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Predicting the Impact of Information Systems to Accounting in Greece using Fuzzy Cognitive Maps

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Abstract. In this paper we use Fuzzy Cognitive Maps (FCMs), a well-established Artificial Intelligence technique that incorporates ideas from Artificial Neural Networks and Fuzzy Logic, to create a dynamic model for predicting the changes that the application of Information Systems will bring to Accountants in Greece. The ways that Accountants operate in Greece will change dramatically in the next few years, by the application of new technologies (e.g. obligatory electronic submission of VAT statements). FCMs create models as collections of concepts and the various causal relations that exist between these concepts. The prediction capabilities of the FCM structure are examined and presented using two models developed based on the beliefs of a domain expert. The models are first examined statically using graph theory techniques but also dynamically thought simulations to estimate the impact that the application of Information Systems will have to Accountants in Greece. Scenarios are introduced and predictions are made.

1. Introduction to Fuzzy Cognitive Maps

Cognitive Map (CM) models were introduced in the late 1970's by Axelrod and were used initially for Decision Making [1]. Axelrod studied the structural and decision potentials of such models and identified their explanation and prediction capabilities [1]. The introduction of Fuzzy Logic gave new representing capabilities to CMs and led to the development of Fuzzy Cognitive Maps by Kosko in the late 1980's [2], [3]. The use of fuzzy logic allows the representation both of the type (positive or negative) of the causal relationships that exist among the concepts of the model but also of the degree of the causal relationship.

FCMs models are created as collections of concepts and the various causal relationships that exist between these concepts. The concepts are represented by nodes and the causal relationships by directed arcs between the nodes. Each arc is accompanied by a weight that defines the degree of the causal relation between the two nodes. The sign of the weight determines the positive or negative causal relation between the two concepts-nodes. An example of FCM is given in figure 1, showing the causal relationships that were identified in a car industry [4].

The main areas where FCMs are used are: a) Decision Making, b) Forecasting, c) Explanation (of actions already made) and d) Strategic Planning. A great number of

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FCMs have been developed concerning the business industry and financial activities. Table I gives some such references found in bibliography.

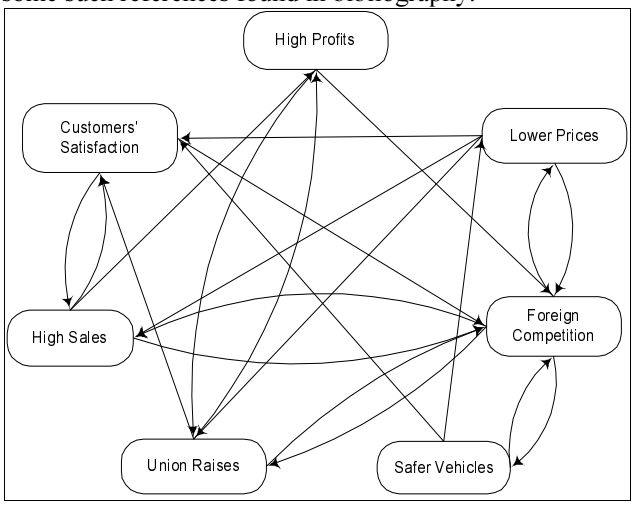

Figure 1. FCM model of a car industry
(modified version of original taken from [4])

Table I

Cognitive Map topic	Reference
Japan's and USA's industry	[5]
The strategy of NeXT computer Company	[6]
The strategy of Sony Company	[6]
USA's economy	[7]
The introduction of new drink in the market	[8]
Measuring the efficiency of a company's departments	[9]
The development phases of a company	[10]
The sales of a company	[11]
The management of a company	[12], [13]
The bureaucracy in companies	[10]

