Fuzzy Cognitive Maps In Estimating The Repercussions Of Oil/Gas Exploration On Politico-economic Issues In Cyprus

Costas Neocleous
Department of Mechanical Engineering
Cyprus University of Technology,
Lemesos, Cyprus
costas.neocleous@cut.ac.cy

Christos Schizas
Department of Computer Science
University of Cyprus
Nicosia, Cyprus
schizas@ucy.ac.cy

Maria Papaioannou
Department of Computer Science
University of Cyprus
Nicosia, Cyprus
cs03pm2@ucy.ac.cy

***Abstract*—Some important politico-economic dynamics, in relation to different scenarios involving the finding and exploitation of oil/gas in the exclusive economic zone of Cyprus, have been modeled and examined through the use of suitable fuzzy cognitive maps. In the interrelated dynamics, various important dynamical parameters have been taken into account, reflecting the interests of the republic of Cyprus, as well as the interests of the Greek and Turkish Cypriot communities. In some respects these interests are antagonistic, while in others could be cooperative. The interests of other countries involved in the Cyprus politico-economic problem have also been taken into account. These are primarily Greece, Turkey, United Kingdom, USA, Russia, Israel and the European Union. The main parameters involved in the interrelated dynamics are nationalism, religiousness, knowledge of history, level of educational development, tourism, unemployment, external debt, oil extraction, Anatolian settlers, and the general interests of the countries involved and those of the two communities. The system that has been developed can be used to study the effects of a change in any parameter or a combination of parameters, on the growth and stability of the remaining parameters. Different scenarios on the effects on economies, politics and military involvement have been implemented, observed and appraised.**

Keywords-fuzzy cognitive maps; Cyprus problem; politico-economic modeling.

I. INTRODUCTION

Cyprus is a small island in the Eastern Mediterranean. It has about 900,000 inhabitants. The population consists of approximately 78% Greek-Cypriots, 18% Turkish-Cypriots and the remaining 4% of Armenian, Maronite and Latin-Cypriots. Turkish and Greek Cypriots lived mostly harmoniously for almost five centuries. Since the early 1960s and more intensely after July 1974 when Turkey invaded the island, there have been political problems between the two dominant communities. Turkey occupies about one third of the territory of the Republic of Cyprus, and is systematically changing the social fabric by bringing Anatolian settlers into the island. This creates thrifts and conflicts among the genuine inhabitants.

The dynamics involved for the security and stability of the island, as well as the economic development, are related to the interests of both the Greek-Cypriot and the Turkish-Cypriot communities. Theses dynamics have been influenced largely by the strategic position of the island, being at the Eastern Mediterranean, where many conquerors and civilizations spread their influence (Greek, Roman, Byzantine, Arabs, Francs, Venetians, Crusaders, Ottomans, Turks, and English). The historical roots of the two communities forged them to be both cooperative and antagonistic. Also, the interests of other countries involved in the problem played a significant role in the politico-economic developments. These are primarily Greece, Turkey and the United Kingdom.

The accession in 2004 of Cyprus into the European Union, as well as the recent political – social unrest in the wider Mediterranean neighborhood (Tunisia, Egypt, Libya, Syria and Jordan) has made the involvement of Europe, USA, Russia and Israel to be highly important influential-dynamical factors.

In this work, an attempt to model the dynamics of the problem, using a fuzzy cognitive map-like (FCM) approach has been made. More specifically, the main parameters involved in the interrelated dynamics are:

- The overall interests of the Republic of Cyprus,
- The economic welfare of both communities,

- The risk of conflict between the two major communities,
- The importance of oil/gas exploration,
- The unemployment,
- The level of tourism, and
- The general interests (political, economic, military) of the countries mentioned previously and the interests of the two dominant communities.

A cognitive map is a set of cause-effect relationships that model the interrelationships among specific concepts (also identified as characteristics, factors, parameters, attributes, states, actions, values, goals, trends, events, components, resources etc). By using an appropriate systematic process it is possible to estimate the effect of a change in the state of a specific concept on any other concept (or set of concepts) of the system. The concepts are related through directed graphs. The intensity of the interrelationships among them is not clearly known, and thus, suitable membership functions may be used. Different fuzzy cognitive map paradigms have been proposed [2, 3, 4, 5, 6, 7], and different application areas have been investigated [8, 9, 10, 11, 12, 13]. In most of the applications each concept is related to the other concepts through appropriate degrees of effectiveness (also called sensitivity, weights, causality). Once the parameters have been identified and initialized, the system is allowed to grow through proper simulation. When the system settles, a researcher can observe the effects of a change in the state of one factor on the intensity of change in another.

