protocol enabled mobile devices. As shown in Table 1, research efforts that include the Internet of Things (IoT), search engines, etc are part of these location-based studies. For instance, the pager system [5, 6, 9] is an old application that provides the method to address personnel location problems conventionally. To locate personnel from a central facility, signal(s) is sent out that address a precise receiver unit. The expectation is for a number to be displayed to which a recipient could reach the sender back. The requirement that may be necessary for other systems is the reception of vocal messages transmitted to a number to call back. It was also possible for recipients to call back using the conventional telephone system to confirm a signal and provide a suitable response. In game-based scenarios, some other research interests focused on enabling user interaction. This focus found relevance in the context-aware situation of storytelling and gaming, where contextual content was realised based on the state of an application and the user [7].

Location-awareness is not new in the gaming context [7, 53]. Game-based scenarios with commercial intention have applied multi-player network gaming strategies. These strategies allow players to exchange plays, engage other players as enemies, and simultaneously track each other within the same virtual space [53]. Shimadar et al. in [8] proposed a system that assists medical doctors in selecting the right first-line drugs. The system was specialist-centric and was not helpful for patient-centric prescriptions. In Mathkour [9], a service locator system that uses a GPS-based mobile support system allowed individuals to locate services of interest and their corresponding addresses irrespective of their profession. Worthy of note is that the system could determine the distance proximity between users and the desired locations where services are needed. The system was extendible and flexible in that with ease, additional mobile service providers that are new are easily incorporated. Compared to GPS-enabled devices that are not mobile-based, the service locator system demonstrated the provision of more accurate location computation.

In the research work of Bao and Jang [10], a medicine-based recommender system was designed and implemented. The system used a support vector machine technique that outperformed existing Neural networks and ID3 decision tree techniques. A good trade-off was observed among model accuracy, efficiency, and model scalability. The work also proposed a mistake-check mechanism that ensures accurate diagnosis and service quality. In a very closely related work, a haversine model was developed to discover the location of laundry kiosk(s). These kiosks are domestic service providers [11]. Similarly, Nurizal et al. [12] designed a haversine based model that finds the best route for urban transportation. In [11] and [12], the haversine technique was implemented such that using them to find the distance between a user and the nearest place when the need arises was not possible. However, in this paper, the focus is on determining the nearest distance between users of the L-aS and a pharmaceutical store where prescribed drug(s) can be purchased.

Some Research Effort in L-aS	Type of L-aS provided	Technique(s) Employed	Other Contributions	Comment	Cite
IoT-Aware System for the Monitoring of the elderly	Support geriatricians for the early detection of Mild Cognitive Impairment & Frailty conditions	RDA and other ensemble of statistical, knowledge engineering and MLA	System Architecture; Personal Data Capturing System; performance analysis	L-aSs is useful for emergency situation by providing location information regarding Distance & other Con-textual In-formation	[16]
Sensing Architecture that use IoT-Aware Technologies	Analyze the Elderly's Behaviour unobtrusively & prevent mild cognitive impairment and frailty problems	Inertial sensors; PDA ; wearable device/ user's smartphone; BLE devices	SPM ; Sensing Architecture		[17]
Location-aware Outpatient Support using Mobile App	Examined factors that influence the willingness of counsellors to use location -aware services for outpatient support	Survey Methodology	Examined location-based reminders; identified factors of influence	Gave knowledge about factors that influence Acceptance	[18]
Circle Distance Model for Locations on non-Flat Surfaces	Determine the distance b/w two locations on a non-flat surface for determining closest location	Researched with Haversine Algorithm	Graphical visualization of Calculated Distances	Gave insight on the use of longitude and latitude for determining locations	[19]
A Search Engine Location-Aware System	Location-Aware Information Detection & Extraction from web pages	Rule-based Algorithm that Uses web page Structures	Framework with L-A ability; T-MA ; Identified components for building L-ASE to D&ELI	Inspires implementation of framework	[20]
NOTE: L-aS (Location-aware System); WAP (Wireless Application Protocol); IoT (Internet of Things); RDA (Risk Detection Algorithms); MLA (Machine Learning Algorithms); PDA (Position Detection Algorithm); BLE (Bluetooth Low Energy); SPM (Stability Period Mechanism); L-A (Location-Aware); T-MA (Text-Matching Algorithm); L-ASE (Location-Aware Search Engine); D&ELI (Detect and Extract Location Information); L-ASS (Location-Aware Systems)					

Table 1. Summary of other research efforts in L-aS aside from the use of WAP

Generally, mobile computing comes with the challenge of maintaining the awareness of locations [53]. Location awareness is thus an irrefutable attribute. Among many studies in the literature regarding location awareness, no known study has combined location findings with the availability of drugs in the database to help patients become aware of where drugs are available. This study fills this gap using the haversine technique to assist patients (i.e. users) to know whether a particular drug is available in a pharmaceutical store. Information about the cost of the drug(s) a user needs and the distance between the user's location and the pharmacy where the drug(s) are available for purchase is provided by the proposed LaS before the user ventures out. In case of emergency, patients or their relation(s) will not need to figure out by themselves the pharmacy store within their locality that has the drugs they need. With the use of the LaS, users will not need to rigmarole from one pharmacy store to another in search of drugs. The distance provided by LaS to users will help them know exactly

where to go and make their drug purchases, and they are also able to make decisions in terms of drug prices. In emergencies, the chances are that the farthest pharmaceutical store in terms of distance sells in prices that fit people's budgets. In this case, an informed decision can be made to buy in the closest pharmacy store as a trade-off for saving a life. This study provides an easy and convenient method to drug accessibility by patients, which is very germane in healthcare delivery [13].

2.2. Shortest Path Computation and Functional and non-Functional Requirements

The haversine algorithm has shown promise in finding the shortest path among several routes for location-aware guidance. In Mahmoud & Akkari [21], user location served as a yardstick to suggest the nearest location based on this algorithm. Other similar research (e.g., [23], [24], and [25]) show that the provision of accurate location information, judging by a significant reduction in navigation time, is hinged on two essential parameters - latitude and longitude coordinates - in the algorithm. Based on a Desk-based Literature Search (DLS), existing L-aS are implemented based on either functional or non-functional requirements. There are also instances where a mix of both requirements are known to guide the implementation of L-aS (e.g. [26, 27, 28]. Available in Table 2 is a summary of the DLS findings concerning the functional and non-functional requirements that guided the development of L-aS in the literature. The DLS findings conclude that the goal of an L-aS (is what) determines the functional and non-functional requirements that guide its development. Some of the literature search findings also show that the primary goal-oriented purposes of L-aS include using location-based data within a time frame to locate nearby facilities where services are available. The other found design goals were the conduction of route search, the provision of trail experiences, sharing location-based information within a social network, enabling shoppers to re-discover their proximities to what they want, etc [19, 24].

In order to satisfy L-aS goal-oriented purpose, the concept of valence has been relevant. This concept is a novel way of abstracting and fusing functional and non-functional requirements to enhance the service delivery and performance of L-aS [28, 29]. In Philips et al. [30], this practice was used to enhance the performance of an outpatient L-aS. Similarly, in Yew et al. [24], the functionalities to help search and record experience were critical components of the proposed L-aS. Users' experiences going by their report showed heritage and tourism trail experiences and serendipity were supported. Route search by calculating distances to suggest the shortest path between two locations has been of high priority, along with the provision of visualisation experiences in L-aS. These functional considerations provided the support users needed to figure out distances on non-flat surfaces, as shown in the research work of Prasetya et al. [19]. Recent debates in the literature are about the knowledge and understanding that valence of requirements is necessary to implement important system features in L-aS [28, 29]. Therefore, to enhance the performance and service delivery of L-aS that met the user experience needs of users, non-functional requirements such as engagement, usability, privacy, positive appeal, user experiences

and satisfaction, and trustworthiness assessment have been considered in the literature [24, 28, 29, 30].

Identified Require - ments	Delineations	FR	n-FR	Citation					
				[43]	[40]	[44, 45, 20]	[46]	[47, 48, 49, 50]	[30]
Location and Time- Awareness	Signify the Possibility of Collecting Location Data, which is Time Bound	✓	✗	✗	✓	✗	✗	✗	✗
Modular System Design	Systematic approach to develop modules that are application- independent with tasks functionality that provides easy solution-pattern that are adaptable	✓	✗	✗	✗	✗	✗	✓	✗
Relevant Location Informati on	L-aS use this Information to adapt itself to Learn/be Aware of other Information	✗	✓	✓	✓	✗	✗	✗	✗
Scalability	It is about adding more data and improving database easily	✗	✓	✗	✓	✗	✗	✗	✗
Location PLan	This is information about nearby facilities or services	✗	✓	✓	✗	✗	✗	✗	✗
Contextua l Informati on	From this information; (i) entities associated to locations are easily identified; (ii) lead to new/additional facts and knowledge; and (iii) present more information to users' vis-à-vis their current position and location	✓	✓	✗	✗	✓	✗	✗	✗
Service Accessibili ty	Reveals if L-aS is easily available with QoS with profit provisioning service metrics	✗	✓	✗	✗	✗	✓	✗	✗
Usability	L-aS is Fit to use when personalization, search, location- &-orientation-aware services, location accuracy, portability, response time are present	✗	✓	✗	✗	✗	✗	✓	✗
Valence	(i) Is about the use of performance metrics - engagement, usability, privacy, cost to find positive intrinsic appeal to L-aS and (ii) it is also about ease of use, system usefulness, ease of understanding, trustworthy assessment	✗	✓	✗	✗	✗	✗	✗	✓
FR (Functional Requirement); n-FR (non-Functional Requirement); L-aS (Location-aware System); QoS (Quality of Service)									

Table 2: Summary of identified functional and non-functional requirements that has informed L-aS development

The justification for using a mix of functional and non-functional requirements stems from the finding that performance in terms of how systems meet their users'

information needs depends on the technical part of the system and how users value or perceive the system. A balance of these aspects of performance is needed. As enshrined in the literature, in this paper, a combination (i.e., a mix or a valence) of requirements - functional and non-functional - were considered during system implementation [24, 28, 29, 30]. Consistent with the valence concept, the first functional requirement to adopt was location specificity using distance as a determinant to make it functional to use users' mobile phone functionalities. For the second functional requirement - system interaction, the non-compromising of mobility was considered necessary, among other conceptions. This characterisation frame the context of implementation that aimed to promote the easy adoption of the prototype system.

In order to complete the valence criteria, two non-functional requirements - portability and response time- were also considered. It was observed that the locals in the study area use mobile phones. This usage context implied that mobility was a primary concern to the locals. This understanding invariably shows that portability was a non-functional requirement to consider. Secondly, information about the location(s) where drugs are available for purchase was essential in light of the goal of the L-aS. As such, the location information must be displayed as promptly as possible with a very short (or fast) display rate. This attribute was considered critical because users do not have to spend hours finding the nearest distance (or the shortest part) to where drug purchases can be made when using the prototype L-aS. This consideration made this research work consistent with the general philosophy of L-aS that highlights response time in terms of fast display rate. This metric is thus essential to characterise the performance of L-aS systems and determine their value.

3. Theoretical Framework and Conceptual Model Design

This section presents the frameworks, both theoretical and conceptual that guided the model design, as shown in subsections 3.1 and 3.2 respectively.

3.1. The Theoretical Framework

The model uses Haversine (H_θ) formula to compute the shortest path between point A and point B on a sphere using latitude and longitude along the surface [11, 19]. The H_θ is expressed as trigonometric function:

$$H_\theta = \sin^2\left(\frac{\theta}{2}\right) \quad (1)$$

The H_θ of the central angle d is calculated by

$$d = H_\theta ((\beta_2 - \beta_1) + \cos(\theta_1)(\cos\theta_2)H_\theta(\varphi_2 - \varphi_1)) \quad (2)$$

Where H_θ is the haversine, r is the radius of the earth approximately 6371 Km, d is the distance between two points β_1 and β_2 and latitude of the two points φ_1 and φ_2 .