Although in FCMs the degree of the causal relationships could be represented by a number in the interval [-1,1], each concept could be either activated or not activated, in a strict binary manner. In 1997, Certainty Neuron Fuzzy Cognitive Maps (CNFCMs) were introduced [14] to overcome this limitation. CNFCMs provide additional fuzzification to FCMs by allowing each concept's activation to be activated just to a degree. In this way the activation level of each concept can be any value of the interval [-1,1] and not only one of the two levels –1 and 1. The aggregation of the influences that each concept receives from other concepts is handled by function $f_M()$ that was used in MYCIN Expert System [15], [16] for certainty factors' handling. The dynamical behaviour and the characteristics of this function are studied in [17]. Certainty Neurons are defined as artificial neurons that use this function as

their threshold function [18]. Using such neurons, the updating function of CNFCMs as a dynamical evolving system is the following:

$$A_i^{t+1} = f_M\left(A_i^t, S_i^t\right) - d_i\, A_i^t \quad (1)$$

where, A_i^{t+1} is the activation level of concept C_i at time step t+1,

$S_i^t = \sum_j w_{ji} A_j^t$ is the sum of the weight influences that concept C_i receives at time step *t* from all other concepts,

d_i is a decay factor and

$$f_M(A_i^t, S_i^t) = \begin{cases} A_i^t + S_i^t(1 - A_i^t) = A_i^t + S_i^t - S_i^t A_i^t & \text{if } A_i^t \geq 0,\ S_i^t \geq 0 \\ A_i^t + S_i^t(1 + A_i^t) = A_i^t + S_i^t + S_i^t A_i^t & \text{if } A_i^t < 0,\ S_i^t < 0 \quad |A_i^t|, |S_i^t| \leq 1 \\ \left(A_i^t + S_i^t\right) \Big/ \left(1 - \min\left(|A_i^t|, |S_i^t|\right)\right) & \text{otherwise} \end{cases} \quad (2)$$

is the function that was used for the aggregation of certainty factors to the MYCIN expert system.

2. Information Systems - TAXIS

The Greek General Secretary of Information Systems (http://www.gsis.gov.gr/) has developed a plan for the construction of Information Systems that will facilitate citizens and companies to their various transactions with tax offices. The development of TAXIS system (https://www.taxisnet.gr/web/) provides Greek Citizens and Accountants various electronic services such as:

- The electronic submission of VAT statements (e-VAT)
- The electronic submission of tax statements.
- The electronic clearance of tax statements
- The electronic payment of car circulation taxes.

The electronic submission of VAT sheets will be mandatory in 2002 (http://www.e-gov.gr/article.php?sid=573) making extremely big the accountants' need for computer skills. Services provided by TAXIS have been honored by the European Union (https://www.taxisnet.gr/web/eu.cfm).

The actions taken in the development of TAXIS is a part of the Greek Strategic Plan for Electronic Governance (http://www.e-gov.gr). Systems like TAXIS should interact with companies' modern Accounting Information Systems [19], [20] to integrate the services.

3. Construction of FCM Models

In our study, two FCM models were developed. The first model concerns the impact of the application of Information Systems to Greek Accountants, while the second model studies the way that this impact will be spread to Greek Accountants according to their computer skill capabilities and their attitude towards new technology.

To develop a reliable FCM model, all the necessary rules that ensure its reliability should be followed. The main two methods for the construction of FCMs are:

a) The Questionnaire method [21], [22] which involves interviews and filling in of questionnaires by domain experts.
b) The Documentary Coding method [23] which involves the systematic encoding of documents that present the assertions of a specific person for the specific topic.

For the construction of both FCMs models we followed the first method, interviewing and also supplying with questionnaires a domain expert. The domain expert was a faculty member of the Business Administration Department of the University of Macedonia. During the interviews, the concepts that should be included in the model were identified. The list of the concepts that were identified as playing important role in the first FCM model and should be included in it, are the following:

1. Information Systems (TAXIS)
2. Services to Citizens
3. Services to Accountants
4. Accountants' supply
5. Income of Accountants
6. Number of Accountants

In questionnaires the causal relationships that exists between these concepts were defined, accompanied by the degree to which a concept influences another concept. The format of the questionnaire is given in figure 2.

