An IFCM Approach for Evaluating Digital Transformation Factors in Banking Sector

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Abstract: - Digital transformation is the integration of digital technology into all areas of a business. It's also a fundamental change in how an organization gives value to its customers. The aim of this work is to identify the importance degrees of factors of digital transformation in banking sector by using intuitionistic fuzzy cognitive map (IFCM) approach. IFCM is considered as suitable tool due to the existence of causal links among the factors, lack of crisp data and the presence of hesitation in data.

Key-Words: - Banking sector, causal links, cognitive maps, digital transformation, IFCM, intuitionistic fuzzy data

1 Introduction

Digital transformation is an important process to keep the companies up to speed with the technological changes. It may be a quite complex process in which multiple digital projects should be managed at the same time, and the employees have to learn new technological skills to be able to adapt this transformation in their organization [1].

In general, digital transformations are more difficult than the other traditional changes, however the output obtained from an effective digital transformation will be result in success indicators [2]. Besides, digital transformation involve cloud computing, internet of things, and artificial intelligence, which are all popular notions in digital environment [3]. In the last years, few scholars have contributed to the literature of decision making applications in digital transformation. Kettunen and Laanti [4] observed digital transformation in decision making processes with agile goals in order to define the principles of future software organizations. Bienhaus and Haddud [5] evaluated the factors that have influence on digital transformation in procurement and supply chain by focusing especially on procurement 4.0. Gastaldi et al. [6] assessed digital transformation processes in hospitals and healthcare systems by providing several case studies. Yoo and Kim [7] developed a decision model to adapt a cloud computing system, and employed analytic hierarchy process (AHP) and Delphi analysis.

Banks tend to integrate digital transformation into their processes for cost savings, risk reduction, capturing more customers, retaining existing customers, developing new business models, maintaining customer satisfaction, and decreasing dependency on branches.

This study presents an intuitionistic fuzzy cognitive map (IFCM) approach to identify the importance degrees of factors of digital transformation in banking sector. IFCM is thought as an appropriate tool due to the causal links among the factors, lack of crisp data and the presence of hesitation in data.

The rest of the paper is organized as follows. Section 2 explains material and methods. The following section illustrates the application via a case study conducted in banking sector. Final section delineates conclusions and future research directions.

2 Material and Methods

2.1 Cognitive Maps

Cognitive maps (CMs) were originally proposed by Axelrod [8] as a tool to model decision support systems in political and social sciences. CMs comprise directed edges which provide modeling causalities and interrelationships among concepts.

There are multiple types of CMs, such as signed, weighted and functional graphs.

CMs may also be utilized for forecasting, research and development, strategic planning. The binary relations (i.e., increase and decrease) are used in crisp (conventional) CM. CMs are advantageous tools that are required in order to provide an engineering planning, by considering causal links, managing complexity, comparing the models with real cases, providing efficient assessments [9].

Certain or deterministic information can be available only in a small portion of real world problems. The knowledge with no ignorance, vagueness, imprecision or chance, is not accessible in real life. Uncertain information, which can take a lot of different forms, arises due to the complexity of problems, and the inability to measure adequately or lack of knowledge.

The type of uncertainty in a specific problem is crucial for scholars to select a suitable method to imply the uncertainty. Fuzzy sets are appropriate to provide a mathematical way in order to represent vagueness and fuzziness in systems [9].

2.2 Fuzzy Cognitive Maps

A crisp CM, which is indeterminate, can be solved by providing a numerical weighting, however, it requires computational and conceptual efforts [10]. If the causal arrows are positively or negatively weighted, the indirect influence is the product of the weights in the corresponding path, and the total influence is the summation of the products. This weighting framework not also eliminates the problem of indeterminacy from the total influence computation; yet also requires a more sensitive causal discrimination. This sensitivity may not be possible for decision makers who are supposed to construct the CM. Forcing decision makers to create CM with crisp numbers causes insufficient decision information, different numbers from different decision makers or different numbers from the same decision maker on different days. However, causal links can be stated by linguistic variables rather than numerical terms by proposing fuzzy cognitive map (FCM) methodology [9].

FCM, helping model complex decision systems, is a causal knowledge-based method which is originated from the combination of fuzzy logic and neural networks [10]. The concepts stand for an entity, a state, a variable or a characteristic of a system, a behavior of a knowledge-based system is represented by concepts in FCM. Concept nodes and weighted edges are the elements of FCM which can be graphically showed with feedback. Edges are signed to understand the direction of causality: whether the causal relationship is positive, negative or null, and connect the nodes through which causal relationships among concepts are produced [11].