Applying the inverse of sine function, then

$$d = rhav^{-1}(h) = 2r \sin^{-1}(\sqrt{h}) \quad (3)$$

The haversine computation may not give accurate distance due to the fact that the earth is not a perfect sphere. But, the estimate it gives is very useful for this application. The difference between the real value and the estimate is very negligible, therefore it was ignored in the computation of the distance. It was also observed that the ratio of the variation is not constant. This depends on the distance and some other factors, which is not part of this work. In this paper, the angle used by haversine algorithms comes from the position on latitude and longitude which is θ and ϕ respectively. This latitude are lines that run from west to the east and are parallel to the equator while longitudes are parallel to the prime meridians and converged at the pole. It was important to clarify this, since latitude increases from 0^0 to 90^0 as movement goes to the north or south, and then since they are also the instruments that help to determine the precise location of any point on the earth's surface, which this paper leverages.

3.2. The Conceptual Model Design

The conceptual design of the system assumes that all the Pharmaceutical stores that are available are currently connected into the Internet and that their products are digitized and stored in the database, which is connected to the Internet. This design is presented as shown in Figure 1 as follows.

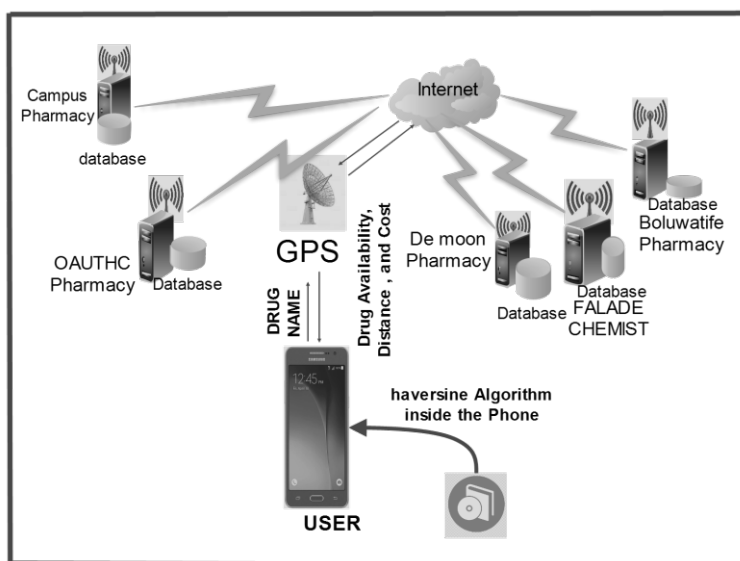


Figure 1. System Architecture

The system design used five pharmaceutical stores that are located within the study area - Ile-Ife and their position on the Latitude and Longitude as presented in Table 3. Each of the stores is expected to be connected to the Internet. All the pharmaceutical products in each store are expected to be digitized and stored in a database connected to the Internet. The haversine algorithm was developed using the haversine theoretic.

This theoretic has earlier been presented as a theoretical framework (see equations 1 – 3 above). It is this formalisation that was transformed into the android-based prototype application - L-aS. The application in a smart phone will get connected to the Internet through the Global Positioning System (GPS). Search will be possible to the database of the connected stores as shown in Figure 1 to provide information to the end users. If the medicine required by the end user is available in any of the store, the application will list the stores chronologically using the distance to the end user. The price of the product in each of the store and the distance to the user are provided for the user to make informed decision. This application solves the problem of running here and there when patients are in dare need of medicine for survival.

Name	Latitud e	Longitude
Campus Pharmacy	7.50669	4.56974
OAUTH Pharmacy	7.51854	4.52089
De moon Pharmacy	7.50078	4.5716
Falade Chemist	7.49249	4.55778
Boluwatife Pharamacy	7.5009	4.54998

Table 3. Latitude and Longitude of the Pharmacy Stores

4. Methodology

4.1. Haversine Model Formulation and Use

Whenever a user wants to check pharmacy locations, the haversine algorithm is called as a function to calculate the current (or new) position of the user and compares it with the location of the pharmacies where prescribed drugs are available. The algorithm, which performs the haversine function is as shown in Algorithm 1. It computes the shortest distance using the latitude and longitude parameters in Table 3.

Algorithm 1: Outline of procedure to use CDD

```

1: function:
2:   haversineGreatCircleDistance ($latitudeFrom,
3:   $longitudeFrom, $latitudeTo,
4:   $longitudeTo, $earthRadius = 6371000)
5:   {
6:     convert from degrees to radians
7:     $latFrom = deg2rad(floatval($latitudeFrom));
8:     $lonFrom = deg2rad(floatval($longitudeFrom));
9:     $latTo = deg2rad(floatval($latitudeTo));
10:    $lonTo = deg2rad(floatval($longitudeTo));
11:    $latDelta = $latTo - $latFrom;
12:    $lonDelta = $lonTo - $lonFrom;
13:    apply Haversine formula

```

```

14:      $angle = 2 * asin(sqrt(pow(sin($latDelta / 2), 2) +
15:      cos($latFrom) * cos($latTo) * pow(sin($lonDelta / 2),
16:      2)));
17:      convert result to kilometre
18:      $result = (($angle * $earthRadius) / 1000);
19:      return the result of the haversine algorithm
20:      return round($result, 2);
22:  }

```

* CDD (Coordinates to Determine Distance)

For better result, every time the system receives a GPS update from a user location the technique outlined in Algorithm 2 is called. As a result, distance, pharmacy latitude, and pharmacy longitude variables are called persistently by this method. With this arrived at, it was necessary to implement location awareness and the technique in Algorithm (procedure) 3 made this possible.

Algorithm 2: Outline of update procedure to use raw GPS data

```

1:  UpdateDistance (lat, lon):
2:    if current_lat != null && current_lon != null:
3:      distance += haversine (pharmacy_lat,
4:      pharmacy_lon, current_lat, current_lon)
5:      current_lat = lat
6:      current_lon = lon

```

Algorithm 3: LA procedure to determine the location of a user and PS

```

1:  //Location awareness
2:  function watchLocation (successCallback, errorCallback)
3:  {
4:    successCallback = successCallback || function() {};
5:    errorCallback = errorCallback || function() {};
6:    Get geolocation.
7:    var geolocation = navigator.geolocation;
8:    if (geolocation) {
9:      Check for a real geolocation service.
10:     try {
11:       function handleSuccess(position) {
12:         successCallback(position.coords);    }
13:       geolocation.watchPosition(handleSuccess, errorCallback, {
14:         enableHighAccuracy: true,
15:         maximumAge: 0, // 5 sec.
16:         timeout: 10000
17:       });
18:       Report error in getting location
19:     } catch (err) {
20:       errorCallback();    }
21:     } else {
22:       errorCallback();    }
23:     Co-ordinates detected (latitude and longitude)

```

```

24:         function init() {
25:             watchLocation(function(coords) {
26:                 document.getElementById('latitude').value = coords.latitude;
27:                 document.getElementById('longitude').value = coords.longitude;
28:             }}, function() {
29:                 init();}

```

*LA (Location Awareness); **PS (Pharmacy Store)

The mobile-based pharmacy store L-aS is named “Pharmfinder”. It was developed to reduce the stress of users/customers going to several pharmacy stores before getting to know a particular pharmacy store where the prescribed/required drug is available. The system is meant to tell the user if a particular drug is available, which pharmacy has such drug and the closest pharmacy to the current location of the user. The steps to follow for a customer using the proposed system are as follows:

- (i) The user must ensure location icon is turned on before launching the application
- (ii) Type or Key-in the drug name into the textbox and click on search
- (iii) A list of related drugs, prices and pharmacy stores are shown and the user checks which one is preferable
- (iv) The user now gets direction to the selected pharmacy.

The system administrator follows the following steps to register/add a pharmaceutical store:

- (i) Open the Pharmfinder application
- (ii) Select switch app to Administrator
- (iii) Username and password based on the registration from the superadmin is entered
- (iv) The drugs, prices and description can then be added to the application by the administrator.

The opening user interface developed for the registration of a pharmaceutical store is shown in Figure 2 as follows:

The screenshot displays the 'PharmFinder Admin Dashboard' with a section titled 'Add Pharmaceutical Store'. This section contains a form with the following fields:

- Name:** A text input field with placeholder text 'Enter pharmaceutical store name'.
- Address:** A text input field with placeholder text 'Enter address, city, state'.
- Phone:** A text input field with placeholder text 'Enter phone number'.
- Latitude:** A text input field with placeholder text 'Enter latitude'.
- Longitude:** A text input field with placeholder text 'Enter longitude'.

Figure 2. Opening page for super-admin to register interested pharmacies

4.2. System Implementation

The Knowledge of the type of phones those in the study area (i.e. locals) uses was important. This informed the choice of android base smart phone technology for the system implementation. Both functional and non-functional software requirements provided the foundation for the prototype development of the L-aS. The non-functional requirements provided support in the area of ensuring that quality assurance as a service-based system requirement was met. These non-functional software requirements served as constraint (or quality) attributes following the operations of the system to gauge its success as perceived by its users. This decision is consistent with the provisions in the literature [31, 32, 33] that the use of functional and non-functional requirements guarantees the success of the L-aS. In Table 2 functional and non-functional requirements were identified with the caveat that the non-functional requirements that is adopted depends on the functional requirement or the goal of the system in question. To this end non-functional requirements that portends location, usability and users valence towards the use of the L-aS (hereafter used interchangeably with PharmFinder) were enforced.

Based on the requirements proposed earlier, a resultant user friendly mobile application (app) with versatile functionality was developed in Java with a sample user interface of the system shown in Figure 3. The backend was set up following the practice in [34] and [35] that support the use of real-time Database (Db). Therefore, the My Sequential Query Language (MySQL), which is a real-time Db and suitable for location-based technologies were used to setup the backend of the prototype L-aS. This made it practicable to cloud-host the backend database for remote location and synchronised real-time connection to client - user interaction.

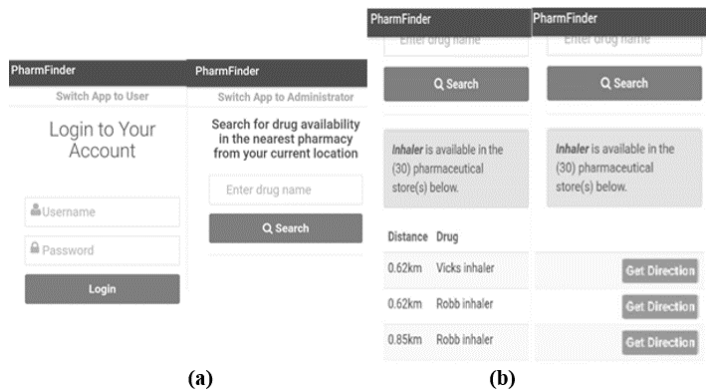


Figure 3. Developed interface to interact with the mobile app (i.e. PharmFinder)

Purposefully, when users of the L-aS sign-up, they receive unique user ID. This made it easy to store and retrieve the data that belongs to specific users. Every pharmacy's latitude and longitude along with their names, and address were collected, and the database of the prototype system was designed to be updated regularly with what is available in a particular pharmacy. The backend view of the proposed system

is that of a database created using MySQL. The database contains two tables which are the `pharmacy_stock` table and the `pharmacy_user_drug` table (see Snippet in Figure 4). In the `pharmacy_stock` table, what is found is the `stock_id`, `pharm_id`, `drug_name`, `drug_price`, `drug description` – the status and the date added. Additionally, the `pharmacy_users` table contains `user_id`, `role`, `username`, `password`, `pharmacy_name`, `phone_no`, `address`, `longitude`, `latitude` and `date_added`. While the `pharmacy_stock` table shows the details for each pharmacy such as pharmacy names and location through addresses, the `pharmacy_userdrug` table shows all kind of drugs in a pharmacy. The database was hosted in the cloud for the purpose of the experiment and for future use and support for all access from remote location. The prototype system used the Internet for testing and to show its workability.