The work reported here is mainly involved with an effort to apply an FCM variant to the dynamics of the Cyprus problem, aiming at getting some useful insight on the effectiveness and interactivity of the important contributing parameters, primarily the importance of the oil/gas exploration in the future events in Cyprus. Also, it may be used as a study tool for exploring complicated economic-political dynamics through the use of computing simulations.

II. THE FCM SYSTEM

Computationally intelligent systems have largely been inspired by natural or real life systems. A general observation is that dynamical systems in nature as well as political-economical-social systems, in which the parameters are characterized by causal relations, tend to reach quasi-steady states. That is, after interacting with each other, the parameters may reach equilibrium, cyclic behavior, or chaotic oscillation. The parameters of a system change iteratively their values, as a response to the first change(s) that happen in the system. Also, in real systems, an adaptive evolutionary behavior is usually observed, something that is not captured in the classic FCM paradigms.

In the present study, a slightly different approach from the established FCM formalism is adopted.

Consider an FCM system of n interrelated concepts (parameters), which are connected by causal relations, here called sensitivities. The sensitivity relating the changes in the activation of a concept C_j to changes in the activation of a concept C_i is defined by:

$$s_{ij} \equiv \frac{\partial C_j}{\partial C_i} \tag{1}$$

Thus, the total accumulated change in the activation of concept C_j due to changes in concepts C_i is given by:

$$\delta C_j = \sum_{i,i\neq j}^{n} \frac{\partial C_j}{\partial C_i} \delta C_i = \sum_{i,i\neq j}^{n} s_{ij} \delta C_i \tag{2}$$

where,

C is the activation strength of the concept of interest.

s_{ij} is the sensitivity (weight).

It is a measure on how much a change in the current standing of concept C_i affects the changes in the standing of concept C_j.

In discrete time form the above equation becomes:

$$C_j(t+\delta t) = C_j(t) + \delta C_j = C_j(t) + \sum_{i=1}^{n} s_{ij} \left(\delta C_i\right) \tag{3}$$

and in iterative form has been implemented by:

$$C_j(k+1) = C_j(k) + \sum_{i,i\neq j}^{n} s_{ij} \left(C_i(k) - C_i(k-1)\right) \tag{4}$$

where,

k is the iteration counter.

It is pointed here that this approach is different than the approach that is followed by most FCM implementations in two respects:

i) The weights (sensitivities) are defined differently, as previously explained, and

ii) No smoothening activation function, such as the logistic has been used.

The updating is done quasi-statically and interactively until the system evolves to settlement specified by desired boundaries. Any changes in the various concepts affect either directly or indirectly all the other concepts of the system.

III. THE FCM CONCEPTS

For the study presented here, 42 influencing parameters (concepts) have been used. These are shown in Table 1.

It should be mentioned that these factors are difficult to quantify. Also they are not fully agreed by every person involved in the analysis and decision. Some form of fuzzy approximation may be employed, using persons having good knowledge (experts) and extensive experience (politicians). Furthermore, each one of them embodies a general state (and associated trend), as it is commonly employed and understood. For instance by the term “General welfare of the Republic of Cyprus” we mean a state that has characteristics of prosperity, political stability, social development, high quality of life, etc. The initial starting values are also shown in Table 1. These have been estimated by the experts, and given as the average of their suggestions.

Three knowledgeable persons have been asked to suggest the various sensitivities that were used to update the various concepts as per Equation 4. Obviously, there are discrepancies between the values given by each person. This is indicatively

shown in Figure 1, where the values given by three persons are displayed in colours. The green colour shows a non-relationship ($s_{ij} = 0$). The blue numbers are positive sensitivities, and the red negative.

The average of the sensitivities that have been used are as shown in Table 2.

