Intelligent information systems for defence problems

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INTELLIGENT INFORMATION SYSTEMS SOLVE COMPLICATED DEFENCE PROBLEMS

THE GREEK–TURKISH ARMS RACE AND THE CYPRUS ISSUE

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To our parents Seviros and Maroula, Andreas and Eleni

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INTRODUCTION

INTRODUCTION

"Greeks and Turks have been condemned by History to learn how to co– exist" (Constantine Mitsotakis, Greek Prime Minister, Parliament speech on foreign policy, February 24, 1992).

If we were asked to describe the relations between Greece and Turkey in a manner as comprehensive as possible then a good idea would be "a long history of unsolved problems". The extent to which some or, maybe, even all of these problems would have been solved in the course of time, has remained an open issue offering ample room to what economists call "normative thinking" involving personal evaluations and value judgments. A representative sample of such normative thinking, can be easily traced during various media shows in Greece when a wide variety of "experts" are invited to support an even wider variety of opinions, presented as a rule, with a few notable exceptions, in the form of sweeping generalizations. It seems, at least according to the polls, that Greeks adore this kind of fruitless argument for the sake of argument. They even use a very descriptive term to refer to it as "conversation between deaf" to underline the chaotic atmosphere created by the panel members raising their voices to a stentorian level hoping that this will make their point of view more convincing. We suspect that the reason why the public adores such a show is simply because it seems that it is the best that the media can offer in terms of entertainment.

Joking apart, however, history has pointed out in more ways than one that the problems in the relations between Greece and Turkey are matters far too intricate to be treated as media shows. And the first thing one must do in order to appreciate the complexity of the relations between the two sides is to take a look at their historical background in the area. In fact, archaeology indicates that the roots of the Greek civilization in the Aegean date back to the Neolithic age (7000 to 6000 b.C.) its presence culminating during the prime of the Minoan and the subsequent Mycenaean civilization (since 1600 b.C.). By 500 b.C. all the islands in the Aegean and along the entire Asia Minor are inhabited by Greeks whose colonial expansion reaches as far as Syria and Italy. The Byzantine Empire has made the Greek presence in the area even stronger until its fall in May 1453, which started the Turkish occupation of Greece that lasted about 400 years. In fact the Turks who appeared in the region during the 11th century A.D. conquered the Greek mainland and the islands between 1456 and 1669. Greece had to wait until 1821 to resume its independence with the revolution in March of that year marking the revival of the Greek dominance in the area. All territorial disputes remaining were terminated by the Treaty of Lausanne (July 24, 1923) while all Greeks were driven away from Asia Minor. Finally, the Treaty of Paris (February 10, 1947) acknowledged Greek sovereignty on the Dodecanese isles thus raising the number of Greek islands to a total of 3,100 of which 2,463 are found in the Aegean inhabited by about 15% of the total Greek population.

The case of Cyprus is equally interesting: The Greeks settled on the island during the 2nd millennium b.C. while the Persians conquered it in 540 b.C. and held it until 330 b.C. when Alexander the Great put an end to the Persian rule of the island. Cyprus was ruled by Alexander's Ptolemy descendant dynasty until 30 b.C. Since then, and until 330 A.D. the island became a province of the Roman Empire and, later on, of the Byzantine Empire. After the fall of Constantinople, the Ottoman Empire took over Cyprus from the Venetians in 1571, only to cede it to Great Britain in 1878. In 1923, the Treaty of Lausanne formally acknowledged the British rule over Cyprus while Turkey renounced all claims on the island. In 1960 Cyprus was established as an independent Republic.

In both the Aegean and the Cyprus case, the status, as described above, has been under continuous challenge by Turkey since 1973, questioning, in particular, issues concerning the Greek F.I.R, the territorial waters in the Aegean Sea and the continental shelf of the islands. Concerning the case of Cyprus, moreover, the occupation of about 40% of the island by Turkey since July 1974, following a coup aiming at overthrowing President Makarios, is rather unacceptable being, among other things, in direct conflict with the status of Cyprus as a full E.U. member since April 2003. In fact, it seems that the rapid developments with regard to the rapprochement of the Greek and the Turkish Cypriots after that date have revealed an intrinsic dynamism which may prove to be much more effective in terms of settling the Cyprus issue compared to all efforts undertaken thus far mainly by the U.N.

In any case, however, and given their degree of complication, the Greek-Turkish relations and the Cyprus issue are problems the solution of which requires much more than just personal opinions and subjective evaluations. Those involved in such debates, be it discussants, experts or, even, decision-makers, remind of players trying to play football in the absence of an appropriate playing field. Their next option, of course, will be to play in the streets meaning that it is going to be a matter of time before the ball breaks the neighbor's glass window or dirties the laundry drying in her backyard. Exchanging opinions can certainly be very useful provided that those involved agree on an objectively determined platform or framework that outlines the problem and provides the constraints within which they are allowed to apply their proposed solutions. In the absence of such a constraint such exchange of opinions and ideas is bound to remain fruitless and may even cause more trouble instead of contributing to settling the matter.

The purpose of this book is to provide such a platform or framework that will describe the Cyprus problem as a major issue affecting the relations between Greece and Turkey and the arms race between the two countries. It is very important to point out, however, that solving the Cyprus issue is not exactly a prerequisite for settling all disputes between Greece and Turkey. The Greek-Turkish relations and the Cyprus problem must be regarded as being two very important, however entirely distinct issues. It goes without saying, however, that a mutually acceptable solution to the latter will contribute to the improvement of the former to a large extent. Going back to the construction of our platform, what we have decided to do is to resort to the help of mathematics, always bearing in mind that they can be a useful servant, however a very bad master. In other words we have applied a number of mathematical techniques that have contributed just to the point at which the key determinants in this conflict are underlined thus offering a clear description of the relations between the two sides with emphasis on the issue of Cyprus. The picture thus obtained is then used for suggesting answers on a number of key questions, much more effectively, we believe, compared to the results of any panel discussion. In any case, however, the responsibility of the final decision concerning policies employed on such complicated issues certainly burdens the politicians' shoulders. As far as we are concerned, we will be happy to know that the conclusions reached in this book are taken in consideration during the decision-making process in the interest of peace. After all, it is only natural to expect that it will require all the "intelligence" of our defence information systems in order to provide plausible answers to such crucial political and strategic issues.

Irrespective of the importance of our contribution, however, one must always bear in mind that "computational intelligence is no match for natural stupidity". In other words no matter how helpful the results of techniques of analysis may be their usefulness or otherwise can only be certified to the extent that the policy makers use them appropriately. We feel, however, that such a possibility is too good to be true. In fact, one cannot help but be disappointed by the way, in which politics for the sake of politics has disregarded national interests in Greece during the past. This is why when we first decided to write this book, we did so as a reaction to a feeling of regret that had overwhelmed us. Regret about the ignorance, superficiality and loss of values, indifference to national interests, demagogy and personal interests triumphing over national interests. The dominance of the former at the expense of the latter is crystal clear if one takes a look at the proceedings of the Parliament discussions on how to spend the leftovers of what used to be the 5-year procurement programme of the Greek armed forces. The main complaint of the opposition during that session focused not on the extent to which the purchase of a specific weapon would prove to be useful for the defence of the country, but, instead, on why the procurement had been assigned to dealer A rather than dealer B! We believe that this is more than enough to indicate complete loss of sense of responsibility the consequences of which can be fatal to such an extreme, that no technical analysis could ever rectify.

Given, however, that optimism has never hurt anyone we have decided to present our views on the Greek-Turkish relations and the Cyprus problem in this book. We would consider ourselves the happiest people on earth if our conclusions would contribute, even to a very small extent, to settling these intricate national issues.

The first paper of the book aims at forecasting the burden on the Greek economy resulting from the arms race against Turkey. We employ alternatively the military debt or the defence share of GDP in order to approximate the measurement of such a burden, using artificial neural networks. The use of a wide variety of explanatory variables in combination with the promising results derived suggest that the pressure on the Greek economy resulting from this arms race is determined to a large extent by demographic factors which strongly favor the Turkish side. Prediction on both debt and expenditure exhibited highly satisfactory accuracy, while the estimation of input significance, has indicated that variables describing the Turkish side are often dominant over the corresponding Greek ones.

The next paper proposes a measure of relative military security applicable to evaluating the impact of arms races on the security of alliance members. This measure is tailored to fit the case of Greece and Cyprus, on one hand, and Turkey on the other, in which demographic criteria play a dominant role. Once again, artificial neural networks were employed, this time trained to forecast the future behavior of relative security. The high forecasting performance permitted the application of alternative scenarios for predicting the impact of the Greek-Turkish arms race on the relative security of the Greek-Cypriot alliance.

Professor Michael Vrahatis and Dr. Konstantine Parsopoulos of the University of Patras have contributed substantially in determining the optimal figure for defence expenditure, which is the scope of the third paper. What we do, more specifically in this case, is evaluate the optimal military expenditure for Greece and Cyprus compatible with the constraints imposed by the resources of their economies in the context of the Integrated Defence Doctrine. All experiments and scenarios examined using a special algorithm designed by the two experts lead to the conclusion that the current defence burden of the two allies seems to be driving their economies beyond capacity limits. Reducing defence expenditure, however, seems prohibitive given the volatility of the current political circumstances. This means that the one-sided disarmament policy followed by Greece, since 2001 is a risky choice bearing in mind the long-term armament programmes pursued by Turkey, whose role in this arms race has been proven as leading.