pharmacy_stock table

arch

Insert

Export

Import

Operations

Triggers

[Edit inline][Edit][Create PHP code]

Show all

Number of rows: 25

Filter rows: Search this table

Sort by key: None

Options

←T→

▼

user_id

role

username

password

name

phone

address

info

latitude

longitude

date_added

☐

Edit

Copy

Delete

1

admin

admin

admin

Administrator

09876556778

NULL

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NULL

NULL

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Edit

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5

pharm

central

central

CENTRAL PHARMACY OAUTHC

0812345678

CENTRAL PHARMACY OAUTHC, Ife, Nigeria

7.506689

4.569744

07-02-2019

☐

Edit

Copy

Delete

6

pharm

demon

demon

DE MOON PHARMACY

081200987

DE MOON PHARMACY, Ife, Nigeria

7.500781

4.571603

07-02-2019

pharmacy_userdrug table

SQL

Search

Insert

Export

Import

Operations

←T→

▼

stock_id

pharm_id

name

price

description

status

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18

5

10% Dextrose Water

195

Liquid

1

☐

Edit

Copy

Delete

19

5

10cc Syringes and Needles

2633.8

Solid

1

☐

Edit

Copy

Delete

20

5

20 cc Syringes and Needles

3455.4

Solid

1

☐

Edit

Copy

Delete

21

5

4.3% Dextrose Saline

195

Liquid

1

☐

Edit

Copy

Delete

22

5

5% Dextrose Saline

140

infusion

1

☐

Edit

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Delete

23

5

5% Dextrose Water

185.25

infusion

1

Figure 4: Snippet of pharmacy stock and user_drug tables

4.3. Experimentation

Going by the literature [39], when systems behavior is observed in practical sense (i.e. scenario) that is when the reliability of a system in terms of expected service delivery can truly be justified. To comply with this the experimental setup for the system operation in subsection 4.3.1, the user experience testing in subsection 4.3.2, and performance evaluation in subsection 4.3.3 are presented as follows.

4.3.1. System's Operation

To set up the experiment a smart phone with android version 2.3.4 as the minimum requirement though was provided and used. The android operating system was chosen for the experiment since the majority of the locals use android-based phones. This was why Android Studio integrated development environment was set up and used for the experiment. A public server within the university hosted the database that the android

phone with GPS enabled functions interacted with. This experiment was performed on an android phone, which version was stated earlier with the experimental app written in Java (i.e. the mobile app. stated earlier) and developed for the android mobile phone operating system, which version is stated above. In this process, the haversine implemented in the app (i.e. PharmFinder) was applied to perform its function of distance calculation using parameters from the Db. This process successfully simulated the processes captured in the system architecture shown in Figure 1. The second part of the experiment was the testing to ensure that more than one user can use the technology. This is explained in the next subsection under user experience testing.

4.3.2. *User Experience Testing*

The User Experience Testing (UET) was carried out on the prototype system - PharmFinder. The UET involved randomly selected users who have used at least a mobile app before. They were drawn from among locals in Ile-Ife - a town in Nigeria that was adopted as the pilot study location. Armed with the questionnaire as a fact-finding technique, users' views of the system after use were elicited. This questionnaire was vetted by experts in the Department where the research was conducted and then hosted using Google form (G-form) for easy accessibility. The question in the hosted questionnaire was drawn from non-functional requirements to ascertain the quality of the system. System quality was delineated for the purpose of this evaluation as a system that assists users to find the location of drug availability. This was done to ensure that the user experience of users; that is their perceptions and responses, which resulted from their use of the system deliver the required services as prescribed in [36]. A total of eighty four (84) end users partook in the UET exercise. The 84 end-users installed the Pharm-Finder prototype system on their mobile phones from the local but public server facility stated earlier in subsection 4.3.1. A five point Likert scale of Strongly Agree (SA), Agree (A), Indifferent (I), Disagree (D) and Strongly Disagree (SD) with Likert points of 5, 4, 3, 2 and 1 respectively was engaged to present the question for rating. After using the prototype system (i.e. mobile app), the users were asked to fill the G-form, from which data was collected for the UET.

4.3.3. *System Performance*

To test the system performance two performance metrics: Response Time (ResTm) and System Resources Usage (SRU) were used as the performance indicators. These were system-based metrics. They were meant to show that the prototype system gave standard users' experience in terms of the amount of data that the system can process within a unit of time and show the extent to which the system will use available system resources. This approach is consistent with what is obtained in the literature [37, 38]. This is because as performance metrics, accurate description of end user's experience during system use can be proven [37, 38] through ResTm and SRU. This was possible using JMeter since its use minimised some inevitable effects. Many factors such as system reliability, user requirement and available capacity could have affected

ResTm. Therefore, ResTm was tested with SRU with available capacity and system resources (i.e. memory, data and storage usage) in mind. PharmFinder was installed on five different Android phones and ResTm and SRU of the system were observed based on the usage of system resources.

5. Result and Analysis

The existing drug purchase scenario described at the inception of this paper is fraught with uncertainty as captured in the formalism presented using the sequence diagram of the unified modeling language shown in Figure 5. This formalism highlights both the challenge of uncertainty that locals face regularly and the proposed solution and contribution of this research work. The solution is shown within the broken lines highlighted in red, which is the development of a prototype system - called PharmFinder – that helps users in uncertain situation. With the prototype system on their mobile phone it was possible to know the number of pharmacies in their locality with the drugs that are available for sale.

As shown in Figure 3b earlier, the prototype system was able to show the list of distances in terms of Kilometers (Km) and the drug(s) that are available after login in and using the system. By this the location in terms of distance between the pharmacies and users' location are known. The other location-awareness information that is available is the direction to the pharmacy where the drugs are available using the Get Direction button. This implementation was guided by the philosophy that uncertainty as a non-deterministic phenomenon will fizzle out in the face of knowledge (or information).

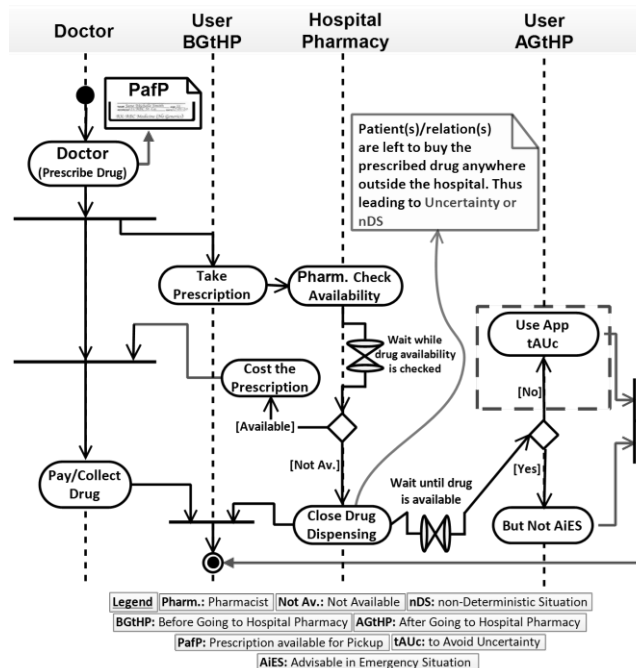


Figure 5. Reworked procedure of existing drug purchase

Hence, with these relevant information users’ uncertainty particularly in emergency situation were mitigated based on results from user experience testing. In non-emergency situations the prototype system was also found to be useful. Users’ time and money were saved. The usual wear and tear locals pointlessly experience when left guessing about where to find prescribed drug to buy was also mitigated, which is consistent with findings from the research effort in Phillips et al. [18]. Of particular interest is the technical capabilities offered by the proposed L-aS and the operational context provided by locals’ mobile phones as was the case also in [18]. This synergy leveraged the context of users’ location(s) to provide the support needed for an L-aS to serve interested local users.

Users’ willingness to utilise the technical capabilities, which the system offered was significant. The lack of a priori information, as was the case with the participants (i.e. locals) in the context of this study highlighted this significance in that the tendency to blindly attempt to locate the right pharmacy, which was always the norm was solved by using the developed system. This meant that in the case of emergency, when a particular drug is needed to save a life; if the drug is not available in the hospitals pharmacy, the first idea is no longer to go round existing pharmacies outside the hospital based on guesses. This feeling of speculation based on wild guesses was often frustrating and like other L-aS [24], the developed system was found to mitigate (if not remove) the feeling as shown in the test run case report. It was found also that users were able to engage the developed prototype system after installing it on their android mobile phone through the user interface in Figure 3a. Based on usages experiences the test case result in Figure 6 shows the responses of users who participated in the UET of PharmFinder.

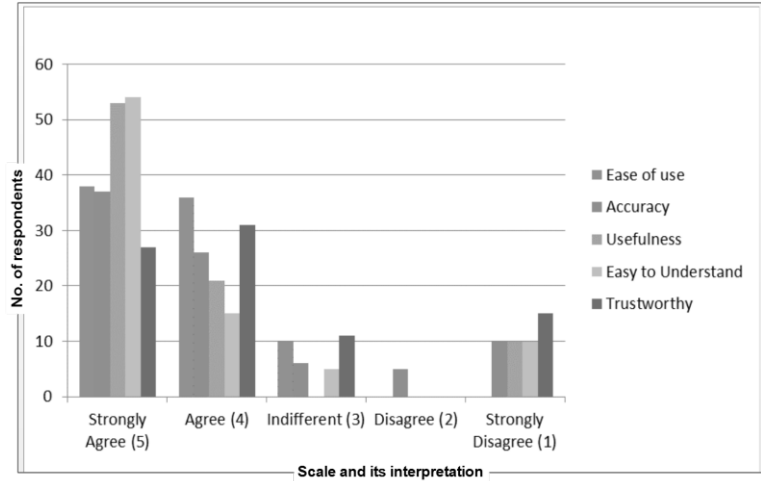


Figure 6. Test case result based on locals usage experiences

In comparison to what obtains in the literature, the level of accuracy the prototype displayed affirms the findings in [19] and [24] that L-aS can provide accurate information about location(s) and the direction to such locations(s). The result in

Figure 6 clarifies this by the number of users of the prototype system who strongly agree and agreed that the prototype system's location accuracy was okay. This number is unarguably more than those who were indifferent as well as strongly disagreed. This implied that the haversine technique used was rightly applied as demonstrated in [24].

The accuracy of recommendation based on distance calculation was a keen interest. This criterion showed that distance recommendation is necessary, when the real location of points must be determined. For the L-aS prototype (i.e. PharmFinder) users of the prototype app were able to locate the exact pharmacy to make drug purchase. As an important functional requirement, this was met in the proposed prototype system going by users' validation, which is consistent with the assertion in [20] and [21] that L-aS accuracy criterion must be met. There are other Subjective non-functional Criteria (SnC) that showed the prototype system as a valid tool to help users transcend the experience of serendipity in their quest to locate the exact pharmacy where to find drugs. These SnC are ease of use, usefulness, ease of understanding, and trustworthiness. From the result in Figure 6, more users agreed and strongly agreed that L-aS is easy to use. Accordingly, system usefulness was also rated by more users who strongly agreed and agree that L-aS is useful in detecting pharmacy proximity. Similarly, the number of users of the prototype system who strongly agreed as well as agreed that the system is easy to understand were more too. This implied that the L-aS was not too complex for users to understand and engage.