IV. Results and conclusions

The effects of finding and exploring oil and/or gas, on various political, economic and military issues and parameters - based on the average sensitivity values from the three experts (Figure 1) - are shown in Figures 2, 3, 4. In these figures, the horizontal axis shows the initial (starting) values of the concept "IMPORTANCE OF FINDING AND EXPLOITATION OF OIL/GAS", from 0% to 100%, i.e from no natural gas available, to the highest possible. In the vertical axis, the resulting percentage changes in various parameters and factors of interest, which are due to natural gas exploration variations, are shown. These values are obtained after evolution and settling to stable values of the FCM model. The initial values used, other than those of oil/gas, are those displayed in Table 1.

Due to the constraint of having to maintain a reasonably short paper, only three major areas of interest are presented, namely the economic and political effects as well as the military interests. In all the cases examined, the concept C38 (importance of oil/gas exploration) was sequentially initialized to starting values of: 0%, 15%, 30%, 45%, 60%, 75%, and 100%. The exact absolute values are not that important, but rather the relative changes that indicate trends, and can serve as guidance to decision makers, and for better appraisal of the system dynamics.

The various changes and associated trends have been investigated for the following areas of concern:

- Effects on the economic interests of USA, Russia, UK, Israel, Greece, Turkey and Europe.
- Effects on the military interests of USA, UK, Israel, Greece and Turkey.
- Effects on various economic characteristics of the Republic of Cyprus.
- Effects on nationalism of the two communities and the risk of conflict between them.

The FCM model has shown interesting and somewhat expectable trends and effects based on the scenarios studied. However, by closely observing the various trends, some notably interesting observations and conclusions may be made. Specifically, the model predicts that the Turkish Cypriot community and Greek Cypriot community will benefit approximately equally from the prospects of finding and exploiting any natural gas/oil, even though the potential oil/gas fields are located in the south-eastern zone of the Republic, whereas most of the Turkish Cypriot population lives in the north of the island. This of course depends on whether the exploitation is done through peaceful operations. In fact, another relevant observation made, is that any oil/gas exploitation increases the risk of conflict between the two communities. Thus, the situation becomes strongly politically influenced.

As expected the military interests of the countries mentioned, are increasing as the prospects for oil/gas exploitation increase. This increase is also nonlinear, resulting at even more interest, as more natural gas may be exploited (Figure 4). It is also observed that Turkey will show the greatest increase in military interests, followed by Greece.

Also, a very interesting observation can be made concerning the growth of nationalism in the two communities (Figure 3). It is noted that the model predicts a significant increase in the nationalism of the Greek Cypriots, but even higher for the Turkish Cypriot community.

However, it should once again be pointed out that the model is based on what the three experts considered as important parameters, and influencing sensitivities, that may not necessarily agreed by all, and that they may be incomplete and vague. In order to make the model more reliable, one has to get more expert opinions (from politicians, journalists, historians, authoritative analysts etc). Also, results from large scale public opinion research may be incorporated into the system.

Despite that, the proposed FCM model is a highly useful tool for quick explorations, for better understanding of the dynamics involved, for more sound decisions, and for building a basis for more complicated scenarios. However, further explorations are needed to verify the credibility and to fine-tune the various parameters and processes.