TAXIS will increase /decrease and to which degree the following:	Very Big		Big		Moderate		Small		Very Small		None
Services to Citizens											
Services to Accountants											
Accountants' supply											
……											
Numerical weights	*1*	*0.9*	*0.8*	*0.7*	*0.6*	*0.5*	*0.4*	*0.3*	*0.2*	*0.1*	*0*

Figure 2: Part of the questionnaire concerning the impact of Information Systems to Accountants

The expert had to fill in the sign + or – whether he believed that there is a positive or negative causal relationship between the concepts. The degree of these causal relationships was captured by allowing the expert to fill in the sign in one of the fields "Very Big", "Big", "Moderate", "Small", "Very Small". These linguistic values could be transformed into numerical weights by assigning weights from the interval [0,1] according to the way that is shown in figure 2. If according to his belief there is no causal relationship, the field "none" could be checked. After studying the questionnaires and taking the weights identified by the expert, the first model was developed which is presented in figure 3.

Statements from the domain expert that were taken into account during the construction of the FCM model are the following:

1. Information systems (TAXIS) increase services provided to Citizens and Accountants. In return they ask for the application of more and better services.
2. Information systems (TAXIS) increase the availability of Accountants by decreasing the time that Accountants have to interact with tax offices. This gives Accountants more free time during the working hours and the potentials to serve more customers.
3. The possibility to do more work in the same time or to serve more customers increases the competition between Accountants and this may decrease their income.
4. An increase or decrease in the income of Accountants will cause correspondingly an increase or decrease in the number of Accountants.
5. An increase or decrease in the number of Accountants will cause correspondingly an increase or decrease in the supply of Accountants in the Greek Labour Market.

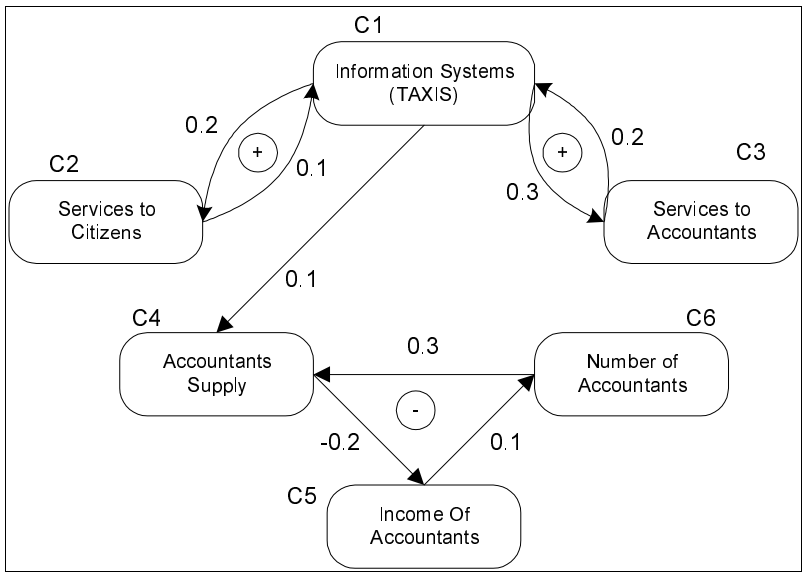

Figure 3: FCM model for the impact of Information Systems to Greek Accountants

In the second model, we focus on the study of the effect that the application of the new technology will have to Accountants, depending on whether they are capable of using this technology. For this reason we separate the Accountants into the following two categories:

a) New Era Accountants: These are the Accountants that are willing to use and get the advantages that Information Systems provide. They have the basic computer skills and they are trained or willing to be trained in the use of Internet and new Information Systems, in order to follow the evolution that new services and technologies bring to Accounting.
b) Past Era Accountants: These are the Accountants that are not willing to use the new technology but they are determined to keep working in the same classical way they used to work, all these years.

After extensive interviews with the domain expert, the concepts that should be included in the model were identified as follows:

1. Information Systems (TAXIS)
2. Services to Citizens
3. Services to Accountants
4. Customers served by a New Era Accountant
5. Customers served by a Past Era Accountant
6. Total Customers served by New Era Accountants
7. Total Customers served by Past Era Accountants
8. Income of New Era Accountants
9. Income of Past Era Accountants
10. Ratio New Era Accountants to Past era Accountants

Using questionnaires, as that of figure 2, the causal relationships that exists between the concepts above were defined, accompanied by the degree to which a concept influences every other concept. Using the concepts and weights identified by the expert, the model of figure 4 was developed.