The number of users who "Strongly Agreed" and "Agreed" that the system is trustworthy going by the result in Figure 6 is in agreement with the findings in [41, 42] that the criterion of trustworthiness is important in determining the usefulness of L-aS to users. This validated the question of the fact that L-aSs are trustworthy. Intentionally, the trustworthiness criterion was meant to find out if the prototype system would help locals overcome the fear of uncertainty. Before launching the prototype system locals would go to pharmacies only hoping to find the drug they want by chance. But, with the prototype system this changed according to users' assessment. Based on the result in Figure 6, PharmFinder assisted users in finding the drug they want at the nearest pharmacy location displayed to them by the app. It was interesting to know that this made users to earn the trust of PharmFinder since it helped users to transcend from serendipity into certainty when the need arose to patronize the pharmacy.

Aside from users' attesting to the usefulness of the prototype system based on the summarized results in Figure 6, the results in Tables 4 and 5 also corroborated it by showing the technical usefulness of the system. Two performance metrics - ResTm and SRU were employed to show that the developed prototype system would perform well with guaranteed user experience (i.e. user satisfaction). By implication the average amount of memory usage by the system over a period of time going by the result in Table 5 was 1.9116 kb /sec. Based on the interpretation provided in Table 4, this implies that user satisfaction from using the system was guaranteed.

6. Conclusion

This paper presented a location awareness system that provided pharmacy location based services. The system is a prototype Mobile-based Pharmacy Store.

Response Time (in seconds)	Interpretation	Comment
0.1	-Most preferred response time	-Signifies that a System is working as Expected
1.0	-The maximum limit of a response time	-Any response time > 1.0secs but < 5.0secs shows user experience is guaranteed
Between 0.1 & 1.0	- Maximum user satisfaction	- User satisfaction guaranteed
10	- Maximum limit after which response time goes beyond acceptable limit	- Users are likely going to abandon the system when response time > 5secs

Table 4. Response time and interpretation

S/N	Android Specification	Android Version	Average Response Time (in milliseconds)	Storage (in Megabyte), Data (in Megabyte) & Memory usage (in Kilobytes/seconds)	
1.	Infinix Hot5	7.0	421	Storage:	4.87
				Data usage:	4.92
				Memory:	1.544
2.	Techno Wx3p	7.0	382	Storage:	4.14
				Data usage:	0.568
				Memory:	0.778
3.	Motorola X8	4.44	352	Storage:	3.75
				Data usage:	3.55
				Memory:	0.244
4.	Infinix X510	5.1	449	Storage:	6.11
				Data usage:	0.380
				Memory:	0.1122
5.	ZTEE 7L Tablet	5.1	469	Storage:	5.95
				Data usage:	5.73
				Memory:	6.88
Average Total			414.6	Average Storage Used:	4.964
				Average Data:	3.0296
				Average Memory Usage:	1.9116

Table 5. Performance evaluation result of prototype system

Location-aware System. An architecture-based approach guided its implementation such that as an ICT – based system users were able to use it on their smart phone devices. The techniques - algorithms applied and the results from user-based evaluation and performance assessment showed that the system was capable of giving standard user experience to users when they use the system. This is consistent with the belief that Mobile applications should seek to facilitate the resolution of

paradoxical experiences. For example, users should not lose it or themselves, particularly when they are unable to find their way in a situation where prior knowledge could have been of utmost assistance. Based on Yew's et al. [24] postulation this type of experience is paradoxical. The solution is to deploy a system that has the potential to provide up-to-date information on the go as demonstrated in [18, 24, 40]. The developed system presented in this paper was able to provide appropriate location information, and thus performed the role of a guide assistance. It can be concluded that the system satisfied the requirement of stepping in to intervene when users' needed direction and certain level of information about the nearest pharmacy where prescribed drug(s) is available and as such helped users to rise from serendipity into certainty. The performance testing carried out as a critical task to determine if a software system can provide users with optimal experience when used showed that the prototype system gave commendable user experience when deployed. For future work, effort will be made to (i) work on the system to become an app that is downloadable from Google play store to assist users find exact pharmacies where prescribed drugs are available in a locality, (ii) upgrade the user and pharmacies geographical positioning system automatically when both move to new location, to help continue to map and do purposeful tracking, (iii) make sure that more pharmacies are involved in the project to help prevent a situation where prescribed drugs are not available when the system is in use, (iv) consider drug inventory that was not possible now because of trust and other related issues from the owners of the pharmacy stores.

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The Contribution of Women on Corporate Boards: Board's Effectiveness – Focus on ICT

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Abstract

The composition of supervisory and board of directors in companies is extremely important for the successful operation of companies. Nowadays, women in the workplace, and especially in management positions, encounter a form of discrimination that has its own professional name - the phenomenon of "glass ceiling". Therefore, it is very important to analyze the representation of women and men on the company's supervisory board and board of directors. This paper will explain women's leadership style, differences between men's and women's leadership style, and the problems that women in employment, and especially in promotion. The aim off this paper is to determine whether the "glass ceiling" phenomenon is prominent in Croatian companies and to what extent. In addition, women's representation in senior positions will be related to business performance criteria.

Keywords: „glass ceiling", female executives, discrimination, supervisory board, board of directors, promotion, IT companies

1. Introduction

According to the statistics provided by the European Institute for Gender Equality in 2019, the percentage share of women on the supervisory boards or boards of directors in the largest quoted companies in the EU was 25%, with men comprising a significantly larger proportion – as much as 70% – of corporate board members. Moreover, a research conducted in 2015 covering the 400 largest Croatian companies by revenue in 2014 has shown a similar distribution of data. The boards of directors of the companies covered by the research comprised of 15% of women and 85% of men, while the supervisory boards consisted of 21% of women and 79% of men [9]. Furthermore, based on their 2017 research, the Network of Executive Women estimates that women will account for only 15% of executive ranks if their status does

not start to improve. This proportion is significantly lower in comparison with the current percentage of women executives, which is 35% [25].

The principal indicator of discrimination against women in the workplace is precisely their position in management. Discrimination is reflected in the fact that the number of female executives is inversely proportional to the level of management [2]. In many companies, there is a great deal of unequal distribution of women and men on different hierarchical levels within the same occupation – a type of discrimination better known as vertical segregation or the “glass ceiling” phenomenon [21]. Reasons contributing to women’s underrepresentation in senior positions are multiple. The main reasons for discrimination against women in employment, and especially in promotion, are various stereotypes and prejudices. According to one of those stereotypes in management, “women’s place is in the house and they do not devote themselves to work or a career” [2]. Such a deep-rooted belief cannot be shattered at once. However, as years bring about positive changes in society, this stereotype is gradually wearing off.

One extremely important factor which had an impact on women’s advancement in the past was their education. Today, the situation has improved in this respect, as numerous analyses have shown [1]. In fact, according to the Croatian Bureau of Statistics, in the Republic of Croatia in 2017 women outnumbered men in higher education with 34.7% against 23.2% [8]. Moreover, women have fewer opportunities to build networks, which is a significant obstacle hindering their professional advancement [2]. A study conducted in 2018 in Germany involving 37 female executives deals with the reasons why women are less successful at professional networking than men. The findings of the study reveal that women underestimate their selfworth in professional networking, and restrain from exploiting the opportunities which may come from social ties, leading them to engage less in networking activities [18].

The introduction of this paper will be followed by an overview of literature dealing with the types of discrimination women face in the workplace as well as the importance of the “glass ceiling” phenomenon. Afterwards, the methodology used for the analysis will be described. The fourth chapter will deal with the results of the analysis, the aim of which is to get an insight into women’s representation on boards of directors, supervisory boards, and recruitment committees. More precisely, the aim is to determine whether the “glass ceiling” phenomenon is prominent in Croatian companies and to what extent. Additionally, the study will examine female representation in executive positions in IT companies conducting information and communication activities. Finally, women’s representation in senior positions will be related to business performance criteria. The conclusion of this paper will be provided in the final chapter.

2. Literature Overviews

2.1. Types of Discrimination Women Face in the Workplace

According to research conducted on the global as well as national level, women differ from men in the workplace in several key aspects. The most prominent difference is evident in the fact that, on average, women earn less than men with the same level of education [2]. Gascoigne lists several reasons for the gender pay gap. The first reason is related to the fact that, unlike women, a greater number of older men occupy positions which have existed for a long period of time. Naturally, older, and more experienced employees with longer seniority are paid more than their younger counterparts. Moreover, women are paid less than men due to the imbalance between different positions and flexible working hours. In other words, women tend to opt for low-paid jobs in order to be able to take care of their families, while men are more flexible, and therefore have more opportunities to work in managerial positions, which are high-paying [17].

According to the data available from the Croatian Bureau of Statistics, in the Republic of Croatia in 2017, the average monthly income of men was higher than women by 1,126.00 HRK. On the other hand, the average monthly net income of women was 5,552.00 HRK, which was lower than men's average monthly net income by 794.00 HRK, which was 6,346.00 HRK [8]. However, the European Commission's data suggest the Republic of Croatia fares significantly better than the rest of the EU and their average. Specifically, in the Republic of Croatia in 2014, the gender pay gap was almost half the average of the European Union, i.e. women were paid for their work 8.7% less than men [11]. It is important to note that in 2011 in the European Union, women earned on average 16.8% less than men. Nevertheless, five years later, in 2016, the situation had somewhat improved. To be more precise, women earned 16.2% less than men [14].

Another reason stated as important for the gender pay gap is that higher paying jobs are in fact less flexible and require employees to devote a great deal of their time to work. Consequently, it is maintained that women taking care of their children, families, households, etc. cannot completely dedicate themselves to such obligations, which predetermines their inclination towards lower paying jobs with fewer responsibilities [4]. An analysis of the data from the Croatian Bureau of Statistics reveals that in 2017 in the Republic of Croatia, most of the women was employed in education and human health and social work activities, accounting for 78,7% of employees. The other two leading sectors dominated by women include the financial and insurance activities, where female representation amounts to 69.5%. Additionally, in 2017, women had lower earnings than men in the activities dominated by women. More precisely, in financial and insurance activities, women had the average monthly net income of 7,580.00 HRK, in contrast to 10,156.00 HRK men had, which represents a pay gap of 2,576.00 HRK [8].

A similar distribution of data is found in other activities where women's representation exceeds 50%. To illustrate, in wholesale and retail trade in 2017, women had the average monthly net income of 4,884.00 HRK, while men had

6,116.00 HRK. In addition, in 2017, men's net income in education was 6,599.00 HRK, while women were 5,551.00 HRK. Similarly, the data from human health and social work activities showed discrimination against women regarding net income in 2017. To be specific, women earned a 6,024.00 HRK salary for their work, while men were paid on average 2,025.00 HRK more for their work in the same activity [8].

The main very important and salient difference between men and women is the fact that women occupy managerial positions more rarely than men and that women with the same level of knowledge and skills advance more slowly than men [23]. Additional research [22] stated that, unlike men, women feel less inclined to compete against others. In fact, women are less willing to compete against men, which accounts for their underrepresentation in managerial positions. On the other hand, women are apt to compete against themselves, rather than other people from their company.

A study conducted in 2019 by the Credit Suisse Research Institute involving 3,000 companies from 56 countries yielded the following findings: the US, Canada, Scandinavia, the UK, France, Germany, South Africa, Australia and New Zealand are the countries with the highest share of women in managerial positions. Precisely, the proportion of women in managerial positions in companies operating in these countries ranges from 20% up to 43%. With not more than 4%, Japan stands out as the country with the smallest share of women in managerial positions in the covered companies. Mexico and Brazil have a somewhat higher percentage of women in managerial position – 8% to be more precise, while the rest of Latin America has only 9% of women in senior management [7].

Moreover, the study by the Credit Suisse Research Institute clearly shows the difference between financial indicators when a company is run by a woman. When the female representation in senior management exceeds 20%, the data representing EBITDA margins, CFROIs and P/E ratios are higher than in the case when there is less than 15% of women in senior management of a company. When female representation on boards is more than 20%, the EBITDA margin is higher by 2%, the Cash Flow Return on Investment (CFROI) is higher than 2.04, and the Price-to-Earnings ratio is higher by 16% [7].