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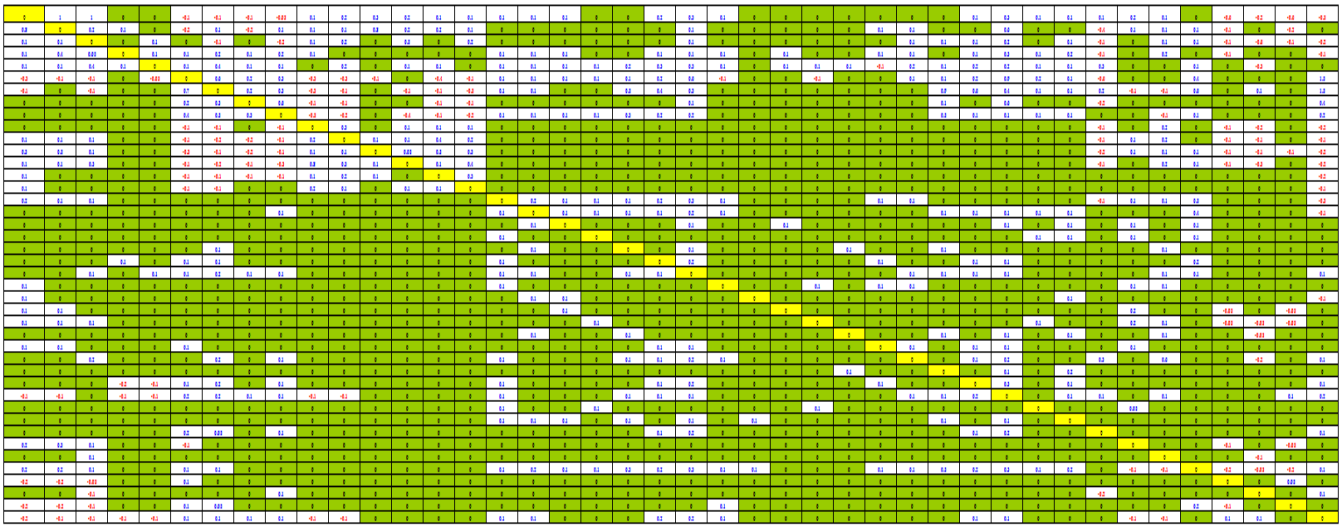
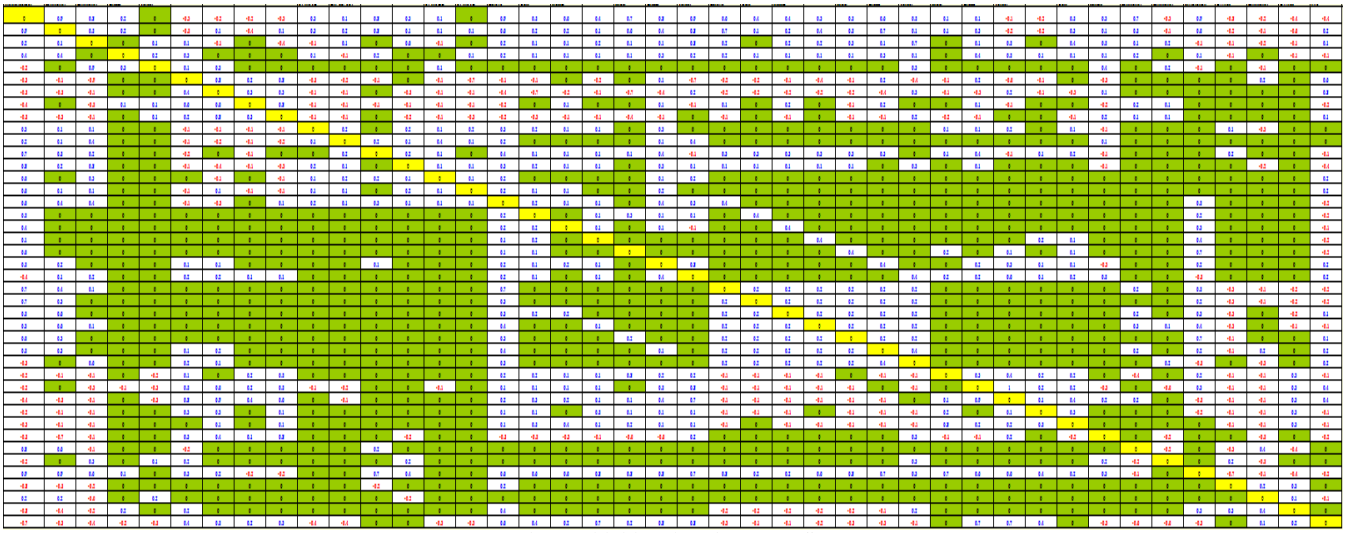
TABLE 1
THE VARIOUS INFLUENCING PARAMETERS THAT HAVE BEEN STUDIED
(GC = GREEK CYPRIOT, TC = TURKISH CYPRIOT)