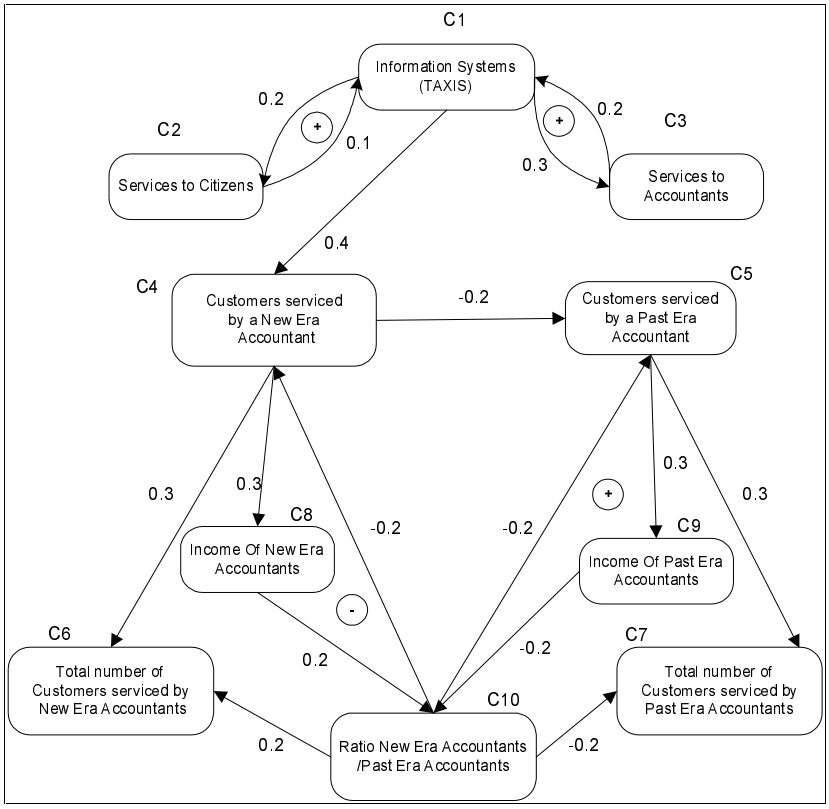

Figure 4 : FCM model for the impact of Information Systems to the two categories of Accountants

Some of the statements from the domain expert that were taken into account during the construction of the FCM model are the following:

1. Information systems (TAXIS) will increase the availability of New Era Accountants by decreasing the time that they have to interact with tax offices. This will not happen to Past Era Accountants. This gives New Era Accountants more free time during the working hours and the potentials to serve more customers.
2. The possibility of New Era Accountants to serve more customers will potentially decrease the customers served by Past Era Accountants.
3. New Era Accountants income will increase (decrease) if they serve more (less) customers.
4. An increase or decrease in the income of New/Past Era Accountants will cause correspondingly an increase or decrease in the number of New/Past Era Accountants, affecting correspondingly the Ratio New Era Accountants/Past Era Accountants.
5. The total number of customers that New Era Accountants serve increases as the ratio New Era Accountants/Past Era Accountants is increased or as the number of customers that a New Era Accountant can serve is increased.

The two models created are studied in the following sections both statically and dynamically.

4. Static Analysis of FCM Models

The static analysis of the model is based on studying the characteristics of the weighted directed graph that represent the model, using graph theory techniques. The most important feature that should be studied is that of the feed back cycles that exist in the graph. Each cycle is accompanied by a sign, identified by multiplying the signs of the arcs that participate in the cycle. Positive cycles behaviour is that of amplifying any initial change, leading to a constant increase in case an increase is introduced to the system. This is why they are also called deviation amplifying cycles, [10] augmenting cycles [22] or vicious cycles [10], [24], [6]. An example of a positive/vicious cycle is that of C1(Information Systems -TAXIS) ⇨ C2 (Services to Citizens) ⇨ C1(Information Systems -TAXIS). Through this cycle the use of TAXIS and the services provided to Citizens will constantly increase.