According to data from 2019, there was 28.1% female and 71.9% male ministers in the European Union. Moreover, a similar distribution of men and women is found in the Parliament and regional assemblies. There is 29.3% female and 70.7% male members of Parliament. Similarly, 28.5% of members of regional assemblies are female, while 71.5% are male. However, in financial institutions or, to be more accurate, on the Central Bank board, the ratio of women is 20.3%, while the ratio of men is 79.7%. A share of 39.9% of female and 60.1% of male board members participate in the organization of financing research in the member states of the EU. Data provided by the European Institute for Gender Equality in 2019 suggest that the smallest proportion of women can be found on executive boards of national Olympic organizations. The share of women in such executive bodies is 14.8%, while male representation in the same bodies is 85.2% and more [15].

There are multiple reasons why women are underrepresented in STEM fields, including stereotypes, gender bias and socio-cultural complexities [12]. Despite the evidence that women are as effective or even more effective than men in IT

professions, the stereotype about men's better competence in the same profession continues to undermine women's position. The glass ceiling phenomenon is still pervasive even in today's "digital era", which is supported by the fact that women account for only 11% of executive positions in companies in Silicon Valley. Thus, it is not just the low number of women in the IT industry that is problematic, but also the fact that they are not perceived as competent and quality workers [3]. In a study of GitHub users, it was revealed that male programmers were favoured over women when the quality and acceptability of their codes was assessed. However, women and their codes scored better when their gender was left unknown, rather than when it was clearly stated which code was written by a woman and which one was written by a man [5].

According to the data provided by the European Commission in 2018, the number of men taking ICT studies was four times higher than the number of women. Moreover, the number of women enrolling in ICT studies had decreased compared to 2011. The interest and entrepreneurship women demonstrate in this field is not sufficient to encourage higher female representation in ICT companies. The European Commission's study showed that the proportion of female CEOs in IT companies stood at 14.8%, while the highest number of women employed in ICT fields was in Bulgaria (26.5%), as well as in Romania and Lithuania (25.7%) [12]. Women's position as ICT specialists in the Republic of Croatia did not differ so much from their position in the rest of the EU. As much as 13% of women were employed in ICT fields in the Republic of Croatia, while their share in the same field stood at 17.2% at the level of the European Union [13]. On the positive side, there were almost no disparities in women's and men's salaries. In fact, women earned a 0.7% lower salary than men in this field [24].

2.2. "Glass Ceiling" Phenomenon

The discrimination of qualified and competent women in their promotion within a company is known as the "glass ceiling" phenomenon [19]. As the term itself suggests, it is transparent that this phenomenon assumes the existence of barrier within a company preventing women from rising beyond it and advancing in their careers. [23]. The glass ceiling hinders women's advancement regardless of the type of sector: private, public, or business [20]. The first woman to identify this type of discrimination was the editor of the Working Woman magazine, Gay Bryant. However, it was not until 1986 and the publication of an article by two journalists from the Wall Street Journal that the term "glass ceiling" entered common usage [19].

Additionally, the term can be explained as favoring men, rather than women, for leadership positions [26]. Therefore, the glass ceiling phenomenon refers to vertical discrimination preventing women from reaching management positions. Women who succeed in reaching a managerial position tend to remain in it. In fact, they most commonly manage business functions such as procurement, sales, marketing, finance, etc., seldom accessing higher managerial positions or becoming executive managers [2]. Research has shown that women tend to give up more easily than men once they have reached management positions, i.e. women in managerial positions leave their

jobs at three times the rate of their male colleagues [10]. Although the glass ceiling phenomenon refers primarily to women, it is increasingly used to denote discrimination against other minorities [6].

In most of the cases, this type of discrimination is not perceived neither by the woman facing it nor other people in the workplace. Consequently, women only perceive it when they “hit” their heads against this glass ceiling. Over the years, the glass ceiling phenomenon has worn off, but is still substantially salient in companies. This phenomenon can be shattered, but only over a longer period. Furthermore, to tackle the glass ceiling phenomenon, a personal plan should be created. This includes a continuous knowledge and competence development, efforts aimed at building relationships and communication with colleagues at work, as well as a proactive attitude towards task completion [23].

3. Methodology Description

The data on board members and authorized company representatives, as well as the data on total revenues, profits/losses in the accounting period, and credit ratings of the analysed companies were gathered by using the info.BIZ service launched by the Financial Agency. The collected data were then analysed in Microsoft Excel. The 500 largest companies by total revenue in 2018 and 2019 were initially supposed to be included in the analysis. However, 17 companies were excluded from the analysis, including those categorized as institutions, other companies, limited partnerships, as well as companies in the insolvency and pre-insolvency proceedings or companies which have been erased from the register. The final sample comprised 483 companies that were either joint-stock companies or limited liability companies according to their legal structure. The largest portion of the sample, i.e. 76.40%, comprised limited liability companies, while joint-stock companies account for 23.60% of the sample. In other words, the analysis includes 114 joint-stock companies and 369 limited liability companies.

A sample of 472 companies, either joint-stock companies or limited liability companies according to their legal structure, was also included in the analysis based on the criterion of total revenue in 2019. The final analysis for 2019 does not include 28 companies, namely those categorized as institutions, other companies, limited partnerships, as well as companies in the insolvency and pre-insolvency proceedings or companies which have been erased from the register. As in the analysis for 2018, the majority of the sample included in the analysis for 2019 comprised limited liability companies with a share of 80.51%, while joint-stock companies account for 19.49% of the sample. It is important to note that the analysis for 2019 does not include authorized company representatives because they were not listed in the database retrieved from the info.BIZ service.

4. Analysis

The analysis of the data from 2018 on the number and gender of board members and authorized company representatives found that, out of the total of 2,654 members of the bodies of the joint-stock and limited liability companies, 618 were females, and the remaining 2,036 were males. Figure 1 clearly shows that there was an unequal distribution of men and women in managerial positions, at least in 2018 in the 483 joint-stock companies and limited liability companies covered by this research. Furthermore, in all the joint-stock companies analysed in this study, there was 76.71% of men on the management boards, supervisory boards or working as authorized representatives, while women accounted for a significantly smaller portion of executives with a share of only 23.29%.

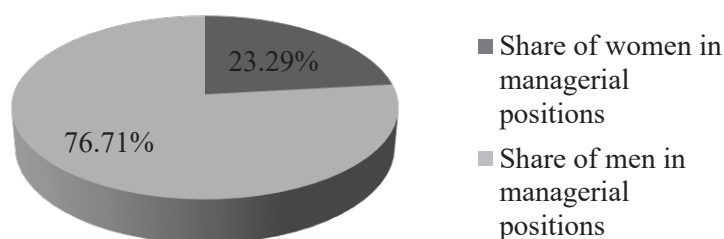


Figure 1. Share of women and men in managerial positions in the analysed companies in 2018. Created by the authors according to the data provided by [16].

The results of the analysis for 2019 lead to similar conclusions. Out of the total of 2,423 members of the analysed companies that have management boards and supervisory boards, 562 of them were female, whereas the remaining 1,861 were male members. Figure 2 shows that male representation in managerial positions was significantly higher than female representation in 2019 as well. To be more precise, in all the joint-stock companies and limited liability companies analysed in 2019, men held 76.81% of positions on management boards and supervisory boards, while the share of women holding managerial positions was significantly lower, i.e. it was 23.19%. The presented data indicate that the distribution of men and women in managerial positions was nearly identical in 2018 and 2019. The results indicate that there is a difference of 0.1 percentage point between the two years.

There was no equal distribution of men and women on management boards, supervisory boards and among authorised representatives. In 2018, the share of women on the management boards of all the analysed companies was 11.57%, whereas their share in 2019 was 11.72%. The share of men in 2018 was 40.66%, while in 2019 they accounted for 44.57% of all members of the other bodies in the companies. This translates into only 307 women and 1,079 men on the management boards of all the analysed companies. The next year the distribution had not

significantly changed: there was 284 women and 1,080 men on the boards of all the analysed companies.

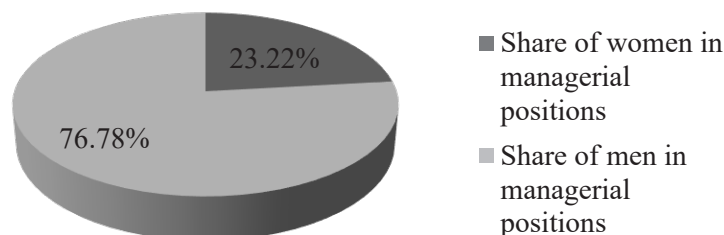


Figure 2. Share of women and men in managerial positions in the analysed companies in 2019. Created by the authors according to the data provided by [16].

There were 297 women and 864 men on the supervisory boards of all the analysed companies in 2018. Therefore, the share of women was 11.19%, while the number of men was three times higher, resulting in a share of 32.55% of male representation. In 2019, there were 278 women, with a share of 11.47%, and 781 men, with a share of 32.23%, on the supervisory boards. The majority of authorized company representatives in the analysed companies in 2018 were male. More specifically, 93 of them, or a share of 3.50%, were male and 14, or a share of 0.53%, were female.

In order to be able to conclude whether companies with women on management boards, supervisory boards and among authorized company representatives are more successful than those who do not have them, it was necessary to compare certain criteria. Business performance was observed according to three criteria: total revenue, profits and losses in the accounting period and credit rating. It should be stressed that, in 2018, total average revenues of all the joint-stock companies covered by this study were higher than total average revenues of all the analysed companies. This was not the case with the analysed limited liability companies. Total average revenues of all the analysed limited liability companies were lower than total average revenues of all the analysed companies. In 2019, total average revenues of all the analysed joint-stock companies were higher than total average revenues of all the analysed companies. Furthermore, total average revenues of the analysed limited liability companies with one women on the management board and supervisory board and two or more women on the supervisory board were lower than total average revenues of all the analysed companies (Table 1).

According to this, average revenues of joint-stock companies with one woman on the management board were somewhat lower than average revenues of all the analysed joint-stock companies in 2018, but they were higher in 2019. On the other hand, average revenues of joint-stock companies with one woman on the supervisory board were higher in 2018 and lower in 2019 in comparison to average revenues of

all analysed joint-stock companies. However, average revenues of joint-stock companies with one woman among authorized company representatives were significantly lower than average revenues of all the analysed joint-stock companies in 2018. As for the joint-stock companies with two or more women on the board in 2018, their revenues were similar to those of joint-stock companies with one woman on the board. This means that their average revenues were lower than average revenues of all the analysed joint-stock companies. Average revenues of all the analysed joint-stock companies with two or more women on the supervisory board were higher than average revenues of all the analysed joint-stock companies. Average revenues of joint-stock companies with one woman on the management board were somewhat lower than average revenues of all the analysed joint-stock companies. In 2019, average revenues of all the analysed joint-stock companies with two or more women on the management board and supervisory board were higher than average revenues of all the analysed joint-stock companies (Table 1).

Moreover, in 2018 and 2019, average revenues of the analysed limited liability companies with one woman on the management board, supervisory board and among authorized company representatives were lower than average revenues of all the analysed limited liability companies. Yet, after analysing the data for each year, it was found that average revenues of the analysed limited liability companies with two or more women on the management board and supervisory board were higher than average revenues of all the analysed limited liability companies. Total average revenues of all the analysed limited liability companies with two or more women among authorized company representatives could not be compared to other average revenues. This was not possible because only one limited liability company with two or more women among authorized company representatives was included in the calculation of average revenues (Table 1).