The same algorithm by Parsopoulos and Vrahatis has been used in the fourth paper to point out that the security benefit that Greece derives thanks to its alliance with Cyprus exceeds the corresponding Cypriot benefit by far. This conclusion is supplemented by pointing out that Cyprus is able to contribute to the alliance security more in terms of human resources. As regards Greece, its demographic weakness justifies its recent defence policy revision that emphasizes on quality, capital equipment and flexibility of forces in order to face the security requirements of the alliance and the increasing demands of its arms race against Turkey.

A couple of words of caution may be necessary at this point: It is our firm belief that the disagreement as to the extent to which an arms race is indeed going on between Greece and Turkey (Brauer 2002 and 2003) is due, in most cases, to the shortcomings of the traditional techniques of analysis employed, as pointed out by Taylor (1995) and Kuo and Reitch (1995). We have, therefore, decided to resort to using advanced mathematical techniques to prove not only the existence of such a race, but also the causality direction that determines the side that takes the initiative in this race. More specifically, Chapter 1 employs the technique of artificial neural networks to establish the arms race between the two sides, as well as the various causal relationships between the variables involved. What Chapter 3 does, in addition, is to take a step further by calculating the optimal defence expenditure for the two allies, namely Greece and Cyprus. It will become clear during the analysis that the term “optimal” refers to the maximum defence burden allowed by the constraints imposed by the economy in each case and does not consider any non-economic restrictions related to geopolitical or strategic matters. While this optimal defence expenditure can be supported by the economy without any major redistribution problems, any defence increases over and above this optimal level may be feasible only by shifting resources from non – defence to defence activities which can be taken to approximate the so called “peace dividend”.

We are certain that the reader realizes the importance of these issues, especially when it comes to the arms race between Greece and Turkey, bearing in mind the adverse economic conditions prevailing in the economy of the latter in view of its request for a full EU membership. The $150 billion long term Turkish procurement programme, in particular, is expected to impose a disproportionally heavy burden on the country's economy (Pavlopoulos 2000). The interesting part in this story refers to the substantial fraction of this sum representing the orders for the Turkish navy which requests, among other purchases, an aircraft and a helicopter carrier. Given that, according to the defence dogma of Turkey, the only possibility of a crisis requiring emphasis on naval warfare will involve Greece it is only straightforward to see the extent to which the allegation that we "presume the existence of an arms race between Greece and Turkey" in our research (Brauer 2003, page 29) is by all scientific standards simply wrong!

The second important point concerns the objections we have faced with regard to referring to the Integrated Defence Doctrine as a form of alliance between Greece and Cyprus. In fact the spectrum of objections has been so wide that it starts by questionning our translation of the Greek "Ενιαίον Αμυντικόν Δόγμα", claiming that the word "Joined" is more applicable than "Integrated". The former, however, is much weaker, since the degree to which two parts may be joined may vary from a loose to a very tight extreme, while "integration" reflects exactly what "Ενιαίον" means: A complete unification. As regards the extent to which such an alliance exists, the answer is the following: There are very few sources in the literature describing the "de jure" structure of this alliance (Hellenic Ministry of Defence 2000), a thing that may justify, partly at least, the reluctance of this criticism to accept the Integrated Defence Doctrine. In its "de facto" form, however, this alliance has been fully operational for about twenty years or so despite the fact that its technical description reminds very little of what the standard Theory of Alliances dictates.

After providing the necessary background describing the relations between Greece and Turkey with special reference to the arms race between them, we make use of a genetically evolved certainty neuron fuzzy cognitive map in order to forecast developments concerning the Cyprus puzzle. What we do, in this case, in which Nicos Mateou has contributed substantially, is forecast the extent to which a settlement of the Cyprus issue may be possible given the decisions taken during the Copenhagen EU summit. We then consider the possibilities of an improvement in the Greek-Turkish relations which would, under certain conditions, lead to reducing the arms race between the two countries. The simulation exercises involve a number of scenarios examining the possible reactions of all sides involved in the Cyprus issue, namely Greece, Turkey, Cyprus, the Turkish-Cypriot community and the international environment. The results derived suggest that the Greek and the Cypriot side must not necessarily rely on the decisions taken during the Copenhagen summit conference with regard to the EU full accession of Cyprus. The forecasts point out, in addition, that the optimism of the Greek government concerning the outlook of its relations with Turkey and the subsequent reduction of the arms race against it is far from being justified.

Concluding this introductory chapter we must point out that we have benefited a great deal by our discussions with Ambassador I. Bourloyannis and Professors M. Evriviades and P. Ifestos to whom we are indebted. Needless to say that we are responsible for any remaining errors as well as for the lack of any dose of diplomatic flavour, especially in the technical chapters. In fact the entire book reveals our preference for straightforward mathematical logic at the expense of diplomacy. Despite the fact that the two are not necessarily mutually exclusive, the fact remains that this book addresses primarily decision - makers to whom we leave the task of translating our proposals into the language of diplomacy.

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A.S. Andreou and G.A. Zombanakis

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CHAPTER 1

CHAPTER 1

Financial Versus Human Resources in the Greek-Turkish Arms Race:

A Forecasting Investigation Using Artificial Neural Networks[*]

By

Andreas S. Andreou and George A. Zombanakis

1.1 INTRODUCTION

The Greek-Turkish conflict over a variety of strategic issues dates back several centuries, having entangled the two countries to the vicious cycle of a very expensive arms race (Kollias and Makrydakis, 1997). The aim of this paper is to forecast the pressure due to this arms race between Greece and Turkey exercised on the economy of the former. This forecast, established on the basis of the most appropriate explanatory variables, will provide the opportunity to comment on the nature and relative importance of the explanatory variables that determine the burden of this arms race on the Greek economy, as this is approximated by either the military debt of the country or the defence share of GDP. The method of analysis used is that of Artificial Neural Networks, which has been considered preferable to the conventional estimation methods for the purposes of the present analysis for reasons analyzed later on in this paper.

It is well known that the cost of an arms race is the disturbance that the excessive military expenditure and the ensuing budgetary imbalances, bring about to the long-run economic growth of the countries involved, as these strive to maintain the balance of power between one another. The foreign sector of these countries, in particular, to the

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extent that these are characterized as small, open economies, is considerably burdened since military expenditure is highly import-demanding, crowding out funds intended for alternative, non-military uses, and leading to borrowing abroad in order to finance the military spending programmes. This foreign borrowing exerts an adverse impact on both the domestic and the foreign sector: on the former due to the slow-down of economic growth, as stated earlier, and on the latter because of the burden on the balance of payments, which causes the need for more borrowing, thus creating a vicious cycle of an ever-increasing foreign debt (Stavrinos and Zombanakis, 1998). The impact of the arms race with Turkey upon the Greek economy has been particularly painful since about 6% to 7% of the country's GDP is annually devoted to military expenditure. The military debt, moreover, has doubled within the decade of the 1990s to reach about 4 billion dollars at the end of 1997, representing roughly 15% of the total external debt of the country. Both these variables reflect the seriousness of the problem for the Greek economy.

1.2 LITERATURE OVERVIEW

Research seems to favor the military expenditure rather than the stock of the military debt as an indicator of the pressure exercised upon an economy due to an arms race, with only a few notable exceptions, like McWilliams (1987). A large number of papers have followed Benoit (1978), examining the effects of defence spending on growth, like Deger (1986) and, later on Ward et al. (1991), Buck et al. (1993), Looney (1994), as well as several authors in Hartley and Sandler (1990).

Concentrating on the impact of an arms race on the balance of payments and the external debt of the countries that are involved in such a race, the only topic regarding the external sector which appears in the literature concerns the concentration of defence investment on the leading export sectors such as machinery and capital equipment, something which leads to reduction of the availability of exportable and the slowing down of economic growth. Empirical research by Fontanel (1994), considers the independent variables that affect defence expenditure focusing on the impact of military spending in the case of both developed and developing economies, while Levine and

Smith (1997), concentrate on the role of military imports in an arms race between two countries. Specific reference to the case of Greece or to the Greek - Turkish conflict is found in Kollias (1994, 1995 and 1996) and Antonakis (1996 and 1997) who have investigated the economic effects of defence expenditure upon the Greek economy.

The overwhelming majority of papers employ conventional estimation methods with the notable exception of Refenes et al. (1995) who have employed the artificial neural networks approach for determining the defence expenditure of Greece. The advantages of using the neural network facility are multiple and have been repeatedly analyzed in the literature (Kuo and Reitsch, 1995; Hill et. al., 1996). The ones that have attracted our attention for the solution of the specific problem are the following. First, the neural networks do not require an á-priori specification of the relationship between the variables involved. This is a major advantage in our case, since there is no such thing as an established theoretical background that describes the behavior of either the military expenditure or the military debt when these are affected by the independent variables chosen. There does not even seem to be an agreement as to which these variables are. Second, in cases like the present one, in which certain variables are correlated between one another and the pattern of behavior may be non-linear, the neural networks are more applicable. Finally, studies agree on the superiority of neural networks over conventional statistical methods concerning time-series forecasting.

The main objective of this paper, therefore, as earlier stated, is to forecast the pressure that the arms race between Greece and Turkey exercises on the Greek economy and to indicate, with the help of the artificial neural networks technique, the selection of the most appropriate explanatory variables used in specifying such an “arms-race” function. We shall show, more specifically, that the explanatory variables best describing the behavior of the authorities and the reasoning behind such decisions are related to a large extent, to the population characteristics of the two countries, being, therefore, of a non-financial nature in its strict sense. Concentrating on such variables seems to be very interesting in the case of the Greek-Turkish conflict, since the comparison in terms of demographic developments is overwhelmingly against Greece.