Negative cycles on the other hand, counteract any initial change. This means that they lead to a decrease in the case where an increase is introduced in the cycle. Negative cycles are also called deviation counteracting cycles [10], inhibiting cycles [22] or virtuous cycles [10], [24], [6]. An example of a negative/virtuous cycle is that of C4 (Accountants' Supply) ⇨**(-)** C5 (Income of Accountants) ⇨ C6 (Number of Accountants) ⇨ C4 (Accountants' Supply). Through this cycle the concepts participating in the cycle will periodically increase and decrease.

The model of figure 3 has three cycles that appear in Table II. The two positive cycles and one negative cycle are presented in figure 3 with cycles having in their centers the corresponding sign. The existence of one negative cycle indicates that the model can become unstable leading to the periodical increase and decrease of the activation level of its concepts.

Table II

	Cycles	Sign of cycle
1	C1 ⇨C2 ⇨ C1	+
2	C1 ⇨C3 ⇨ C1	+
3	C4 ⇨C5 ⇨ C6 ⇨ C4	-

The model of figure 4 has four cycles that appear in Table III and are shown in figure 4 with cycles having in their centers the corresponding sign. Once again there is a negative cycle in the model, that may cause instability to the model.

Table III

	Cycles	Sign of cycle
1	C1 ⇨C2 ⇨ C1	+
2	C1 ⇨C3 ⇨ C1	+
3	C4 ⇨C8 ⇨ C10 ⇨(-) C4	-
4	C5 ⇨C9 ⇨(-) C10 ⇨(-) 54	+

Another way to examine statically the model's graph is by calculating its density [1]. The density d is defined as

$$d = \frac{m}{n(n-1)}$$

where *m* is the number of arcs in the model and *n* is the number of concepts of the model (product n(n-1) is equal to the maximum number of arcs that a graph of n nodes can have). Density gives an indication of the complexity of the model. High density indicates increased complexity in the model and respectively to the problem that the model represents. The density of the graph in figure 3 is 8/(6x5) = 0.27 which is high. The density of the graph in figure 4 is 16/(10x9) = 0.18 which is also high.

Graph Theory provides also the notion of node's importance [1] that assists the static analysis of FCM models. Node's importance (or cognitive/conceptual centrality as it is called by others [1], [25]) gives an indication of the importance that the node/concept has for the model, by measuring the degree to which the node is central to the graph. The importance of a node *i* is evaluated as

$$imp(i) = in(i) + out(i)$$

where *in(i)* is the number of incoming arcs of node *i* and *out(i)* is the number of outcoming arcs of node *i*. According to this definition, the importance of the nodes of the FCM model of figure 3 is the following:

C1	C2	C3	C4	C5	C6
5	2	2	3	2	2

As it is expected, concept C1(Information Systems -TAXIS) is found to be the most central and important to the model. The importance of the nodes of the FCM model of figure 4 follows. Once again concept C1(Information Systems -TAXIS) is found to be the most central and important.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
5	2	2	5	3	2	1	2	2	6

5. Dynamical Analysis

After some indications for stability or instability of the models from the static analysis, conclusions are drawn by running simulations of the models. The two models were simulated using the CNFCM technique that was mentioned in section 1.

In the introduction of scenarios in the first model we used the assertion of the domain expert that the Greek Economy development creates a demand for Accountants which in turn affects "little" (degree 0.4) in a negative way the supply of Accountants. In the first "what-if" scenario we examined model's prediction in the case where the development of the Greek Economy was "low" (0.4). Introducing this scenario in the model of figure 3, we left the concepts of the system free to interact and after almost 80 iterations the system reached an equilibrium point. The equilibrium point, with the activation levels of all concepts at equilibrium, is given in Table IV. The transition of the system to equilibrium is shown in figure 5.