In 2018, the joint-stock companies with at least one woman on the management or supervisory board earned higher average profits in comparison to the average profit of all the analysed joint-stock companies. Similarly, the average profits earned by the joint-stock companies with two or more women on the supervisory board were higher, though not significantly so, in comparison to the average profit of all the analysed joint-stock companies. By and large, the joint-stock companies with one woman designated as the authorized company representative, and those with two or more women on the management board earned lower average profits when compared to the average profits of all the analysed companies. In 2019, the joint-stock companies with one woman on the supervisory board generated lower profits, while the profit of all the other companies was higher in comparison to the average profit of all the analysed joint-stock companies (Table 2).

	Joint-stock companies (2018)	Limited liability companies (2018)	Joint-stock companies (2019)	Limited liability companies (2019)
Average revenues of JSCs with 1 woman on the management board.	1,088,672,927 HRK	504,588,911 HRK	1,879,230,080 HRK	649,126,244 HRK

Average revenues of JSCs with 1 woman on the supervisory board	1,616,429,490 HRK	600,033,988 HRK	879,528,865 HRK	671,593,333 HRK
Average revenues of JSCs with 1 woman as the authorized company representative	426,016,549 HRK	558,209,876 HRK	-	-
Average revenues of JSCs with 2 or more women on the management board	752,124,826 HRK	900,752,708 HRK	1,302,609,187 HRK	1,074,550,813 HRK
Average revenues of JSCs with 2 or more women on the supervisory board	1,160,995,763 HRK	695,450,886 HRK	1,899,926,011 HRK	752,288,087 HRK
Average revenues of JSCs with 2 or more women as the authorized company representatives	0 HRK	1,594,891,524 HRK	-	-
Total average revenues	1,103,907,418 HRK	601,474,950 HRK	1,163,881,315 HRK	676,919,374 HRK
Total average revenues of JSCs and LLCs	720,307,525 HRK		772,572,612 HRK	

Table 1. Average revenues of the analysed joint-stock and limited liability companies according to the representation of women on management boards, supervisory boards and among authorised representatives in 2018 and 2019. Created by the authors according to the data provided by [16].

In 2018, the companies earning higher profits in comparison to the total average profit of all the analysed limited liability companies were those that had one or more women on the supervisory board or 2 or more women on the management board. The companies earning lower profits in comparison to the total average profit of all the analysed limited liability companies included the companies with one woman on the management board, one woman designated as the authorized company representative, and two or more women among authorized company representatives. In 2019, only the limited liability companies with one woman on the management board earned somewhat lower profits, whereas all the other companies generated higher profits in comparison to the total average profit of all the analysed limited liability companies.

	Joint-stock companies (2018)	Limited liability companies (2018)	Joint-stock companies (2019)	Limited liability companies (2019)
Average profit of JSCs with 1 woman on the management board	100,585,589 HRK	29,463,838 HRK	96,996,020 HRK	36,190,181 HRK
Average profit of JSCs with 1 woman on the supervisory board	103,240,323 HRK	46,252,175 HRK	54,958,660 HRK	44,756,513 HRK

Average profit of JSCs with 1 woman as the authorized company representative	4,922,554 HRK	27,189,842 HRK	-	-
Average profit of JSCs with 2 or more women on the management board	59,188,338 HRK	33,729,600 HRK	90,175,535 HRK	73,275,145 HRK
Average profit of JSCs with 2 or more women on the supervisory board	87,663,662 HRK	50,718,169 HRK	135,262,791 HRK	40,856,285 HRK
Average profit of JSCs with 2 or more women as the authorized company representatives	0 HRK	32,808,684 HRK	-	-
Total average profit	86,466,374 HRK	33,401,837 HRK	79,082,108 HRK	36,309,244 HRK

Table 2. Average profit of the analysed joint-stock companies and limited liability companies according to the representation of women on management and supervisory boards, and among authorized company representatives in 2018 and 2019. Created by the authors according to the data provided by [16].

The analysis of the data on average losses for both years reveals that nearly all of the analysed joint-stock companies that suffered losses and had at least one woman on the management board, supervisory board or among authorized company representatives suffered lower losses in comparison to the average loss of all the analysed joint-stock companies. According to the data from 2018, the analysed joint-stock companies suffered over 50% lower losses when there was one woman on the management board or among authorized company representatives. However, in the case of one or more women on the supervisory board, the average losses were somewhat greater than the average losses of all the analysed joint-stock companies (Table 3).

Out of all the analysed limited liability companies suffering losses, the companies with one woman on the management board and supervisory board suffered greater losses in comparison to total losses of all the analysed limited liability companies. In 2019, the companies with one woman on the management board and supervisory board, and two or more women on the supervisory board suffered greater average losses in comparison to the average losses of all the analysed limited liability companies. In 2018, the companies suffering significantly lower average losses were those with two or more women on the supervisory board, as well as those with at least one woman among authorized company representatives. In contrast, only the companies with two or more women on the supervisory board suffered lower average losses in 2019 (Table 3).

	Joint-stock companies (2018)	Limited liability companies (2018)	Joint-stock companies (2019)	Limited liability companies (2019)
Average loss of JSCs with at least 1 woman on the management board	-40,057,943 HRK	-35,454,395 HRK	-22,449,815 HRK	-35,682,197 HRK
Average loss of JSCs with at least 1 woman on the supervisory board	-92,990,012 HRK	-53,626,564 HRK	-42,611,330 HRK	-40,442,858 HRK
Average loss of JSCs with at least 1 woman among authorized company representatives	-42,377,713 HRK	-4,281,155 HRK	-	-
Average loss of JSCs with 2 or more women on the management board	0 HRK	-14,735,550 HRK	0 HRK	-38,629,817 HRK
Average loss of JSCs with 2 or more women on the supervisory board	-66,414,220 HRK	-25,560,091 HRK	-13,151,646 HRK	-11,816,939 HRK
Average loss of JSCs with 2 or more women among authorized company representatives	0 HRK	0 HRK	-	-
Total average loss	-100,906,594 HRK	-32,353,084 HRK	- 108,304,514 HRK	-28,996,168 HRK

Table 3. Average loss of the analysed joint-stock companies and limited liability companies according to the representation of women on the management board, supervisory board, and among authorized company representatives in 2018 and 2019. Created by the authors according to the data provided by [16].

The assessed credit rating of the majority of the analysed joint-stock companies with one woman in executive positions ranged from negligible expectations of default risk to very low expectations of default risk in both years. Such were the assessed credit ratings of 44 analysed joint-stock companies in 2018, and 36 companies in 2019. On the other hand, the assessed credit rating of the remaining 23 joint-stock companies in 2018 and 11 joint-stock companies in 2019 that had one woman on the management board, supervisory board and among authorized company representatives ranged from B1 to B6. A positive change was noted in 2019 as the most unfavourable score was achieved by a company with one woman on the supervisory board, which was assigned a B4 credit rating.

According to the results obtained for both years, the analysed joint-stock companies with two or more women on their management boards, supervisory boards and among authorized company representatives fared slightly more poorly than the companies with only one woman in executive positions. Furthermore, 19 of the analysed joint-stock companies were assigned the A rating and were grouped into classes from 1 to 3, which means that the expectations of default risk were very low

or negligible in the case of these 19 joint-stock companies. There were 27 companies that were attributed such credit ratings in 2019, when the overall scores were slightly better than in the previous year. As already mentioned, the assessed credit rating for the majority of joint-stock companies with two or more women in managerial positions was poor. The expectations of default risks varied from low to very high in the case of 26 such companies. Just like the A class, the B class was also attributed a better score in 2019 in comparison to the previous year. To be precise, the credit rating of 15 joint-stock companies varied between B1 and B6.

Based on the data for 2018 and 2019, it may be concluded that, in the majority of the analysed limited liability companies, a very good credit rating coincides with the fact that there is one woman on the management board, supervisory board and among authorized company representatives. To put it more precisely, 103 analysed limited liability companies in 2018 and 91 limited liability companies in 2019 with one woman in managerial position were assigned ratings from A1 to A3, meaning that default risks were negligible or very unlikely. The B rating was assigned to 64 analysed limited liability companies in 2018, while there were 61 limited liability companies in the same class in 2019. These were all the companies with a low to average likelihood of default risk in payment. Moreover, one limited liability company with one woman on the supervisory board was assigned the C3 rating in 2018, meaning that there was a strong likelihood of default risk in payment. In 2019, two companies were assigned the C1 credit rating. Both of them had one woman on their management board and one woman on their supervisory board. Only one limited liability company was assigned the C2 credit rating and that company had one woman on the management board, which means that there was a strong likelihood of default risk in payment.

Out of all the analysed limited liability companies, the credit rating ranging from A1 to A3 was assigned to 65 of them in 2018 and to 59 of them in 2019, all of which had two or more women on their management boards, supervisory boards or among authorized company representatives. Consequently, the likelihood of these companies facing default risk in payment was negligible or very low. On the other hand, estimated credit ratings ranging from B1 to B6 were assigned to 37 analysed limited liability companies in 2018 and to 27 of them in 2019, all of which had two or more women on the management board, supervisory board and among authorized company representatives. There was also one company in 2019 whose credit rating was estimated as C1, which means that there was an above-average probability that it will face default risk in payment.

In 2018, there were 16 companies among the 483 joint-stock companies and limited liability companies included in the sample that were classified in section J (Information and communication) according to their economic activities. Among them, 7 companies were joint-stock companies in their legal structure and the remaining 9 companies were limited liability companies. In total, 112 people were identified as members of management boards and supervisory boards. Among them, there were 30 women who were in managerial position in the analysed IT companies, whereas the number of men in executive positions in this profession was significantly higher and it amounted to 82. In percentages, the share of women on supervisory

boards of IT companies was 26.79%, while the share of men was 73.21%. Therefore, it may indeed be concluded that the glass-ceiling phenomenon is largely present in IT companies according to the analysis for 2018. Women in managerial positions in IT companies accounted for 1.13% of all executives in the analysed joint-stock companies and limited liability companies, whereas men's share was 3.09%.

In 2019, there were improvements in terms of female representation in managerial positions. There were 20 IT companies among the 772 joint-stock companies and limited liability companies included in the sample. Among these 20 companies, 7 of them were joint-stock companies, whereas 13 of them were limited liability companies. The total number of members of the management boards and supervisory boards of the 20 analysed IT companies was 59, including 21 women and 38 men. According to this, the share of women in executive positions in IT companies was 35.59%, while the share of men was 64.41%. When the analysis for 2019 is taken into account, it becomes clear that executive positions are predominantly held by men in IT companies as well. However, the data indicate that the share of women had increased in comparison to the previous year. Taking into account joint-stock companies and limited liability companies covered by this study, women accounted for 0.87% of executives, while the share of men was 1.57%.

5. Conclusion

The status of women in companies has changed over the years and is still incessantly changing. Although women started fighting for their rights decades ago, i.e. at the end of the 19th century, this fight is still going strong today. Nonetheless, women are fighting for a different type of rights today, including equal employment opportunities, equal status in companies, as well as equal pay for equal work. Despite their advanced competences and better education than men, women are still underrepresented in senior positions within companies. What accounts for this situation is the so-called glass ceiling phenomenon? Namely, there is an invisible barrier in a company hierarchy beyond which women simply cannot raise, often not even being conscious of its existence. Apart from this phenomenon, women are discriminated against with respect to their pay, which is evident from the data provided by the Croatian Bureau of Statistics, the European Commission, and the European Institute for Gender Equality. Previous research reveals that the glass ceiling phenomenon is still present both in the Republic of Croatia and abroad.

The analysis presented in this paper leads to the conclusion that in 2018 in the Republic of Croatia there was an unequal distribution of men and women in executive positions in the companies covered by the analysis. In all the analyzed joint-stock companies and limited liability companies the percentage share of men on management boards, supervisory boards and among authorized company representatives is 76.71%. In the same executive position, the share of women is significantly lower, i.e. they account for only 23.29% of executives. Additionally, the most radical unequal distribution of men and women is evident in the position of authorized company representative, where the ratio of women is six times lower than that of men. Similarly, the share of women on management boards and supervisory

boards is about the same. More precisely, the ratio of women on management boards and supervisory boards is three to four times lower than that of men. From all this, it can be concluded that in 2018 the glass ceiling phenomenon exists and is present to a very high degree.