The description of the technical background is presented in section 3. Section 4 includes the presentation of the explanatory variables used as input in the analysis as well as the various scenarios considered. Section 5 describes the empirical results obtained, comparing them to those drawn on the basis of an OLS estimate. Finally section 6 sums up the conclusions drawn and evaluates the results.

1.3 TECHNICAL BACKGROUND

1.3.1 Neural Networks

This section is devoted to describing the emerging technology of artificial neural networks. This technique belongs to a class of data driven approaches, as opposed to model driven approaches. The process of constructing such a "machine" based on available data is addressed by certain general-purpose algorithms. The problem is then reduced to the computation of the weights of a feed-forward network to accomplish a desired input-output mapping and can be viewed as a high dimensional, non-linear, system identification problem. In a feed-forward network, the units can be partitioned into layers, with links from each unit in the k^{th} layer being directed to each unit in the $(k+1)^{th}$ layer. Inputs from the environment enter the first layer and outputs from the network are manifested at the last layer. An m-d-1 architecture is shown in Figure 1, which refers to a network with m inputs, d units in the hidden layer and one unit in the output layer.

We use such m-d-1 networks to learn and then predict the behavior of the time-series. The hidden and output layers realize a non-linear transfer function of the form:

$$f(y)=(1+\exp(-by))^{-1} \tag{1}$$

$$y=\sum_{i=1}^{n} w_i x_i \tag{2}$$

where x_i*'s* denote the input values of a node, while w_i's the real valued weights of edges incident on a node and n the number of inputs to the node from the previous layer. Equation (1) is known as the sigmoid function where b is the steepness. Also shown in Figure 1 is a special node at the end of the input layer called "bias". This node has a fixed input value of 1 and feeds into all the neurons in the hidden and the output layers, with adjustable weights as the other nodes. Its role is to represent the adjustable neuron threshold levels explicitly in the transfer function input. The nodal representation eliminates the need to treat threshold as a special neuron feature and leads to a more efficient algorithm implementation (Azoff, 1994).

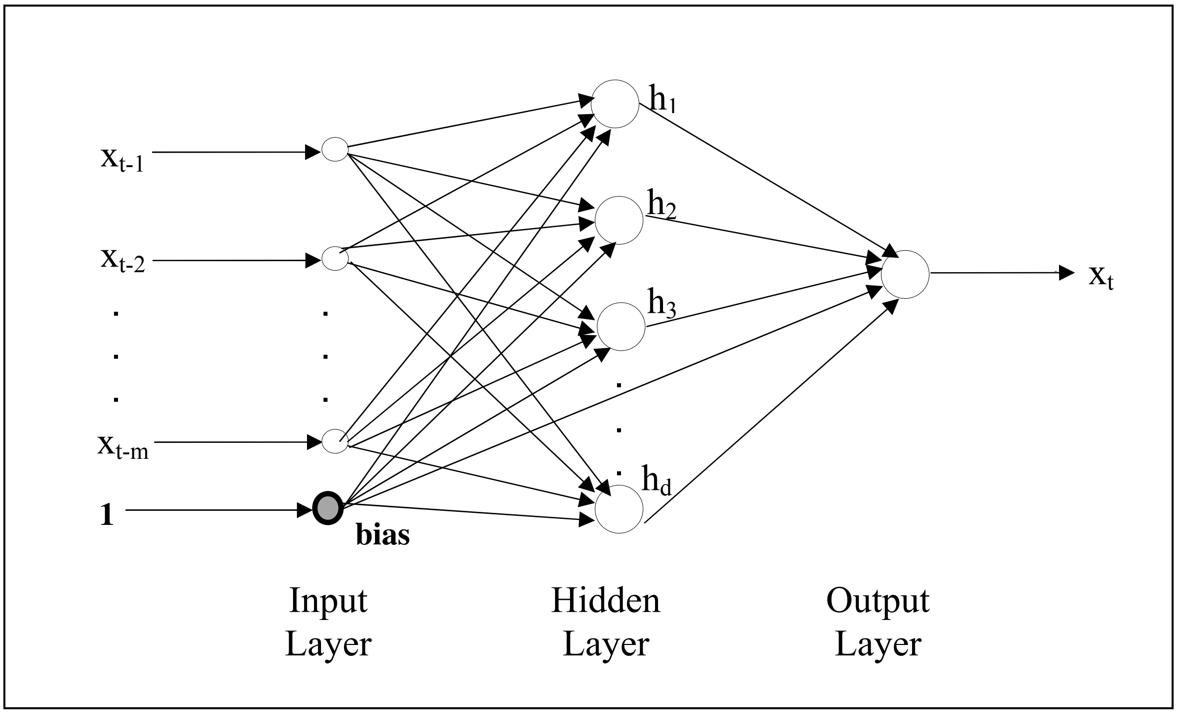


Figure 1. Graphical representation of a Multi-Layer Perceptron feed-forward neural network architecture, with m input nodes, one bias input, d hidden nodes and one output node

1.3.2 System Design

From the given time series $x=\{x(t): 1 \leq t \leq N\}$ we obtain two sets: a training set $x_{train}=\{x(t): 1 \leq t \leq T\}$, and a test set $x_{test}=\{x(t): T < t \leq N\}$, where N is the length of the data series. The x_{train} set is used to train the network at a certain level at which convergence is achieved based on some error criterion. This is done by presenting to the network L-times the sequence of inputs and desired outputs (L from now on will be referred to as epochs) and having the learning algorithm to adjust the weights in order to minimize the diversion of the desired value from the predicted one. The network is asked to predict the next value in the time sequence, thus we have one output neuron.

The range of values for the output neuron is limited to [0,1] by the implementation tool used, so the desired values d_i of both the training and the testing sets are normalized to this range just by taking the ratio *di/dmax*, in order to avoid negative values. Then, the output values o_i predicted by the network can be easily restored by taking the inverse transformation $o_i * d_{max}$. The training algorithm used is the well-known Error Back Propagation with a momentum term (see e.g. Rumelhart and McLelland, 1986; Azoff, 1994).

1.3.3 System Implementation, Training and Testing

The system described above has been implemented using a neural network implementation tool, namely the Cortex-Pro Neural Networks Development System (Unistat, 1994). We used several alternative configuration schemes, as regards the number of hidden layers and the nodes within each layer, in order, first to achieve best performance and second, to facilitate comparison between different network architectures. The number of input neurons and the nature of data fed depend on what we call "scenarios", that is, different cases in which, using some or all of the available input variables/factors, we attempt to forecast the performance of one specific variable not included in the input set. These scenarios will be presented in section 4.

In each scenario, the desired values were normalized in the range [0,1] as stated earlier, while the learning and momentum coefficients (Rumelhart and McLelland, 1986; Azoff, 1994) were kept constant at the positive values of 0.3 and 0.2 respectively.

Every input variable is associated with one neuron in the input layer. Our data series consist of annual observations and the forecasting horizon was set to one step ahead. Determining the number of hidden layers and neurons in each layer can often be a very difficult task and possibly one of the major factors influencing the performance of the network. Too few neurons in a hidden layer may produce bias due to the constraint of the function space, which results to poor performance as the network embodies a very small portion of information presented. Too many neurons on the other hand may cause overfitting of data and increase considerably the amount of computational time needed for the network to process data, something which will not necessarily lead to convergence. We therefore have used a variety of numbers of neurons within one hidden layer, while in some cases a two-hidden-layer scheme was also developed in order to investigate whether performance is improved.

The number of iterations (epochs) presenting the whole pattern set during the learning phase is also very important. We have let this number vary during our simulations, since different network topologies, initial conditions and input sets, require different convergence and generalization times. The number of epochs our networks needed for convergence ranged between 3,000 and 10,000. One should be very cautious though when using a large number of epochs, as the network may overfit the data thus failing to generalize.

The problems of bias and data overfitting mentioned above can be overcome by evaluating the performance of each network using a testing set of unseen patterns (testing phase). This set does not participate during the learning process (see e.g. Azoff, 1994). If the network has actually learned the structure of the input series rather than memorizing it then it can perform well when the testing set is presented. Otherwise, if bias or overfitting is really the case, performance will be extremely poor on these "new" data values. Architecture selection is generally based on success during the testing phase, provided that the learning ability was satisfactory.

Performance was evaluated using three different types of errors, specifically the Mean Absolute Error (MAE), the Least Mean Square Error (LMSE) and the Mean Relative Error (MRE). MAE shows the divergence between actual and predicted samples in absolute measures. LMSE is reported in order to have the error condition met by the Back Propagation algorithm. Finally, MRE shows the accuracy of predictions in percentage terms expressing it in a stricter way, since it focuses on the sample being predicted, not depending on the scale in which the data values are expressed or on the units of measurement used. Thus, we are able to estimate prediction error as a fraction of the actual value, this making the MRE the more objective error measure among the three used. LMSE, MAE and MRE are given by the following equations:

$$\text{LMSE} = \frac{1}{2n}\sum_{i=1}^{n}(o_i - d_i)^2 \qquad (3)$$

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|o_i - d_i\right| \qquad (4)$$

$$\text{MRE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{o_i - d_i}{d_i}\right| \tag{5}$$

where o_i is the actual output of the network, d_i is the desired value when pattern i is presented and n is the total number of patterns.