TABLE IV

Concept	Information Systems (TAXIS)	Services to Citizens	Services to Accountants	Accountants' supply	Income of Accountants	Number of Accountants
Activation level at Equilibrium	0.530	0.515	0.614	-0.246	0.330	0.248

We can see that there is a big increase in the services that Information Systems (TAXIS) provide to Citizens and Accountants. Although Systems like TAXIS tend to increase Accountants' Supply, the overall Accountants' supply is decreased (-0.246) due to the even little development of the Greek Economy. An increase is also predicted to the income of Accountants (0.330) due to the decrease of Accountants' supply and the development of the Greek Economy. An increase is also predicted in the number of Accountants (0.248).

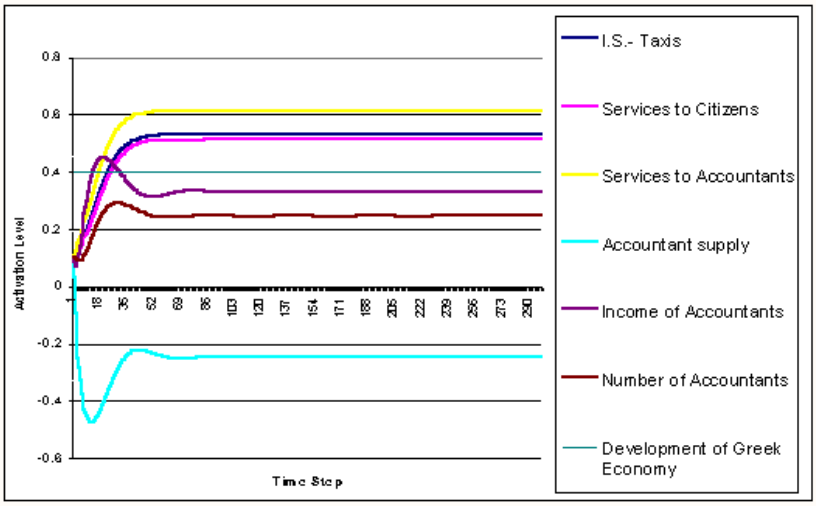

Figure 5 : Transition phase of FCM model concerning the impact of Information systems to Accountants in Greece.
Scenario #1:Development of Greek Economy is low (0.4).

In the second "what-if" scenario we examined model's prediction in the case where the development of the Greek Economy was "very low" (0.2). Introducing this new scenario to the model of figure 3, we left the concepts of the system free to interact. The concepts of the system after almost 300 iterations reached once again an equilibrium point. The equilibrium point, with the activation levels of all concepts at equilibrium, is given in Table V. The transition of the system to equilibrium is shown in figure 6.

TABLE V

Concept	Information Systems (TAXIS)	Services to Citizens	Services to Accountants	Accountants' supply	Income of Accountants	Number of Accountants
Activation level at Equilibrium	0.530	0.515	0.614	-0.042	0.075	0.072

We notice that the prediction for the first three concepts of the model remain the same with those of scenario #1, forecasting big increase in the services that Information Systems (TAXIS) provide to Citizens and Accountants. The predictions of the other three concepts are have changed. After strong interactions between these three concepts, as shown in figure 6, the overall Accountants' supply is predicted to remain almost the same (a tiny decrease of -0.042 is predicted). A tiny increase is also predicted in the income of Accountants (0.075) due to that tiny decrease in Accountants' supply and the very low development of the Greek Economy. A similar small increase is predicted also for the number of Accountants (0.072). We can conclude that even a very low development of the Greek Economy can keep Accountants' Supply, Accountants income and the number of Accountants to the current levels.