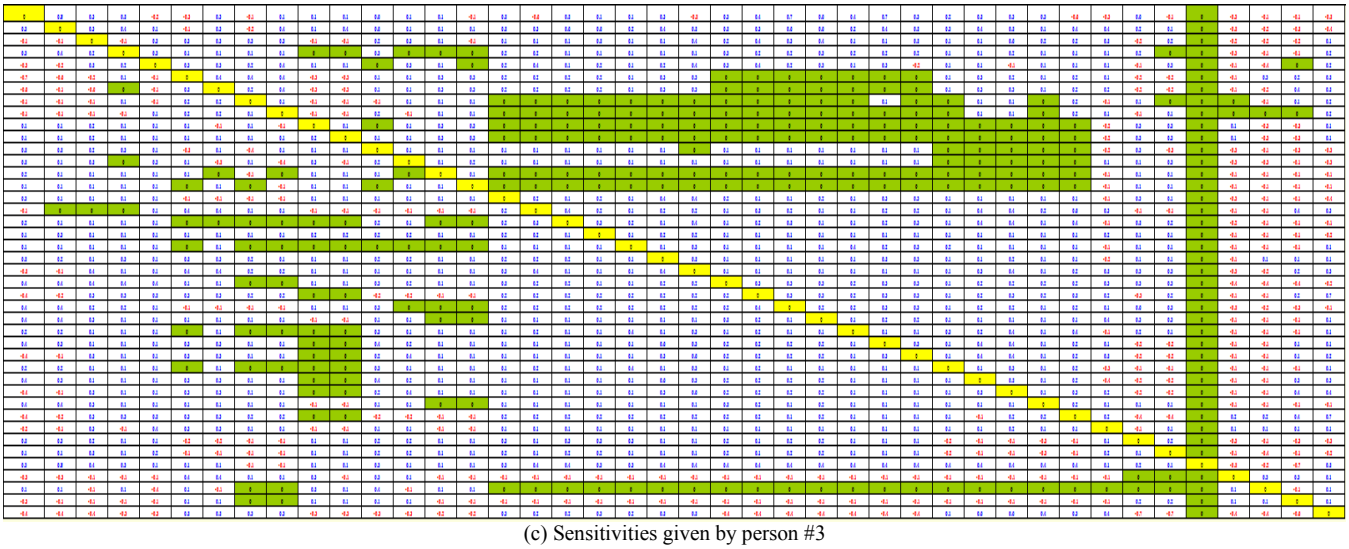
	CONCEPT	INITIAL VALUES
C1	General welfare/standing of the Republic of Cyprus	50%
C2	Economic welfare of GC community	50%
C3	Economic welfare of TC community	30%
C4	Economic welfare of Greece	20%
C5	Economic welfare of Turkey	20%
C6	Greek Cypriot Nationalism	50%
C7	Turkish Cypriot Nationalism	50%
C8	Christian religiousness	50%
C9	Islamic religiousness	50%
C10	Knowledge of Greek language by the TC community	50%
C11	Knowledge of Turkish language by the GC community	50%
C12	Educational level of the GC community	50%
C13	Educational level of the TC community	50%
C14	Knowledge of Turkish history by the GC community	50%
C15	Knowledge of Greek history by the TC community	50%
C16	Political interests of Europe	50%
C17	Political interests of USA	50%
C18	Political interests of Russia	40%
C19	Political interests of UK	50%
C20	Political interests of Israel	50%
C21	Political interests of Greece	60%
C22	Political interests of Turkey	60%
C23	Economic interests of Europe	50%
C24	Economic interests of USA	50%
C25	Economic interests of Russia	50%
C26	Economic interests of UK	50%
C27	Economic interests of Israel	50%
C28	Economic interests of Greece	50%
C29	Economic interests of Turkey	60%
C30	Military interests of Israel	50%
C31	Military interests of Greece	50%
C32	Military interests of Turkey	50%
C33	Military interests of UK	50%
C34	Military interests of USA	50%
C35	Interests of Anatolian settlers	50%
C36	Level of tourism in the GC community	50%
C37	Level of tourism in the TC community	50%
C38	Importance of Oil/gas exploration	---
C39	Unemployment in Republic of Cyprus	50%
C40	Unemployment in TC community	50%
C41	External debt of Republic of Cyprus	50%
C42	Risk of conflict between the two communities	50%