An important aspect examined in the present analysis is the determination of the significance ordering of the variables involved, that is the selection of the variables which contribute more to the forecasting process. This task can be performed using the notions of input sensitivity analysis, described extensively in Refenes et. al. (1995) and Azoff (1994), based on which one can sum up the absolute values of the weights fanning from each input variable into all nodes in the successive hidden layer, thus estimating the overall connection strength of this variable. The input variables that have the highest connection strength can then be considered as most significant, in the sense of affecting the course of forecasting in a more pronounced way compared to others. Presenting the analytical technical background behind these notions is beyond the scope of this work, since the reader may refer to the sources stated above for further information.

1.4 INPUT/OUTPUT VARIABLES AND SCENARIOS

The data set used for the multiple simulations includes the 13 variables listed in Table 1, the sources of which are the Bank of Greece, the International Institute of Strategic Studies, the Swedish International Peace Research Center and the United Nations Population Statistics. Variables A to F and variable Y consist of 36 observations covering the period 1961-1996, while variables G to L consist of 35 observations, up to and including 1995.

Table 1. Variables, data and sources [*]

Code	Data Series	Source
A	Rate of change of Greek GDP.	Greek National Accounts
B	National investment of Greece as a percentage of GDP.	Greek National Accounts
C	Military expenditure of Greece as a percentage of GDP.	NATO, SIPRI (Swedish International Peace Research Institute)
D	Military expenditure of Turkey as a percentage of GDP.	NATO, SIPRI
E	Non-oil civilian imports of Greece as a percentage of GDP.	Bank of Greece
F	Non-oil military imports of Greece as a percentage of GDP.	Bank of Greece
G	Greek defence expenditure per soldier (constant 1995 prices).	IISS (International Institute of Strategic Studies-London)
H	Turkish defence expenditure per soldier (constant 1995 prices).	IISS
I	Greek armed forces per 1000 people.	IISS
J	Turkish armed forces per 1000 people.	IISS
K	Percentage of the Greek population increase.	U.N. Population Statistics
L	Percentage of the Turkish population increase.	U.N. Population Statistics
Y	Rate of change of the Greek military debt.	Bank of Greece

[*]Data series are available upon request

Variable Y represents the rate of change of the military debt of Greece and shall be used as the dependent variable alternatively to variable C, which stands for the Greek defence share of GDP. The first set of explanatory variables representing the developments in resources characterized as of purely financial nature includes the following: Variable A is the rate of increase of the Greek real GDP, while B represents the aggregate national non-defence investment expenditure, both private and public, again as a percentage of GDP. Variables C and D stand for the GDP shares of defence expenditure in Greece and Turkey respectively, while variables E and F denote GDP shares of non-oil, non-defence imports and defence imports respectively.

The next set of independent variables has been selected to include those that place emphasis on human resources, mostly representing demographic features. Thus G and H stand for defence expenditure per soldier in Greece and Turkey respectively, while I and J denote percentage of armed forces in the population of Greece and Turkey. Finally, K and L indicate the population rate of increase in Greece and Turkey respectively.

Using these variables we formed three scenarios, which will be simulated and evaluated:

(i) Financial Resources Scenario, which assumes that the Greek GDP share of defence expenditure or, alternatively, the increase of the stock of military debt is determined by variables representing financial resources of the two countries involved in the arms race as these are described chiefly by national accounts items. The choice of such variables is based on the selection of the variables that seem to perform better in the literature cited earlier on in this paper.

(ii) Human Resources Scenario, which considers the Greek defence share of GDP or, alternatively, the increase of the stock of military debt as determined by the population characteristics of the two countries involved, rather than the financial resources of the respective sides. Emphasizing on such factors does not seem to be the case, at least as far as we know, in the relevant literature and it is therefore interesting to see the extent to which the population factor may affect the arms race of the countries involved.

(iii) Composite Scenario, created by the combination of those variables in the first two scenarios that have been found to be the most significant using input sensitivity analysis. Table 4 (top four rows – see subsection 5.2) presents a comprehensive summary of the first two scenarios, as regards the specification of input and output variables of a neural network, with each scenario including two alternative cases using either the Greek defence share of GDP or the rate of change of the stock of military debt as an output variable.

Our primary goals when formulating these scenarios have been, first to determine the predictive ability of neural networks in the context of an arms-race scenario and second to select those explanatory variables that yield the best forecasting performance.

1.5 EMPIRICAL RESULTS

The training sets of the Financial Resources Scenario consist of 29 annual observations, covering the period 1961-1989 and those of the Human Resources Scenario of 28, representing the period 1961-1988. The testing sets, in all scenarios, consist of 7 annual samples, referring to the period 1990-1996 for the former scenario, while this period is shorter by one observation, that is, 1989-1995, for the latter. The results obtained for each scenario are analyzed in the following section.

1.5.1 Comparison Between Two Scenarios: Financial vs. Human Resources

Tables 2 and 3 summarize the best results obtained in the context of both scenarios providing for the evaluation of the training as well as the testing phase, in cases in which the arms race pressure is approximated either by the change of the stock of military debt or the defence share of GDP.

It is clear that using the latter as a dependent variable yields much better results in terms of predictive ability of the networks in both scenarios, with all error figures for the testing phase of all networks being slightly superior for the financial resources scenario. The best performance yielded a 93% success against 84% for the human resources scenario in MRE terms.

The corresponding network performance when the stock of military debt is used as a dependent variable is rather inferior in terms of all error evaluation figures. In MRE terms the testing phase exhibited 70% and 52% highest prediction success for the financial and human resources scenarios respectively. It is interesting to point out, as a general remark, that when the number of hidden layers and nodes within each layer is increased, providing for a more complex topology, the time needed for the network to converge, as this is expressed in terms of number of epochs, is reduced to approximately half the training time of the simple architectures.

Table 2. Prediction results: Financial Resources scenario, Debt and Expenditure cases (standard errors in parentheses)

		Training Phase			Testing Phase		
Network*	**Epochs**	**MAE**	**LMSE**	**MRE**	**MAE**	**LMSE**	**MRE**
		Debt		***Case***			
	Inputs:	A, B, C, D, E, F			Output:	Y	
6-4-1	10,000	0.05842 (0.0114)	0.00347 (0.0015)	0.091 (0.0191)	0.20003 (0.0487)	0.02710 (0.0106)	0.295 (0.0811)
6-8-1	10,000	0.04259 (0.0102)	0.00212 (0.0014)	0.064 (0.0101)	0.30147 (0.0761)	0.05593 (0.0166)	0.301 (0.0822)
6-8-4-1	5,000	0.05337 (0.0109)	0.00311 (0.0015)	0.080 (0.0145)	0.2301 (0.0585)	0.0368 (0.0146)	0.318 (0.0854)
6-32-16-1	6,000	0.06979 (0.0071)	0.00533 (0.0004)	0.098 (0.0121)	0.18330 (0.0281)	0.02329 (0.0041)	0.288 (0.0400)
		Expenditure		***Case***			
	Inputs:	A, B, Y, D, E, F			Output:	C	
6-4-1	5,000	0.04334 (0.0064)	0.00148 (0.0040)	0.059 (0.0110)	0.09570 (0.0215)	0.00596 (0.0022)	0.124 (0.0279)
6-8-1	3,000	0.03130 (0.0048)	0.00080 (0.0003)	0.031 (0.0061)	0.05413 (0.0052)	0.00248 (0.0009)	0.087 (0.0065)
6-8-4-1	3,000	0.0579 (0.0115)	0.00350 (0.0018)	0.085 (0.0200)	0.06061 (0.0196)	0.00311 (0.0020)	0.089 (0.0196)

* "m-d-n" stands for m input nodes, d nodes in the hidden layer and n output nodes.
"m-d-p-n" stands for m input nodes, d nodes in the first hidden layer, p nodes in the second hidden layer and n output nodes.

Figure 2 presents graphically the course of forecasting of stock of military debt in (a) and the defence share of GDP in (b), for the financial scenario that yielded the best predictive performance. As stated earlier, based on the error measures, the latter appears to have higher predictive ability compared to the former. The two variables apparently have different variances, thus we have calculated the correlation coefficient between actual and predicted samples in order to eliminate the possibility the results are numerical artifacts. Indeed this enhanced our results, as the correlation coefficient for the training phase was 0.86 for the debt case and 0.98 for the expenditure one, while for the testing phase 0.80 for the former and 0.87 for the latter.