2.3 Intuitionistic Fuzzy Cognitive Maps

IFCM tool utilizes intuitionistic fuzzy numbers to express the power of cause-and-effect relationships in cognitive mapping [12]. Initially, concept nodes and power of causal links among them are defined by collecting experts' opinions. Hereafter, intuitionistic fuzzy scale is determined and the power of causal links is represented by intuitionistic fuzzy numbers that are associated with the scale. Hence, membership, non-membership, and hesitation values are identified. By using the information obtained from the experts, N x N weight matrix is constructed. In order to compute the concepts' values, the following iterative formulation is run until the system will be stabilized, in other words, all factor weights will converge Iakovidis and Papageorgiou [13].

$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{j=1 \\ j\neq i}}^{N} A_j^{(k)} w_{ji}^{\mu} - A_j^{(k)} w_{ji}^{\pi}) \right) \quad (1)$$

where $A_i^{(k)}$ is the value of concept C_i at kth iteration, w_{ji} is the weight of the connection from C_j to C_i, w_{ji}^{μ} and w_{ji}^{π} denote the weight matrices that show membership values and hesitation values of causal links, respectively, and f is a threshold function, which is considered as sigmoid function for this work.

3 Case Study

The illustration of the proposed methodology is represented by a case study conducted in a bank that performs in Turkish banking sector. First, the factors that have influences on adapting digital transformation to the bank which are given in Table 1, are identified by interviewing the managers.

Table 1. Digital transformation factors

Label	Concept
C_1	Cost
C_2	Risk
C_3	Capturing more customers
C_4	Retaining existing customers
C_5	Customer satisfaction
C_6	Development of new business models
C_7	Dependency on branches

The evaluation is conducted by a committee of three decision-makers that are all process managers of the bank, who have all been working for more than three years in the case company. The experts provide their opinions by reaching a consensus and they used the linguistic scale shown in Table 2.

Table 2. Linguistic scale

Linguistic term	Intuitionistic fuzzy number
VH	<0.95,0.05>
H	<0.70,0.25>
M	<0.50,0.40>
L	<0.25,0.70>
VL	<0.05,0.95>

The evaluations are given in Tables 3, 4, 5, and 6.

Table 3. Linguistic data for causal links

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	-	-	-	M	M	-	-
C_2	H	-	-	M	L	-	-
C_3	H	-	-	-	-	-	M
C_4	-	-	-	-	L	-	L
C_5	-	-	M	VH	-	-	-
C_6	VH	-	M	H	H	-	-
C_7	H	-	-	L	-	-	-

Table 4. Membership values for causal links

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0	0	0	0.5	0.5	0	0
C_2	0.7	0	0	0.5	0.25	0	0
C_3	0.7	0	0	0	0	0	0.5
C_4	0	0	0	0	0.25	0	0.25
C_5	0	0	0.5	0.95	0	0	0
C_6	0.95	0	0.5	0.7	0.7	0	0
C_7	0.7	0	0	0.25	0	0	0

Table 5. Non-membership values for causal links

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0	0	0	0.4	0.4	0	0
C_2	0.25	0	0	0.4	0.7	0	0
C_3	0.25	0	0	0	0	0	0.4
C_4	0	0	0	0	0.7	0	0.7
C_5	0	0	0.4	0.05	0	0	0
C_6	0.05	0	0.4	0.25	0.25	0	0
C_7	0.25	0	0	0.7	0	0	0

Table 6. Hesitation values for causal links

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0	0	0	0.1	0.1	0	0
C_2	0.05	0	0	0.1	0.05	0	0
C_3	0.05	0	0	0	0	0	0.1
C_4	0	0	0	0	0.05	0	0.05
C_5	0	0	0.1	0	0	0	0
C_6	0	0	0.1	0.05	0.05	0	0
C_7	0.05	0	0	0.05	0	0	0

IFCM methodology is employed and the weights of digital transformation factors are obtained by running the formulation (1) until it will be stabilized, and the values of concepts will no longer change. FCMapper software is utilized for these operations. The criteria weights are provided in Table 7.

Table 7. Weights of factors

Label	Concept	Weight
C_1	Cost	0.954492
C_2	Risk	0.659046
C_3	Capturing more customers	0.805692
C_4	Retaining existing customers	0.953592
C_5	Customer satisfaction	0.882371
C_6	Development of new business models	0.659046
C_7	Dependency on branches	0.785598

4 Conclusions

The objective of digital transformation is incorporating digital technologies into organizational activities, business processes and models. It also aims to sustain customer satisfaction while providing cost efficiency. In recent years, it has been significant for organizations to keep up with increasing technology and competition. In banking sector, a digital project should be managed

by conducting an efficient process for surviving in competition and obtaining advantage in future.

To obtain the importance weights of digital transformation factors in banking sector, related factors affecting the decision of incorporating digital technologies into organizations are listed through expert opinions. The resulting concepts' values are obtained by applying IFCM methodology, cost and retaining existing customers are the most important factor, however risk and development of new business models are the least important ones.

Future research directions will focus on comparing the importance degrees of the factors with another mapping tool, which enables to aggregate different experts' opinions. Herewith, a group decision approach will be proposed rather than making a consensus among decision makers.

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