Very similar results were obtained in the analysis for 2019. Thus, the share of men on supervisory boards and boards of directors was 76.78%, while women held 23.22% of the same managerial positions in all of the analysed joint-stock companies and limited liability companies. The number of women on supervisory boards and boards of directors was also three to four times lower than the number of men in the same positions. After interpreting these results, it was concluded that the representation of women in executive positions had not increased and the glass ceiling phenomenon persisted in the analysed companies in the Republic of Croatia. Nevertheless, it is noteworthy that female representation at least remained at the same level compared to the previous year and it had not declined below that percentage.

Company performance is tightly connected with the representation of women in executive positions. According to the total revenue criterion in 2018, the more successful joint-stock companies are those with at least one woman on the supervisory board, while the less successful ones are the joint-stock companies with one or more women on the management board. In the case of limited liability companies, according to the criterion of total revenue, the significantly more successful companies are those with two or more women on the management board and supervisory board. Furthermore, considering the profit in the accounting period, the more successful joint-stock companies are those with one woman on the management board, and with two or more women on the supervisory board. According to the same criterion, the more successful limited-liability companies are those with one or more women on the management board, and with one woman on the supervisory board. The analysis conducted for the purposes of this paper leads to the conclusion that joint-stock companies with one woman on the management board, supervisory board and among authorized company representatives suffer lesser losses. Similarly, the limited liability companies that suffer lesser losses are those with two or more women on the management board and supervisory board.

According to the criterion of total revenues in 2019, the joint-stock companies with at least one woman on the board of directors and two or more women on the supervisory board were more successful than the companies with one woman on the supervisory board. When it comes to limited liability companies, the results show that the companies with two or more women on the board of directors and supervisory board were more successful than the companies with just one woman in a managerial position. According to the criterion of profit, the more successful companies were those with one, two or more women on the board of directors and two or more women on the supervisory board. Furthermore, limited liability companies with one, two or more women on the supervisory board and two or more women on the board of directors were more successful according to the criterion of profit. A comparison of the companies based on the criterion of losses leads to the conclusion that companies with two or more women on the supervisory board suffered lower losses.

Based on the data for 2018 and 2019, it may be concluded that the glass ceiling phenomenon is pervasive even in IT companies. In 2018, female representation on boards of directors and supervisory boards of IT companies stood at 26.79%, whereas male representation stood at 73.21%. In other words, women in managerial positions in IT companies accounted for 1.13% of all members of the analysed joint-stock companies and limited liability companies, while men accounted for 3.09%. The next year, the glass ceiling phenomenon was still present, but to a lesser extent. Thus, the share of women in managerial positions in IT companies stood at 35.59%, while men's share stood at 64.41%. In the same year, women accounted for 0.87% of all members of the analysed joint-stock companies and limited liability companies, whereas men accounted for 1.57%.

What is more, in both analyzed years, there is connection between credit ratings and the representation of women in executive positions. The majority of the analyzed joint-stock companies and limited liability companies with better credit ratings are those with one or more women in managerial positions. In conclusion, considering the criteria of average profits, revenues and losses in the accounting period and credit ratings, the more lucrative companies are those with one or more women in managerial positions.

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The Role of Human Resource Policies on Work Life Balance Among Information Technology Sector of Women Professionals

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Abstract

Work life balance is the relationship between, how much time and effort someone spends to work and how much time and effort spend to other elements of their life, such as family, children, friends etc., HR policies are the organization's continuing guidelines for managing its employees. As in this study, it mainly focuses on what are all roles played by the human resource department on balancing work and life in the Information Technology sector of women professionals. For this research, descriptive research was done with a sample of 200 women professionals from selected IT companies in Chennai using simple random sampling technique. The questionnaire was created using the independent variable of HR policies on work life balance and mediator of continuance commitment with a dependent variable of work life balance. The statistical tools used in this study are CFA, Discriminant validity and Composite reliability with the assistance of SPSS and AMOS software. The research found that, all the item used in the study are reflect a good measure of the variables.

Keywords: Work Life balance, Information Technology, Women Professionals, HR Policies, Continuance Commitment.

1. Introduction

Work Life balance is the great solution in which an employee can split her time and energy between work and other vital elements of their lives. HR policies are defined as a set of concepts and standards that regulate a company's interaction with its employees. Role of HR policies is that, the policies which are provide how much support to the women professionals when they try to balance their work and life. Continuance commitment is that, the degree to which we believe quitting the company would be costly. It is that, if we have high level of commitment to staying with an

organization, we will do so, because we feel obligated to do so. This continuance commitment is playing the mediating variable for the role of HR policies and work life balance. The role of HR policies with continuance commitment in a balancing of work and life is a daily challenge for women professionals to manage her life. Indian businesses are well-known over the world. With the shifting demographics of the workforce, regulations that are geared toward women are no longer relevant. Apart from the technological adaption and female workforce, the strategic deployment of work life balance policies in Indian enterprises is quite difficult. As the organization, it is responsible for ensuring its successful implementation and budget management. Despite the fact that several top IT companies have taken the initiative to deploy the work life balance policies [4].

2. Literature Review

2.1. HR policies on work life balance

Examined based on empirical research, gives an in-depth look at the work-life balance of working moms in the public and private sectors. Organizations must establish and implement successful work-life balance policies, and employees must be encouraged to use these policies. Employees are unaware of organizational policies regarding work-life balance. This could be included in an induction session to ensure that employees are informed of company policies [15]. Identified a conceptual model that explains regarding influence of work-life balance policy and practice behaviors of floor managers, and the influence of employee work-life balance experience in their workplaces. The study offers suggestions for identifying the essential factors that impact line manager work life balance policy and practice [17]. Investigated the link between contemporary life-friendly HR management policies and individual work life balance as well as the impact of managerial support on the policies. The author presented to enable firms to contemplate the application of life-friendly policies, resulting in a convergence between employee well-being and effectiveness of the organization [27].

2.2. Continuance Commitment

Through the mediation of employee commitment, this paper investigated the impact of strategic human resource management on human capital development. Nursing Personnel, who are often dissatisfied owing to a lack of professional progression chances, should focus on developing career opportunities and dedication. As a result, healthcare executives should devote greater resources to formal training and organizational programs aimed at improving employees' skills and competences in relation to the organizations strategic goals [1]. The research aids in the optimization of organizational commitment in the areas of work life balance, person job fit, and condition of work also job satisfaction as mediation. One of the research findings is the confirmation that higher job satisfaction among private sector employees reflects

more affective organizational attachment. Employees in private sector firms would feel absorbed and have excellent job satisfaction, resulting in higher commitment, when they exercise person job fit, continue fairness between family life & work, and benefit from pleasant working conditions [12].

2.3. Work life balance

Has articulated the factors that influence the employee's perceptions of the team leaders attitude. There are some of the issues that employee in IT organizations experience, which contributes to a high degree of stress among them. The study is focused on the elements that contribute to employee depression in IT organizations, as well as the involvement of the team leader in all of these issues. The study concluded that, the importance of keeping people satisfied in a sector with such a large global footprint cannot be overstated. When employees are happy and pleased, they are more likely to work hard to enhance the industry as a whole [13]. They measured the prevalence of work-life balance among women working in an information technology (IT) sector in Kerala. Women employees whose spouses worked in business had a much weaker work-life balance than women employees whose spouses worked in other private or government jobs. It may be inferred that women working in the IT sector in Kerala are mildly affected by work life balance [8].

3. Conceptual Model

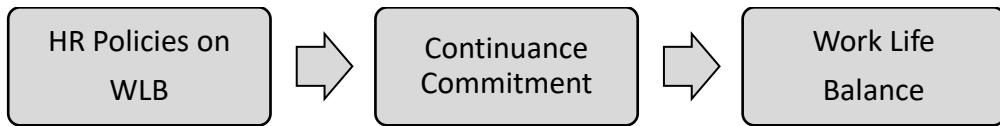


Figure1. Role of HR polices on Work-life balance

In balancing the work & life, the HR policy plays a vital role. HR policies differ from company to company, as every company follows a separate rule under the guidance of government regulations. HR policies mainly regarding for the women is transportation, as in the IT industry many of the time have to work night shift, and if it is a safety transport facility for late night drop, then for women, they can balance in their life little better. As because of this, once they reach home without trouble, then they can start their day without any delay.

The degree to which you believe that leaving the company will be costly is referred to as continuance commitment. If women professionals have high level of commitment, then undoubtedly she feels that, she must work with that company. If incase, she may be concerned that quitting her job may result in an unacceptably long period of unemployment. On the other side, she may feel that she will lose a certain degree of status if the company is a well-respected company. In a life, for women professionals in an IT industry, with her all continuance commitment, she has to balance her life with the role played by HR policies.

4. Research Methodology

4.1. Data Collection

This current research is an empirical study. The data has been collected through primary as well as secondary. Primary data was collected by the structured questionnaire with the demographic section of multiple choice and the forced choice questions. Secondary data was collected from various researches such as journals, magazines and websites.

4.2. Sampling Selection

Sample size is 200 respondents from selected IT companies of women Professionals. The data has been collected from the working women professionals. Simple random sampling technique was used.

4.3. Questionnaire Design

An identification code is created for each indicator as a measurement tool for the variables, and it is measured using a five point Likert scale type as: 5 - Strongly agree, 4 - Agree, 3 - Partially agree, 2 - Disagree and 1 - Strongly disagree.

4.4. Statistical Softwares

Cronbach's alpha values were computed using SPSS 20.0 software, while the measurement model validity was tested using AMOS 21.0 software using a confirmatory factor analysis [9].

5. Validation of Data

5.1. Validity

The most crucial condition for a test's quality is its validity. The concept "validity" relates to whether or not a test actually measures what it claims to. The items on a test with a high level of validity will be closely related to the test's intended purpose. The extent to which the scores from a measure represent the variable for which they were constructed is known as validity.

5.2. Reliability

One of the most essential aspects of test quality is reliability. In a brief, it relates to a measure's consistency. It has something to do with consistency, or reproducibility of a test taker's performance. One of the common used methods for finding internal consistency reliability is Cronbach's alpha. The cronbach's alpha value is being

impacted by group variability. Score reliability, number of items, sizes of the sample and the instrument's difficulty level.

5.3. Validity and Reliability Test

To ensure that the measurement instruments are internally consistent, a reliability investigation was carried out. For the validity, when all item loadings are greater than 0.5, convergent validity is adequate [25]. Cronbach's alpha coefficients are more than 0.7 for all constructions, indicating that, they are reliable [19]. The AVE values are greater than 0.5 for all items and Composite Reliability values are bigger than 0.7 that indicates the perfect association of items with their constructs.

No	Variable	Indicator	Factor Loading	Reliability Value - Cronbach's alpha	AVE	CR
1	HR Policies on WLB	HRP1	0.7130	0.8730	0.5105	0.8043
2		HRP2	0.6710			
3		HRP3	0.8440			
4		HRP5	0.6090			
5	Continuance Commitment	CC4	0.7920	0.9050	0.5189	0.7629
6		CC3	0.6990			
7		CC1	0.6640			
9	Work Life Balance	WLB7	0.5170	0.9010	0.5137	0.8400
10		WLB6	0.5070			
11		WLB4	0.7260			
12		WLB2	0.7370			
13		WLB1	0.7860			

Table 1. Shows Factor Loading, Cronbach's alpha, Average Variance Extracted (AVE) and Composite / Construct Reliability (CR)

The table presented the validity and reliability values as well as fit indices for the constructs of the model. The result is that, all items were found to be valid and reliable after a validity and reliability test.