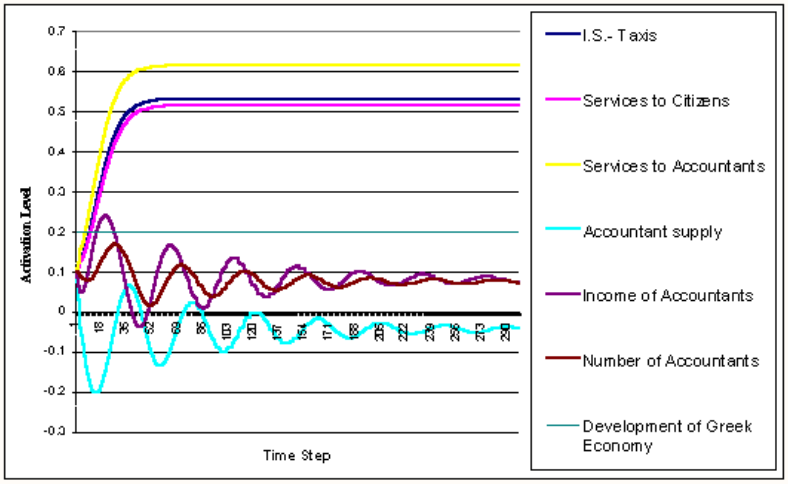

Figure 6 : Transition phase of FCM model concerning the impact of Information systems to Accountants in Greece.
Scenario #2:Development of Greek Economy is very low (0.2).

In the third "what-if" scenario we wanted to see model's prediction in the case where there was not any development in the Greek Economy (development =0). Introducing this new scenario to the model of figure 3, we left the concepts of the system free to interact. The concepts of the system after almost 200 iterations reached once again an equilibrium point. The equilibrium point, with the activation levels of all concepts at equilibrium, is given in Table VI. The transition of the system to equilibrium is shown in figure 7.

TABLE VI

Concept	Information Systems (TAXIS)	Services to Citizens	Services to Accountants	Accountants' supply	Income of Accountants	Number of Accountants
Activation level at Equilibrium	0.530	0.515	0.614	0.098	-0.163	-0.141

In this third scenario, it can be also noticed that the predictions for the first three concepts of the model remain the same with those of scenarios #1 and #2, forecasting big increase to the services that Information Systems (TAXIS) provides to Citizens and Accountants. The predictions of the other three concepts are once again changed. After some interactions between these three concepts, as shown in figure 7, the overall Accountants' Supply is predicted to increase (even to a small degree of 0.098). The income of Accountants is decreasing (-0.163) due to that increase of Accountants' Supply and because there is the not any influence from Greek Economy development. There is also a small decrease is in the number of Accountants (-0.141). We conclude that no development in Greek Economy and the application of systems like TAXIS can increase Accountants' Supply and decrease both the number of Accountants and Accountants' income.

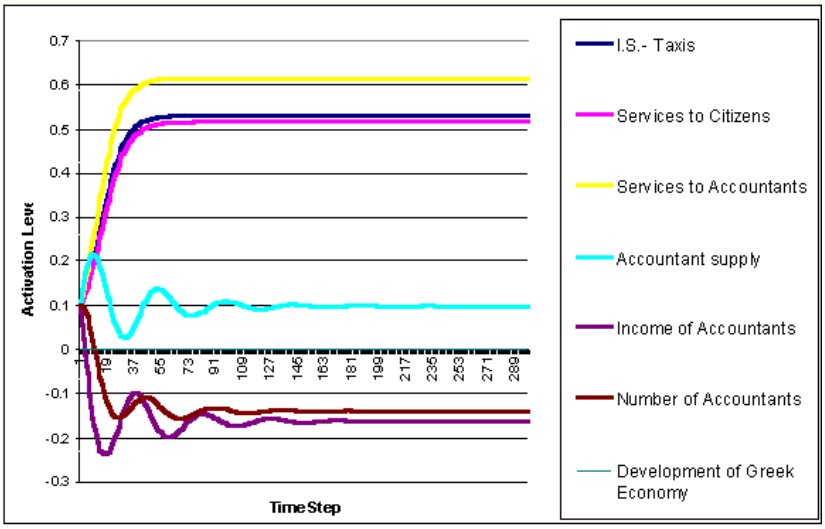

Figure 7 : Transition phase of FCM model concerning the impact of Information systems to Accountants in Greece.
Scenario #3: No Development of Greek Economy (development=0).

To see to impact that the Application of Information Systems to the New Era Accountants and Past Era Accountants, simulations were made for FCM model of figure 4. The concepts of the model were left free to interact. After almost 25 iterations the system reached an equilibrium point. The equilibrium point, with the activation levels of all concepts at equilibrium, is given in Table VII. The transition of the system to equilibrium is shown in figure 8.