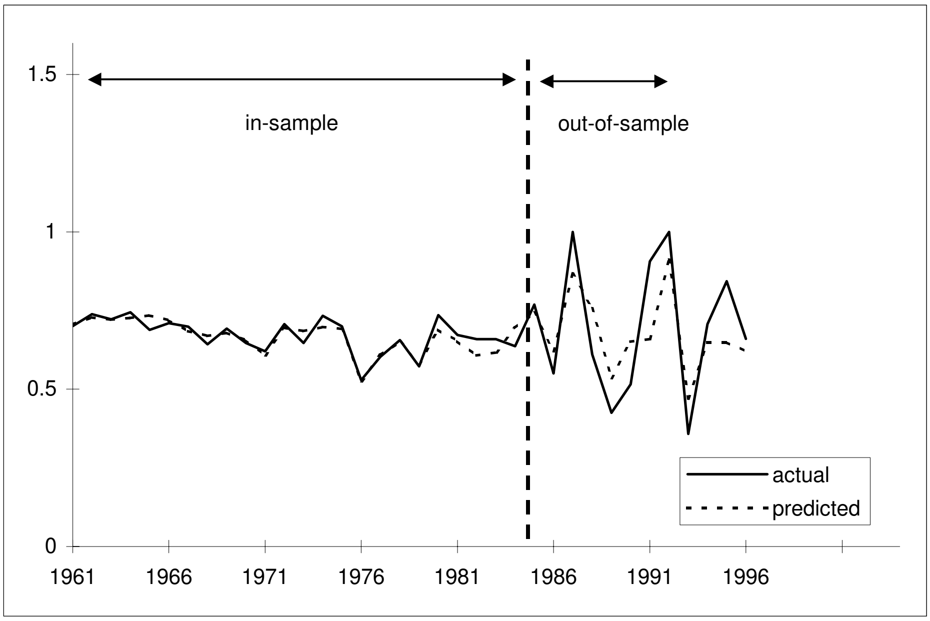
Table 3. Prediction results: Human Resources scenario, Debt and Expenditure cases (standard errors in parentheses)

		Training Phase			Testing Phase		
Network*	Epochs	MAE	LMSE	MRE	MAE	LMSE	MRE
Debt Case Inputs: G, H, I, J, K, L Output: Y							
6-4-1	10.000	0.04548 (0.0097)	0.00236 (0.00090)	0.060 (0.0143)	0.20985 (0.0654)	0.03483 (0.0133)	0.537 (0.2068)
6-8-1	8.000	0.04411 (0.0088)	0.00226 (0.00070)	0.058 (0.0125)	0.30073 (0.0537)	0.05386 (0.0187)	0.610 (0.0901)
6-8-4-1	5.000	0.04303 (0.0093)	0.00218 (0.00080)	0.056 (0.0132)	0.20729 (0.0383)	0.02587 (0.0092)	0.487 (0.1298)
6-32-16-1	8.000	0.01414 (0.0023)	0.00021 (0.00005)	0.017 (0.0038)	0.31205 (0.0714)	0.06403 (0.0231)	0.657 (0.0728)
Expenditure Case Inputs: G, H, I, J, K, L Output: C							
6-4-1	5,000	0.03660 (0.0035)	0.00083 (0.00010)	0.049 (0.0049)	0.16086 (0.0091)	0.01318 (0.0013)	0.205 (0.0135)
6-8-1	3,000	0.02100 (0.0029)	0.00034 (0.00008)	0.027 (0.0047)	0.12362 (0.0166)	0.00846 (0.0022)	0.159 (0.0226)
6-8-4-1	3,000	0.03816 (0.0035)	0.00089 (0.00012)	0.051 (0.0049)	0.16227 (0.0091)	0.01341 (0.0014)	0.207 (0.0135)

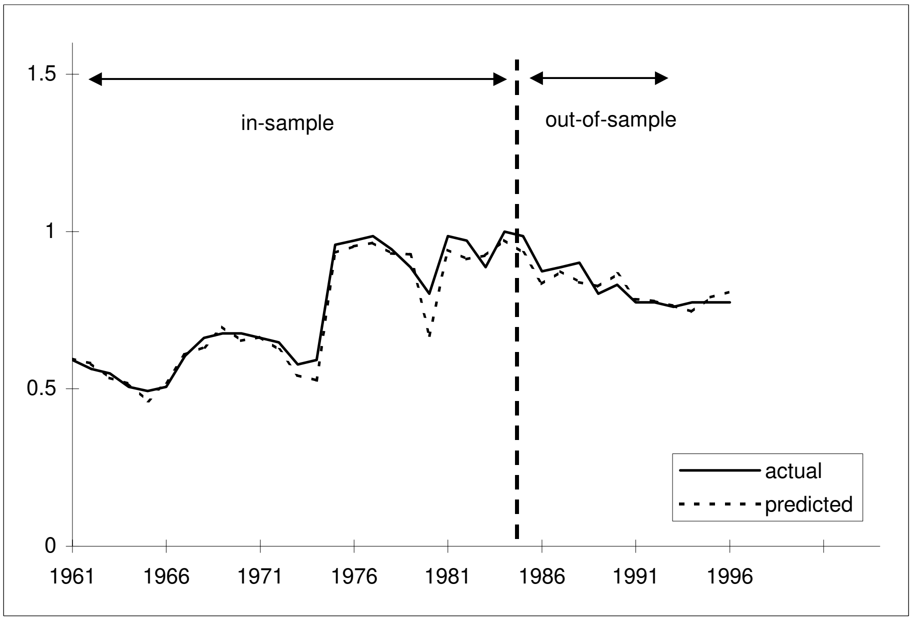
* "m-d-n" stands for m input nodes, d nodes in the hidden layer and n output nodes.
"m-d-p-n" stands for m input nodes, d nodes in the first hidden layer, p nodes in the second hidden layer and n output nodes.

1.5.2 Estimation of Input Significance

The input significance ordering is a procedure most interesting for the purposes of the present paper, since it serves a twin purpose.



(a) Debt Case, 6-32-16-1 neural network topology



(b) Expenditure Case, 6-8-1 neural network topology

Figure 2. Neural networks prediction results on Financial Scenario: (a) Greek Military Debt and (b) Greek Defence Expenditure. Actual values are plotted versus forecasted outputs. In-sample corresponds to the learning period, while out-of-sample to the evaluation period.

First, it involves determining the most significant input variables in terms of explanatory power in the two scenarios considered thus far. This hierarchy ordering is based on the forecasting performance of these variables on both the rate of change of the stock of military debt and the Greek defence_share of GDP, and leads to building the composite scenario. Second, the selection of the most significant variables is expected to lead to interesting conclusions concerning their nature and their role in determining the pressure of the arms race on the Greek economy.

1.5.2.1 Financial Resources Results:

Debt Case

The ranking showed that all networks, regardless the number of nodes or hidden layers, exhibited the same significance order: $w_D > w_C > w_F$, with the remaining variables having very low strengths. It is interesting to see, therefore, that the Turkish GDP share of military expenditure is the leading determinant of the Greek external military debt, its weight being by far the largest, almost double that of each of the rest two, the weights of which are almost equal. This finding supports the view in favor of the existence of an arms race between the two rival countries and underlines the pressure that this arms race exercises on the Greek economy. The second variable in terms of significance is the Greek defence share of GDP, while the Greek import bill on military equipment comes third in significance ordering.

Expenditure Case

The determination of the significant input variables according to their weights summation provided the same ordering for all networks: $w_F > w_Y > w_D$. This result has been, to a large extent, expected. The selection of the determinants is essentially the same as in the previous case, with only the ordering being reversed. It is, therefore, the expenditure on military imports that plays the dominant role in determining the Greek GDP share of defence spending, a dominance being by far the most pronounced compared to the rest two explanatory variables, (i.e. the change of the Greek military external debt and the Turkish GDP share of defence spending, as indicated by the comparison of the relevant weights). This rearrangement of the order of significance, in this case, reinforces the conclusions already derived in the debt case. The pressure exercised from the part of the Turkish side is always dominant expressed by the presence of this country's defence share of GDP as one of the leading determinants of the Greek corresponding share. The importance of the military debt as the second leading variable determining the Greek defence spending simply shows a reversal of roles in terms of causality direction between the two variables with reference to the case of military debt determination and supports earlier work on the topic examining the vicious cycle between defence expenditure and military debt (Stavrinos and Zombanakis, 1998).

1.5.2.2. Human Resources Results

Debt Case

Determining the military debt along the lines of the Human Resources scenario indicates that the Greek defence expenditure per soldier, the rate of increase of the Greek population and the proportion of armed forces in the population of Turkey are the leading explanatory variables in that order ($w_G > w_K > w_J$). The weights of the first two independent variables are almost equal, something that does not allow for a clear-cut determination of the ordering of importance between them. Again, however, a variable representing the resources of the "other side" is strongly present among the leading determinants of the Greek external military debt, only to support, once more, the existence of an arms race environment.

Expenditure Case

This case is unique in the sense that it is the only one in which variables describing the Turkish side are not among the leading determinants of the pressure on the Greek economy due to this arms race. The weight ranking resulted the order $w_G > w_I > w_K$. Thus, the Greek GDP share of military expenditure is determined chiefly by the Greek defence spending per soldier, which this time, appears to be the leading determinant by far, to be followed by the proportion of armed forces in the Greek population and the rate of increase of the population in the country.

1.5.3 Composite Scenario

The preceding Input Significance Analysis leads us to making the main point of the present paper in terms of what we refer to as "the Composite Scenario". This involves combining the three most significant inputs of each of the two scenarios earlier examined, namely the Financial Resources and the Human Resources ones. These input variables have been selected on the basis of the input sensitivity ordering indicated in

Table 4 (top four rows). The training and testing sets of this scenario have the same data length as those in the Human Resources Scenario.

Table 4. Leading determinants for each scenario based on Input Sensitivity Analysis

Scenario	Case Study	Leading Determinants*	Output
Financial Resources	Debt	$W_D > W_C > W_F$	Y
	Expenditure	$W_F > W_Y > W_D$	C
Human Resources	Debt	$W_G > W_K > W_J$	Y
	Expenditure	$W_G > W_I > W_K$	C
Composite Resources	Debt	$W_K > W_J > W_G$	Y
	Expenditure	$W_G > W_I > W_D$	C

*W_N denotes the sum of the absolute values of the weights of the N_{th} input variable node connections.

1.5.3.1. Results

Debt Case

Various network topologies have been developed in the context of the Composite Scenario trained using C, D, F, G, J and K as input variables and over a variety of iterations numbers. Table 5 (top half) summarizes the best results obtained when forecasting the Y variable and provides for an evaluation of both the training and testing phase in the case in which the burden of the arms race for the Greek economy is approximated by the military debt.