6. Data Analysis

In data analysis, here CFA was used to see if constructs had reasonable validity and reliability in assessing the model's factor loadings for a group of items. By comparing the average variance extracted (AVE) to the square correlation between constructs, the discriminant validity was determined. As a result, the AVE estimate was utilized as a supplement to other composite dependability measures [21], [22].

6.1. Discriminant Validity

The Discriminant validity is another significant sort of validity to consider when evaluating models. The Validity assures that the model does not contain any redundant constructs. An index summary for all constructs was created to assess discriminant validity. To examine the discriminant validity of the three components, the average variance (AVE) was used. The finding on AVE for HR policies on work life balance, Continuance Commitment and Work life balance is 0.5105, 0.5189 and 0.5137. While CR for HR policies on work life balances, continuance commitment and work life balance is 0.8043, 0.7629 and 0.8400. Each variables factor loading is significant, indicating a good comprehensive model as proposed by [6].

6.2. Measurement Model

The measurement model explores the link between the latent variables and their measures. The link between the observable and latent variables is depicted in the measurement model. Observed variables can be observed directly, but the latent variables that cannot be directly measured. The latent variables are measured using observed variables. Confirmatory factor analysis (CFA) is a measuring model that is part of Structural equation model (SEM) and is mostly used to see if the scale structure matches the real data [23].

6.3. Confirmatory Factor analysis (CFA)

Validating the measurement model by confirmatory factor analysis, which is also known as the measurement model, was also tested by applying the structural equation model using AMOS_V(21.0) for all multivariate analysis approaches and measuring the goodness of fit. Confirmatory factor analysis was run on all of the construct's items to see if the modified items were appropriately loaded on the respected construct as expected by the study model [5]. The measure of goodness-of-fit of the model, and the significance statistical measurement include the chi-square test (χ^2), the normed chi-square ($CMIN/DF$) = (chi-square/degree of freedom), P value, Goodness of fit index (GFI), The Adjusted goodness of fit index (AGFI) and Comparative Fit Index (CFI). First, the measurement model was connected with the three variables of HR policies on work-life balance, continuance commitment and work- life balance. The following CFA model illustrates the conceptual model of, the role of HR policies on work life balance.

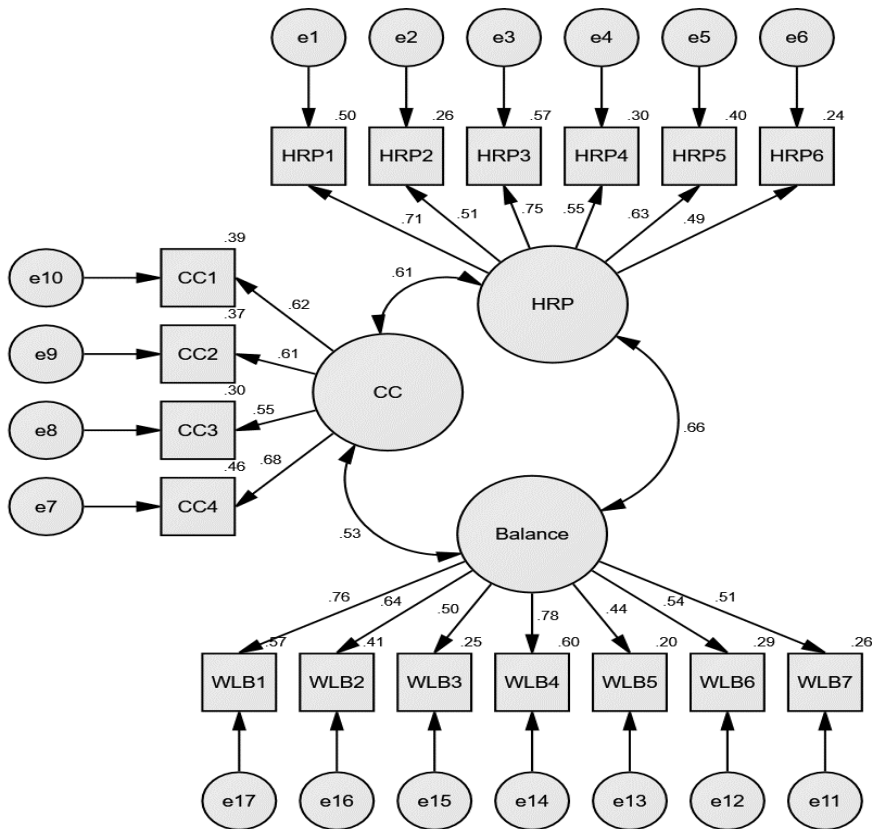


Figure 2. The Conceptual model of CFA

However, based on the above CFA model, the values of the fit indexes of the model were unreasonable. The values obtained as $CMIN/DF = 4.143$, $P \text{ value} = 0.000$, $GFI = 0.754$, $AGFI = 0.675$ and $CFI = 0.698$. The values show that the fit indices of the model were unreasonable. Therefore some items with low factor loadings were deleted [24].

6.4. Confirmatory Factor Analysis (CFA) model Fit

To get the fit model, in each variable, some of the items were deleted. In the independent variable of HR policies on work life balance, the items of HRP4 and HRP6 have been deleted. In the mediating variable of Continuance commitment, the single item of CC2 has been deleted. In the dependent variable of work life balance, the items of WLB3 and WLB5 have been deleted. The unobserved variable of E16 and E14 have been connected under the dependent variable of work life balance as both got the high value of modification indices.

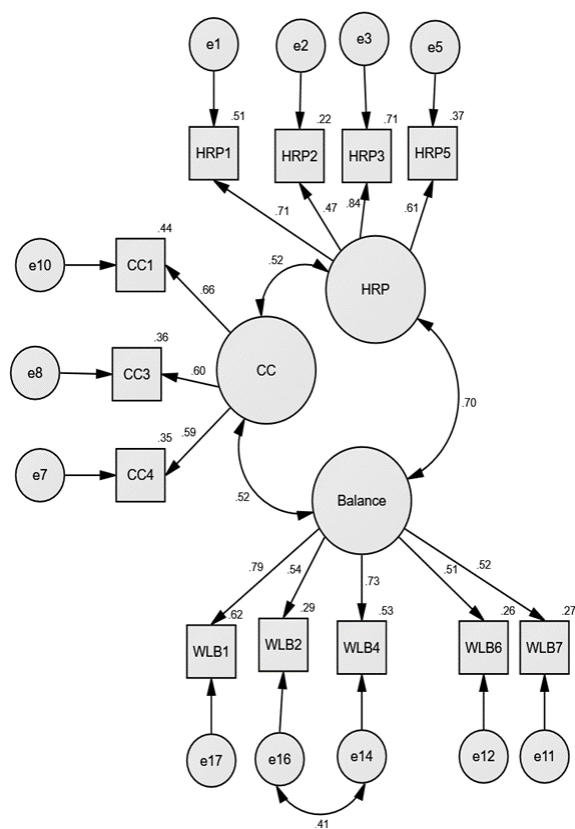


Figure 3. The goodness of fit CFA Model

The following table shows the goodness of model fit indices, source by [10].

Model Fit Summary		
Indices	Value	Suggested Value
CMIN	4. 149	<5
P Value	0.000	<0.05 [10]
GFI	0.84	>0.80 [11]
AGFI	0.85	>0.80 [2]
CFI	0.80	>0.80 [2]

Table 2. Model Fit Indices

After removing the item of each variable and connecting the unobserved variable, get the values of CMIN/DF =4.149, P value=0.000, GFI=0.84, AGFI=0.85 and

CFI=0.80. All the values are fitted with the model fit indices based on the above model fit table, and the AGFI value alone nearly match with the given suggested value of model fit. In this study, all the variables and their items are fit in this CFA model, shown in Figure 3.

7. Discussion

The study's major goal is to look at the role of Human Resource policies on work life balance among women professionals in Information Technology (IT) sector. From all the results, all of the items are used to measure the analysis of the results are statistically significant. All of the measurement model scale items included in the CFA were good measures of their related construct. In CFA, All the values reached the required cut-off for both validity and reliability, leading to the conclusion that all variable's measurements were valid and reliable. As a result of our findings is that, we may conclude that all of the items reflect a good measure of the variables.

The study has been found that, there is a significant positive relationship between HR policies and continuance commitment with work life balance. This study is consistent to the findings of [20] is that normative and continuance commitment and all antecedent variables have positive and significant effects with affective commitment. Then again consistent to the findings of [14], found that HR practices are positively correlated with organizational commitment, job satisfaction and organizational fairness. The findings of the study is consistent with [3] as suggested that, HR Professionals in India have to verify their current policies and practices about work life balance and restructure correspondingly.

8. Conclusion

The concern of the HR profession for a better workplace is to solve work-life balance concerns and create a fantastic place to work. Work life balance concerns must be approached from several perspectives, such as mentoring, counselling and teaching employees to deal with problems as they emerge. Female-friendly work environments should be prioritised, including pay equality policies, telecommuting choices, job sharing and so on. Organizations should keep an eye on what's going on in best-in-class organisations and implement policies ahead of time [15]. Work-life balance harmonies are designed to assist employees in achieving a decent balance in both their personal and professional lives. It has been proven that strong work life balance programmes lead to reduced stress and enhanced workplace performance, loyalty and motivation [16]. In the absence of employee commitment, employees intent to quit or even act to leave increases, lowering overall organizational performance. When people are happy in their jobs, they are more likely to committed to their company. Employees that are satisfied and devoted are more eager to undergo training and are more interested in advancement chances [1]. Work life policies help to retain talented people by increasing their dedication to their company, which minimises attrition and absenteeism. The availability of work life balance policies minimises employee absenteeism, which is a cost advantage to a business [7].

This study tested the relationship between the variables in the model and all the variables are significant. Finally, the role of HR policies mediating the continuance commitment with work life balance. Work and life has to be balanced by the women professionals based on the roles played by the HR department as well as with women's continuance commitment.

9. Recommendations

The HR department needs to help their employees to keep going work life balance. Given some of the decision in which HR can help in, that, providing flexi approach towards work, effective communication systems, family get together at works and workers participation in management [18]. The researcher suggested the recommendation of work life balance to the hotel employees is that, listen to employees, provide more free time, increase the flexibility of the work schedule and provide work place support on family matters [26]. Organization should keep in mind about the women professionals before framing the HR policies. Here, listed out some of the recommendations for the IT industry when they frame the HR Policy:

- Offer flexible timing to boost the employee happiness
- Provide correct remuneration for the productivity instead of hours worked
- Provide performance bonus to improve the work efficiency
- Provide health insurances, which will support their life
- Paid sick leaves to encourage them to work
- Provide alternate shifts, which will help them to plan their personal work accordingly
- Provide work from home option, when needy situation arise
- Provide proper break hours
- Give Maternity leave with payment
- Give Gratuity and provident fund

The current research found the above recommendation for HR policies. The role of the HR policies by every industry is that, it has to be framed with little concern of women professionals, thus will make the women professionals to stay in an organization, then that will be the good sign for any Industry. Website: <https://study.com/academy/lesson/organizational-commitment-definition-theory-types.html>

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Publication Ethics; List of Reviewers; Instructions for Authors

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3. Instructions for Formatting JIOS Articles

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Keywords: formatting instructions, Microsoft word template, JIOS

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To ensure that all articles published in the journal have a uniform appearance, authors must produce a PDF document that meets the formatting specifications outlined in this document. The same document will be used for digital and hard copy version of the journal. Paper submission must be made in one ZIP archive which must include source document (ie. MS Word file) and PDF. When crating PDF make sure all fonts are embedded.

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Paper title and all headings should be capitalized. Please refer to Rules for Capitalization in Titles regarding capitalization of paper title and section headings.

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The figure or table number and the caption should appear under the illustration. Spacing around caption should be 6 pt above and 11 pt below. Captions, labels, and other text in illustrations must be at least 9 pt.

	CPU Speed	Wage
A		
B		
C		

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References

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