(a) Sensitivities given by person #1



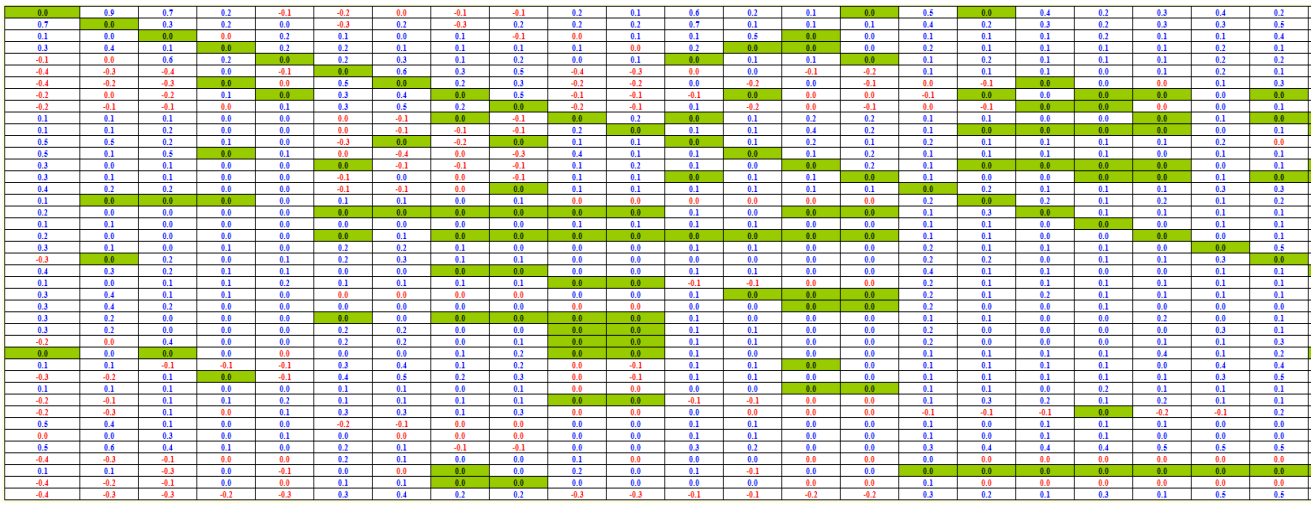
(b) Sensitivities given by person #2



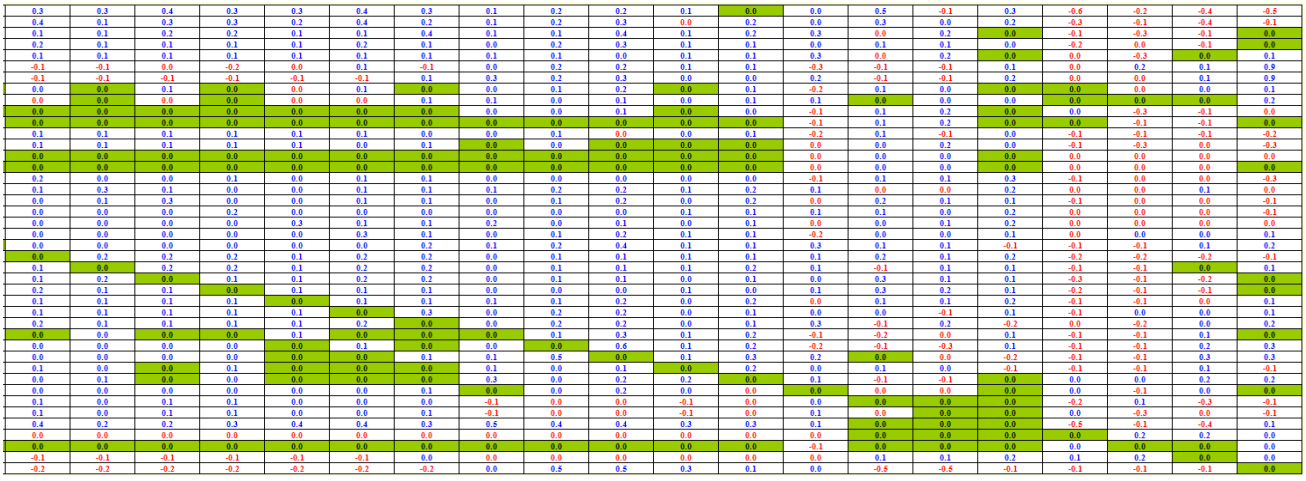
(c) Sensitivities given by person #3

Figure. 1. The sensitivities suggested by three different experts.