The interesting result in this scenario has to do with both the nature of the variables selected as well as their explanatory power. We see that the network performance is almost equally successful compared with the best results obtained in cases of debt determination in the previous two scenarios. In fact, the errors derived in the testing phase are very close to those in the corresponding case of the Financial Resources Scenario and considerably lower compared to the errors of the debt determination case of the Human Resources Scenario. Thus the MREs indicated a roughly 70% prediction success for the 6-8-4-1 topology that performed best, denoting that the new set of input variables performs as successfully as it did in the case of the Financial Resources Scenario in forecasting the military external debt.

Table 5. Prediction results: Composite scenario, Debt and Expenditure cases (standard errors in parentheses)

		Training Phase			Testing Phase		
Network*	Epochs	MAE	LMSE	MRE	MAE	LMSE	MRE
Debt Case Inputs: C, D, F, G, J, K Output: Y							
6-4-1	10.000	0.04074 (0.0120)	0.00290 (0.0016)	0.058 (0.0154)	0.19735 (0.0594)	0.03006 (0.0136)	0.539 (0.2228)
6-8-1	10.000	0.02262 (0.0044)	0.00059 (0.0002)	0.033 (0.0065)	0.25300 (0.0615)	0.04335 (0.0183)	0.496 (0.0932)
6-8-4-1	5.000	0.02221 (0.0043)	0.00052 (0.0001)	0.029 (0.0066)	0.15384 (0.0368)	0.01589 (0.0060)	0.306 (0.0755)
6-32-16-1	6.000	0.02086 (0.0040)	0.00047 (0.0001)	0.031 (0.0067)	0.17177 (0.0479)	0.02163 (0.0099)	0.328 (0.0820)
Expenditure Case Inputs: Y, D, F, G, I, K Output: C							
6-4-1	5,000	0.03014 (0.0039)	0.00066 (0.0001)	0.040 (0.0051)	0.14329 (0.0187)	0.01131 (0.0022)	0.182 (0.0258)
6-8-1	3,000	0.02350 (0.0033)	0.00043 (0.0001)	0.033 (0.0050)	0.09336 (0.0166)	0.00518 (0.0013)	0.119 (0.0222)
6-8-4-1	3,000	0.02605 (0.0029)	0.00048 (0.0001)	0.037 (0.0045)	0.09964 (0.0179)	0.00592 (0.0015)	0.127 (0.0239)

* "m-d-n" stands for m input nodes, d nodes in the hidden layer and n output nodes.
"m-d-p-n" stands for m input nodes, d nodes in the first hidden layer, p nodes in the second hidden layer and n output nodes.

Expenditure Case

The final simulation employs variables Y, D, F, G, I and K, found to be more significant by input sensitivity analysis, to forecast variable C, the defence_share of GDPs in Greece. The results obtained here and summarized in Table 5 (bottom half), being similar to those in the previous case.

All networks provided for a very satisfactory performance, the testing phase errors being very close to those in the corresponding case of the Financial Resources scenario. The best topology is the 6-8-1 architecture with a prediction success of approximately 88% (MRE terms).

1.5.3.2 Estimation of Input Significance

The Input Significance exercise has been performed on the basis of the results obtained in the case of the Composite scenario along the lines of section 5.2. Its findings are summarized in Table 4 (bottom two rows) and they seem to be very interesting since they provide a full picture as to whether and the extent to which human resources may account for the development of the military debt or the Greek share of GDP expenditure, thus illustrating a number of very important points.

Debt Case

As regards the question of determining the military external debt of Greece, the rate of the Greek population increase, a Human Resources indicator, seems to be almost twice more powerful compared to the other explanatory variables, the explanatory power measured by the relevant weight computed. Equally interesting is the fact that the second in order of importance determinant is another Human Resources indicator, this time, however, concerning the “opposite side”, the proportion of the armed forces in the population of Turkey. Finally, the Greek military expenditure per soldier comes third in terms of explanatory power in this case. It is worth noting, finally, that the top three determinants in this case are the same as the top three ones in the corresponding Human Resources case, but in a different order.

Expenditure Case

In the case in which the Greek GDP share of defence spending is taken to approximate the arms-race pressure on the Greek economy, the Greek defence expenditure per soldier is now the leading explanatory variable. The proportion of armed forces in the Greek population comes second in explanatory power, while the GDP share of military expenditure in Turkey is third in importance. It is interesting to see, therefore, that the first two independent variables are derived from the Human Resources Scenario while the third one that is not, represents the “Other side”, underlining once more the dominant influence of the Turkish side on the defence burden of Greece.

1.5.4 Ordinary Least Squares Regression

Concluding this analysis, we thought that it would be interesting to investigate the extent to which our neural network topologies are suitable for forecasting the arms-race pressure on the Greek economy better than a conventional OLS exercise, using the same explanatory variables.

We tried OLS regressions with the dependent variable being the rate of change of the military external debt and, alternatively, the Greek defence share of GDP, for all three scenarios used. All series have been found to be stationary in their first differences, on the basis of the ADF test. Due to the small number of available observations, the OLS has been performed using the entire sample period, (i.e. 1961-1996, while the forecasting period involves the last seven years, the forecasting period of the corresponding neural networks exercise). The estimation results for all equations are presented in Table 6, with t-values indicated in parentheses and the variable *res* denoting the residuals of the corresponding long-run estimates. The results are satisfactory, bearing the expected signs. The ambiguity of the sign concerning the rate of the Greek population increase is expected. One may argue that a high rate of population growth will lead to increasing manpower in most units and therefore, the requirements for more equipment. An opposing view, however, appears to interpret recent developments in the Greek armed forces in a different way: The demands of modern warfare call for small, flexible units, very well trained and equipped with high technology weapons. In face of the slowing down of the Greek population growth this calls for a heavier arms race burden in order to finance this shift to the modernization of the armed forces of the country.

Table 6. OLS regression results on Military Debt and Defence Expenditure (t-values in parentheses)

Financial Resources Scenario			Human Resources Scenario			Composite Scenario		
Varia-bles	**Debt**	**Expen-diture**	**Varia-bles**	**Debt**	**Expen-diture**	**Varia-bles**	**Debt**	**Expen-diture**
Const.	-0.04 (-0.76)	0.00 (0.00)	**Const.**	-0.02 (-0.29)	0.01 (0.16)	**Const.**	-0.01 (-0.10)	0.01 (0.10)
A	0.44 (0.47)	4.39 (4.82)	**G**	0.05 (2.90)	0.15 (5.07)	**D**	0.07 (0.84)	0.22 (1.85)
B	-3.09 (-1.21)	-4.99 (-1.90)	**H**	0.13 (2.03)	0.10 (1.02)	**F**	0.47 (3.05)	0.09 (0.38)
C	0.11 (1.53)	—	**I**	0.14 (2.46)	0.42 (3.36)	**Y**	—	0.12 (0.72)
D	0.09 (1.20)	0.26 (2.94)	**J**	0.10 (2.26)	0.18 (2.10)	**G**	0.05 (2.78)	0.12 (4.51)
E	7.88 (2.80)	0.34 (0.13)	**K**	-0.13 (-3.12)	0.19 (2.61)	**K**	-0.09 (-2.47)	0.10 (1.77)
F	0.30 (1.91)	0.21 (1.30)	**L**	0.07 (1.83)	0.15 (1.98)	**I**	—	0.19 (2.58)
Y	—	0.21 (1.69)	—	—	—	**J**	0.10 (2.07)	—
—	—	—	—	—	—	**C**	0.03 (0.52)	—
***res*(-1)**	-1.39 (-7.22)	-1.27 (-10.22)	***res*(-1)**	-1.35 (-5.93)	-0.94 (-4.24)	***res*(-1)**	-1.27 (-7.12)	-1.23 (-6.31)
$\mathbf{R^2}$	0.78	0.90	$\mathbf{R^2}$	0.76	0.75	$\mathbf{R^2}$	0.81	0.81
D.W.	1.97	1.55	**D.W.**	2.14	2.04	**D.W.**	2.40	1.88

To the extent that one may comment on the hierarchy ordering of the leading determinants taking the t-statistic as a measure, it seems that in the debt case, the OLS ordering coincides with that of the neural networks in the qualification of two out of three major determinants, namely the Greek defence expenditure per soldier and the percentage of Greek population increase. In the expenditure case, the ordering indicated by the OLS exercise shows a remarkable coincidence to that given by the neural networks, since they both agree on the qualification of the top three explanatory variables in the same order of importance.

The results of the forecasts using the OLS regressions are shown in Table 7. Forecasting performance does not exceed the accuracy of 65% for the debt case and 45% for the expenditures case (testing phases) based on MRE terms, suggesting that almost all neural networks topologies performed better than the OLS.

Table 7. Ordinary least squares prediction errors

		Overall Period			**Period of testing***		
Scenario	**Case**	**MAE**	**LMSE**	**MRE**	**MAE**	**LMSE**	**MRE**
Financial Resources	Debt	0.154	0.024	0.912	0.221	0.046	0.409
	Expenditure	0.223	0.031	0.862	0.219	0.037	0.629
Human Resources	Debt	0.165	0.032	0.923	0.175	0.035	0.363
	Expenditure	0.287	0.096	0.727	0.318	0.099	0.862
Composite	Debt	0.152	0.023	0.749	0.192	0.031	0.806
	Expenditure	0.228	0.066	0.521	0.241	0.067	0.543

* This period corresponds to the one used as a testing phase for the neural networks.