TABLE VII

Concept	Information Systems (TAXIS)	Services to Citizens	Services to Accountants	Customers served by a New Era Accountant	Customers served by a Past Era Accountant
Activation level at Equilibrium	0.654	0.567	0.662	0.540	-0.716
Concept	Total Customers served by New Era Accountants	Total Customers served by Past Era Accountants	Income of New Era Accountants	Income of Past Era Accountants	Ratio New Era Accountants to Past era Accountants
Activation level at Equilibrium	0.754	-0.782	0.618	-0.682	0.722

From the activation levels at equilibrium, we can see that the system predicts an increase in the services that Information Systems (TAXIS) provide to Citizens and Accountants. There is an increase (0.540) in the "Customers served by a New Era Accountant" and, in contrary, a larger decrease (-0.716) in the "Customers served by a Past Era Accountant". In a similar way "Total Customers served by New Era Accountants" have increased (0.754) while "Total Customers served by Past Era Accountants" have rather decreased (-0.782). The "Ratio New Era Accountants to Past era Accountants" has considerably increased (0.722) showing the intentions of Accountants to follow the changes that new technology brings. Furthermore the "Income of New Era Accountants" has increased (0.618) while the "Income of Past Era Accountants" is quite decreased (-0.682).

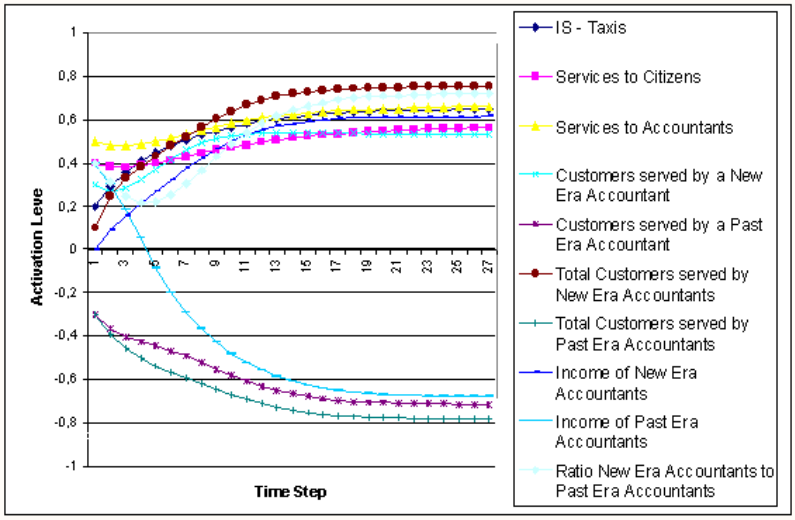

Figure 8 : Transition phase of FCM model concerning the impact of Information Systems to New Era and Past Era Accountants in Greece.

6. Summary – Conclusions

Using the FCM method, two FCM models were created in order to adjudicate for the impact of Information Systems to Accountants in Greece based on the views of a domain expert. The model was examined statically and the signs of models' cycles were identified. Using the CNFCM technique for simulations, various scenarios were introduced to the model. Through the study of the simulations, the conclusions that were drawn are the following:

a) Information Systems like TAXIS that facilitate Citizens and Accountants will increase the quantity and quality of services provided by accountants.
b) If the development of Greek Economy is "low" or "very low", the income of Accountants and the Accountants' Supply in the Greek labour market is expect to slightly increase or remain stable to current levels, while no development of the Greek Economy will decrease the income of Accountants and the Accountants' Supply.
c) New Era Accountants capable of using the new technologies will serve more and more customers, increasing their income, while Past Era Accountants will serve fewer customers, decreasing considerably their income.
d) Many Past Era Accountants due to the situation will become New Era Accountants. This evolution can be achieved only with the support of educational institutes, that will offer to Accountants, the necessary seminars or continuing education courses in order to provide them with the essential skills to use new technologies.

In this study, the CNFCM flexible structure is proved to be suitable for making predictions in fuzzy and uncertain situations like the introduction of new technologies. Through simulations, predictions can be made and scenarios can be introduced and tested. The important key for the success of an FCM model remains the validity of the knowledge that is extracted from domain experts and is used for the creation of the model.

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