TABLE 2
THE AVERAGE OF THE SENSITIVITIES



(a) Sensitivities for concepts 1 to 21



(b) Sensitivities for concepts 22 to 42

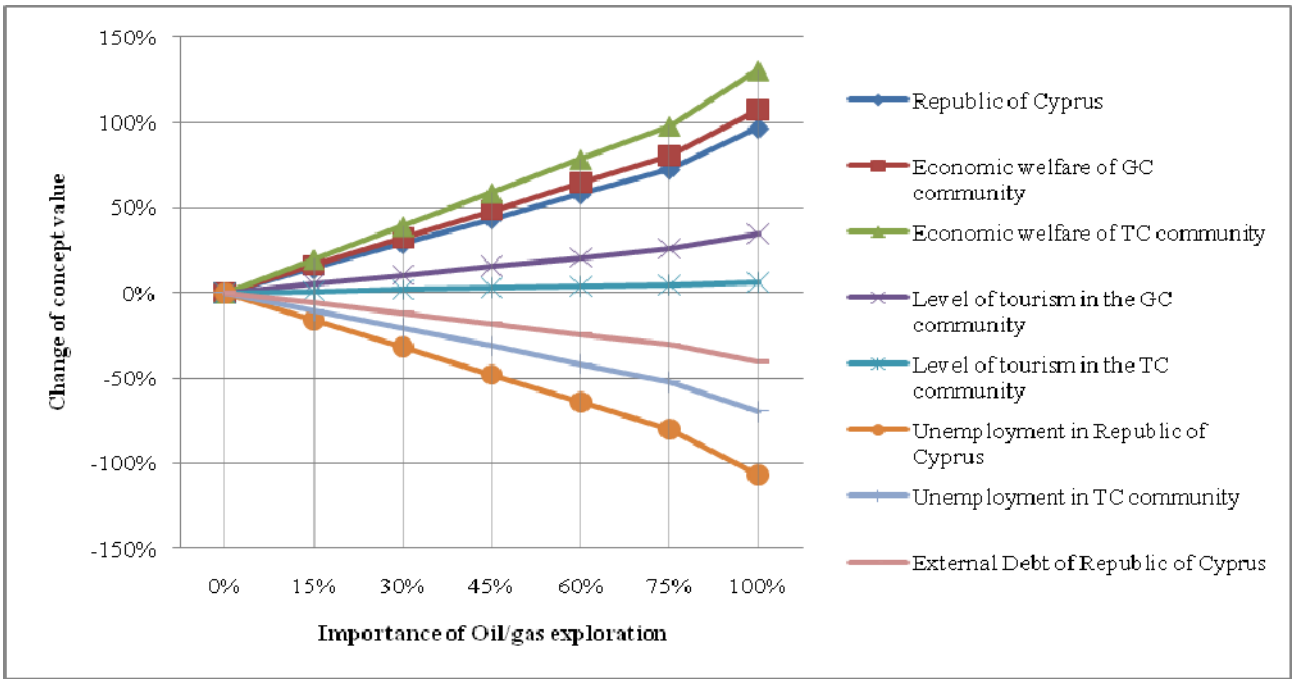


Figure 2. Effects on various economic parameters/issues, based on the average sensitivity values.