1.6 CONCLUSIONS

The arms race that has been going on between Greece and Turkey for a long period of time has become the cause of a considerable pressure on the economies of the two countries. This paper has demonstrated that, apart from the financial aspect of the problem, there is another dimension that of the human resources, which is at least equally important to the financial resources aspect in determining the arms race load imposed on the Greek economy. The demographic developments in the two countries, to be more specific, have been proven to exercise significant explanatory power, affecting the decisions of the Greek authorities on adding to the already heavy burden of the arms race on the economy of Greece. This analysis has thus led to deriving certain interesting conclusions:

i. The neural networks methodology employed has attained a very satisfactory prediction level for the arms race pressure imposed on the Greek Economy, as this is proxied by both the change of the military debt and the defence share of GDP. This prediction performance is superior to that attained using corresponding OLS estimations in all cases.
ii. In the context of the so-called "composite scenario", in which both financial and human resources variables have been included, the latter are dominant over the former in determining and forecasting the burden of an arms race on the Greek Economy, as this is approximated by either the military debt or the defence share of GDP.
iii. In all scenarios and cases tried, variables representing or approximating the Turkish side are among the dominant ones in determining the pressure due to this arms race on the Greek economy. The input sensitivity analysis proves that one of the top three variables determining this pressure represents the "opposite side" in all cases, either in financial resources terms (defence share of GDP) or in human resources terms (proportion of armed forces in the population). The former is indeed one of the top determinants in terms of sensitivity in almost all scenarios. This finding verifies and underlines the fact that the pressure exercised on the Greek economy by this arms race will be very difficult to mitigate since it is to a considerable extent exogenous, depending on the policy followed by the "opposite side".
iv. Combining the above two conclusions leads to suggesting that in the context of the Greek-Turkish arms race, the human resources factor deserves more attention than what it has been given in the literature thus far. Demographic developments in the two countries, provide for a serious disadvantage for the Greek side, since its population, unlike that of Turkey, is aging, increasing at very low rates, which, on certain occasions, have even turned negative during the recent past. These developments, combined with pronounced differences as regards the standard of living between the two countries have made the need for expansion of what is termed "vital space", more than demanding for the Turkish

side. The Greek side, in its turn, aiming at facing this dynamism from the part of its neighbor, and bearing in mind its disadvantages as regards human resources developments, has turned to improving the efficiency of its armed forces, placing emphasis on their flexibility and speed of reaction, as well as on the quality of the equipment and technology used. This policy, in its turn, demands either buying the latest version of equipment or upgrading the quality and efficiency of items already in use. The so-called "purchase of the century", involving placing an order for a large number of highly qualified military aircraft during the mid - eighties has been just the beginning of a series of structural reform measures towards this direction. The problem in this case, as earlier stated, is that Greece, facing a binding and prohibitive domestic supply constraint concerning its defence industry, is compelled to resort to importing expensive, high - technology equipment, thus increasing, not only its defence expenditure but also its debt burden. It seems therefore interesting to suggest that future research should be directed towards the trade - off between capital and human resources as an additional determinant affecting the future course of the Greek - Turkish arms race.

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INTERIM 1

INTERIM 1

"When two armies are about to clash and the second is ten times the manpower of the first, it is certain in advance – irrespective of all other considerations – that the first will flee."

Sun Tzu, "The Art of War"

It seems, therefore, that there is much more to the demographic problem of Greece than what meets the eye. The rapid rise of the standard of living in the country during the past two decades had very little to do with the widely acknowledged recipe provided by the Rostwian pattern of development. This "irregular" pattern of development in Greece, attributed to a large extent to the misallocation of EU funds generously flowing in the country for the last twenty years was not, however, free of any adverse repercussions. In fact, it formulated a mentality founded on excessive materialism, which, in its turn, became the cause of radical revisions as it concerns the moral and ethical standards of the Greek society. These revisions resulted to losing traditional values concerning marriage, family and children and to adopting structural changes in the average family pattern[1] with the abortions figure being a multiple of that of births[2].

The problem, however, is not only a social one. Its economics aspect appears in the form of a rapidly approaching social security problem[3] and a massive flow of immigrants, estimated to exceed one million today, aiming at satisfying the excess demand in selected professions considered as inferior by the local labor force[4]. The labor market rigidities of the Greek economy simply aggravate the situation.

These adverse demographic developments used to be more pronounced in the north of the country, near the Greek-Turkish border, a highly underdeveloped region with a strong Moslem presence. The problem in the area, however, seems to be, at least to a certain extent, resolved thanks to the contribution of the Church which, beginning 1999, has been subsidizing all families in the area having more than two children, a measure that yielded impressive results. Thus, in 1999 the number of families with three children

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[1] These changes include first marriage at an older age, increased number of divorces and a rise in the number of families with just one child. The main economic variables that supported the family pattern revision during these years are the low per capita income, the high unemployment rate and the rising costs of health and education. Whatever the nature of these variables may be, the result of their effect is alarming: The ratio of births per couple in Greece is just 1.2 compared to higher than 2 for the rest of Europe and higher than 4 for Turkey. Given that the Greek Rate of Natural Increase (RNI), measured as birth rate minus the death rate, barely reaches 0.1, the population in the country is steadily ageing, with people over 65 representing 13% of the total population. This figure is projected to reach 20% in 2025. (Michael C. Geokas, 2003, "A Vital Issue for Hellenism: The Demographic Problem of Greece", http://demokritos.org)

[2] Abortions are estimated to about 250,000 compared to 100,000 births per year. Concerning the latter, the birth rate has declined by about 30% since the decade of the eighties and to make things worse, 20% of the latest birth figures refer to immigrants' children. In fact, almost the entire population increase of the country during the past few years is attributed to the flow of immigrants, a large number of whom are Moslems.

[3] During the nineties the number of pensioners increased by about 25% bringing the employed over pensioners ratio down to 1.75. Moreover, the present value of the accumulated liabilities in terms of state social security contributions amounts to a rough aggregate of 150% of the GDP based on the regulations and parameters of the present system (Bank of Greece, "Report of the Governor to the Parliament ", 2002 p.p. 119-123. See also, "Greek Strategy on Pensions", Athens, September 2002).

[4] The latest OECD report points out that Greece is gradually turning to immigrants' heaven. The report mentions that in 1998, there were 382,000 immigrants acquiring residence and work permit, while in 2001 the corresponding figure was 351,000. The majority of these immigrants come from Albania (65%) while Bulgarians come second with 6.8%. These are, however, the legal ones. There is a considerable number of illegal immigrants, most of them refugees coming by boat from Turkey (OECD, 2003 "Trends in International Migration").

was 105, it rose to 404 in the next year and to 670 in 2001, while it exceeded 800 for the year 2002. The tragic part of this story is that these families used to collect this subsidy between 1990 and 1993, when, following a change of government, this form of financial support was declared inefficient and was, therefore, abandoned. It took the government about ten years to realize the extent of the damage caused and beginning 2003 the support of these families has been decided to take the form of tax exemptions. This example simply underlines the considerable degree of government inconsistency in cases in which sensitive issues of top national interest must be handled.

The corresponding picture in Turkey is much more promising and its projection shows that the population will reach 91.8 million people by 2025. The problem in this case, however, seems to be more qualitative rather than quantitative, as Turks account for less than 80% of Turkey's population with the majority of the rest being Kurds[5].

At least in quantitative terms, therefore, the demographic comparison of Greece and Turkey is overwhelmingly in favour of the second. And it goes without saying that such developments will undoubtedly affect the balance of power between the two sides. We shall have the opportunity to refer to this point later on in this book, by arguing in favour of the Greek defence authorities' shift to the new dogma, which places emphasis on technology, flexibility and speed of action rather than large manpower figures. Unfortunately, however, the element of demagogy and vote maximisation has made its presence strongly felt in this case as well, in the form of repeated governmental promises for military service term reduction. Given the outlook regarding the demographic developments earlier presented, the shift from compulsory military service to professional armed forces deserves much more attention than what the authorities attach to it. One cannot deny, of course, the importance of professionals in times of adverse demographic developments and galloping technological advance, which makes weapons more and more sophisticated. However, relying less on manpower does not mean denying the contribution of the population to the defence of the country.

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[5] This figure is declining because the Kurds in Turkey have higher birth rates. Thus, at 2050 about 44.4% of Turkey's population is projected to be Kurds, a possibility that will entail important, social, economic and political implications (Michael C. Geokas, 2003, "A Vital Issue for Hellenism: The Demographic Problem of Greece", http://demokritos.org)

The expression “denying the contribution” has been chosen to reflect its full meaning in this case. The average Greek, with very few exceptions, feels that it is his duty to contribute to the defence of the country. In fact the military service is the only experience that all male Greeks share irrespective of background, social or economic status and, despite their continuous bragging about time wasted, one of their favorite discussion topics has always been their memories referring to their military service. Moreover, reducing, or even abolishing military service comes down to being equivalent to denying the average Greek his right to serve and contribute to the defence of the Nation, given that according to the Greek Constitution, Defence is a public good to which everybody must be willing and able to contribute. The state, in its turn, has always been providing those serving their military service with much more than just daily food and shelter. There is a wide variety of benefits one can acquire during his service term which has been particularly true for the period following the Second World War when the only way to prove that you could exercise any profession, from flying an airplane to being a barber, was to show that you had been doing this during your military service. Paradox as it may sound, the fact remains that this is just one of the ways in which the armed forces and the military service, in particular, have contributed to the impressive post-war growth rates of the Greek economy. Given these facts, the current position of the Greek state simply confirms the radical revision of its traditional values by promising a gradual reduction of the military service offering in return the chance to all young Greeks to join the unemployment lists one or two years earlier. These lists are expected to grow longer in the future in anticipation of a number of inevitable structural changes in the domestic labor market!