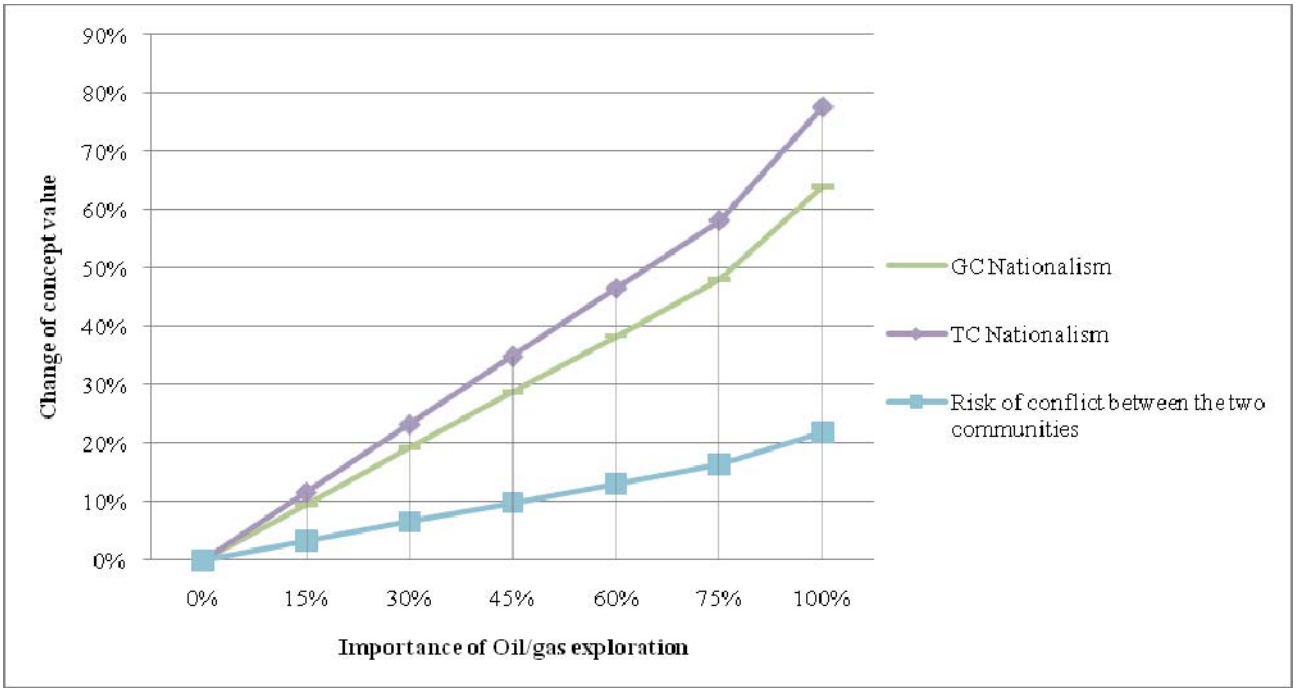


Figure 3. Effects on various political issues based on the average sensitivity values.

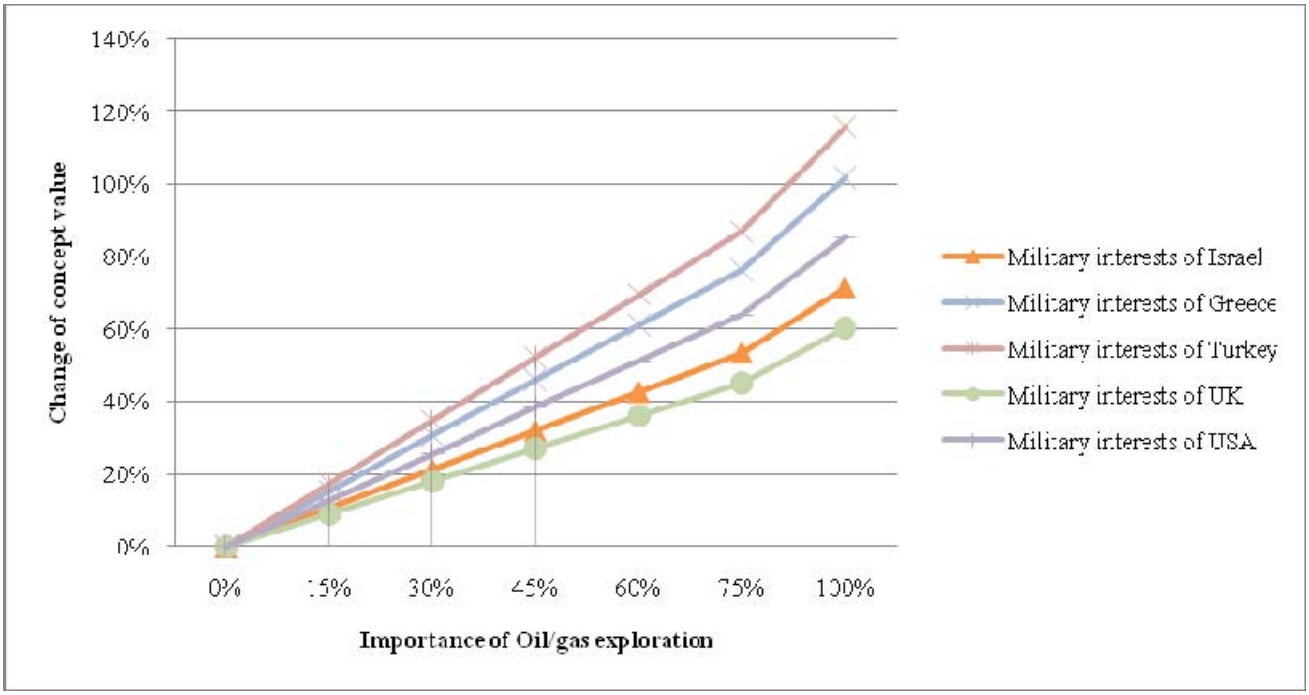


Figure 4. Effects on various military issues, based on the average sensitivity values.