The long military history of Greece provides no example in which professionalism has triumphed over the focus on national interests. The latter, on the contrary, has been one of the leading motives behind the brilliant performance of the Greek armed forces for centuries now. It seems, unfortunately, that everybody consult History except the Defence authorities of Greece. In fact, one cannot help recalling that there are rumors according to which a notorious foreign politician has pointed out that History teaches how Greeks are difficult to handle. He has suggested, therefore, that they may become more manageable if one strikes deep into their cultural roots, i.e. their language, their religion and their intellectual and historical resources, thus eliminating their every possibility to excel and become powerful. As a result, he concluded, the Greeks would stop obstructing his country's foreign policy in the Balkans, the Eastern Mediterranean, the Middle East and all this area that has always been sensitive for his country's interests. Irrespective of whether this is true or not, the mere fact that our modern Greek affluent society tends to prove the usefulness of such an advice more so every day, at least regarding the use of the language and the quality of education, should be enough to alarm everybody, especially those responsible for the defence of the country. It is therefore imperative that the government, instead of offering the military service reduction in exchange for votes should see how to make the best use of the abilities of those drafted, in the framework of the new defence dogma, something which currently seems to be done in a way that leaves a lot to be desired[6].

This suggestion does not exactly exhaust the list of "musts" for the Greek authorities. In cases in which such intricate problems are faced the first task that assumes primary importance involves the thorough study of the problem phased. We have already concentrated on this rather thoroughly in the fist chapter by establishing the importance of human resources for the defence of Greece. The population statistics of Greece and Turkey, moreover, designate the rapid deterioration of the performance of the former with respect to that of the latter in this field. It is more than straightforward, therefore, that to the extent that Greece is compelled to race Turkey in the field of demographic developments it can stand no chances to win. The second task required, following this diagnosis, is to consider how serious the problem is for Greece in its confrontation with Turkey, even if the former is supported by Cyprus along the lines of the so called "Integrated Defence Doctrine". This is exactly what the next paper does: It proposes a relative security measure that relies exclusively on human resource indicators thus introducing the two dimensions of the problem: The leading importance of human resources and the deterioration of the two allies' position with regard to Turkey in this respect, while, in addition, it considers the extent to which an arms race against Turkey would affect the long-term interest of the two allies.

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[6] A good start would be, for example, an effort to understand that money cannot buy everything and that doing business with the armed forces requires increased sense of responsibility. This has not been the case, it seems, when catering services started replacing the traditional army food, an experiment, which turned out to be deleterious for the personnel, both literary and metaphorically.

CHAPTER 2

CHAPTER 2

A Neural Network Measurement of Relative Military Security*

The Case of Greece and Cyprus

By

Andreas S. Andreou and George A. Zombanakis

2.1 INTRODUCTION

The Greek - Cypriot Integrated Defence Space Doctrine has been regarded by the two parties involved as a strategy aiming at facing potential offensive action by Turkey against either of the two allies, with particular emphasis on the protection of their national interests in the Aegean Sea theatre. This paper does not aspire to criticize the effectiveness or otherwise of such a doctrine, since an attempt of this kind would touch upon sensitive issues requiring the use of classified information over and above the needs of scientific research. What one can certainly do, however, is attract the reader's attention to certain related issues, which may contribute to drawing a number of conclusions regarding the usefulness or otherwise of similar strategies, in view of the latest developments concerning the relations of the three countries involved.

These conclusions refer to the extent to which the security of the two allies in the area is promoted given the arms race which has long been going on between Greece and Turkey (Kollias and Makrydakis 1997). Whereas the impact of an arms race on the economy of the countries involved in it has been extensively dealt within the literature (Balfoussias and Stavrinos 1996; Ozmucur 1996; Kollias 1997), research referring to

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the consequences of arms races upon the security of the sides involved leaves a great deal to contribute on the issue. To forecast the impact of this arms race on the security of Greece and Cyprus we resort to using artificial neural networks, with all advantages a data driven approach may entail, given the complexity of the models employed by the theory of alliances and the contradictory empirical results (Hartley and Sandler 1995), as well as the limited theoretical background covering the concept of relative security in similar cases.

The technical support concerning the structure and training of the networks used is given in section 3, after the theoretical background, along with a description of the input variables and a brief review of the relevant literature have been presented in section 2. The forecasting results of the relative security factor, as well as a presentation and analysis of various alternative scenarios concerning arms race tactics between the countries involved are reported in section 4. Finally, section 5 sums up and concludes the findings of this paper.

2.2 LITERATURE OVERVIEW AND THEORETICAL BACKGROUND

The topic of arms races in its general context has been a rather popular issue, which was thoroughly investigated in the literature (e.g. Richardson 1960; Intriligator 1982; Isard and Anderton 1985 and 1988). Concerning the specific arms - race case between Greece and Turkey, earlier research has concluded that the pressure on the Greek economy resulting from this arms race is determined chiefly by demographic factors strongly favoring the Turkish side, while the estimation of input significance has indicated that the leading determinants of such a race describe the Turkish rather than the Greek economic and demographic environment (Andreou and Zombanakis 2000). Having established the above framework for the arms race between Greece and Turkey, we now proceed to investigate the extent to which its impact on the sides involved may be described by introducing a more specific and accurate measure compared to the hypothetical figures of a payoff matrix in the context of a game theory exercise (e.g. Wagner 1983). Such a measure requires defining a Relative Security (RS) coefficient, tailored to fit the environment of such a conflict involving Greece and Cyprus on one hand and Turkey on another. Ayanian (1994) has already employed such a security coefficient aiming at explaining exchange-rate fluctuations better than conventional macroeconomic variables. Combining Ayanian's reasoning on the subject together with our earlier conclusions regarding the leading role of population developments in the Greek-Turkish arms race, we have proceeded to determining an RS coefficient. This coefficient is suitable to use when measuring the impact of the Greek-Turkish arms race on the security of the two allies, namely Greece and Cyprus.

Following Ayanian (1994), we define the security of Greece and that of Cyprus in the context of an Integrated Defence Space Doctrine scenario as follows:

$$S_G = (1/k) * [(F_G + F_C) / F_{TG}] \quad (1)$$

and

$$S_C = (1/k) * [(F_G + F_C) / F_{TC}] \quad (2)$$

where S_G is the military security of Greece

S_C is the military security of Cyprus

F_G is total Greek defence forces

F_C is total Cypriot defence forces

F_{TG} is Turkish forces potentially directed against Greece

F_{TC} is Turkish forces potentially directed against Cyprus

k is the probability of a conflict between the sides involved

The measure of the relative security of Cyprus with reference to Greece RS_{CG}, which is the quintessence of the Integrated Defence Space Doctrine between Greece and Cyprus, is defined as the ratio of (2) over (1):

$$RS_{CG} = [F_{TG} / F_{TC}] \quad (3)$$

Turkish forces potentially directed against Greece and Cyprus can be considered as an increasing function of the relative population growth rates between Turkey on one hand and each of the two allies on the other. This specification is based on the conclusion drawn in the literature, as mentioned earlier on in this section, referring to the dominance of human resources over financial resources in determining the defence burden on the Greek economy as a result of the ongoing arms race with Turkey[7]. Thus, the corresponding relationships for the two allies, Greece and Cyprus, may be stated as follows:

$$F_{TG} = F_T\left[\exp\left(\dot{p}_G/\dot{p}_T\right)\right] \qquad (4)$$

and

$$F_{TC} = F_T\left[\exp\left(\dot{p}_C/\dot{p}_T\right)\right] \qquad (5)$$

where FT stands for the total of Turkish armed forces and $\dot{p}_G$, $\dot{p}_C$, $\dot{p}_T$ denote the respective population growth rates for Greece, Cyprus and Turkey. The interpretation of (4) and (5) requires special attention due to the asymmetric effect of the variables involved: Thus, in a purely hypothetical case which would involve a faster growth of the Greek or Cypriot population compared to that of Turkey, one may argue that this difference in the population rates involved may be considered as representing a potential threat to Turkey, which would, therefore, be compelled to channel more forces to face those of the two allies[8]. However, where the Turkish population exhibits a faster rate of growth compared to that of Greece or Cyprus, which has always been the case, this will allow Turkey to increase F_T, which is the total Turkish forces, and provide for an increase of the forces facing Greece and Cyprus, thus offsetting the effect caused due to the reduction of the exponent.

Substituting the equivalent of F_{TG} and F_{TC} from (4) and (5) in (3) we come up with the following Relative Security (RS) measure between Greece and Cyprus:

$$RS_{CG} = \exp[x] \qquad (6)$$

where

$$x = \left(\dot{p}_G - \dot{p}_C\right) \;/\; \dot{p}_T \qquad (7)$$

[7]Indeed, any variable that represents or includes developments in human resources in the countries involved may be suitable. Since, however, population developments are decisive in affecting most of the human resource variables, we feel that their role must be acknowledged as leading. The use of population growth rates rather than the corresponding levels aims at stressing the dynamic character of the relative security measure proposed.

[8] Such extreme scenarios aim at just facilitating the interpretation of this relative security measure and must not be considered as reflecting reality by any means.

Equation (6) interpreted together with (7) show how the population rates of growth of the three countries involved are expected to affect the relative security of Cyprus with reference to Greece, as this is measured by RS_{CG}. More specifically, for an increase of this index as given by (6), x at time t_2 must be higher than x at an earlier period t_1 (t_1 and t_2 represent years in our case). In terms of (7), therefore, $x_1 < x_2$, or:

$$\left(\dot{p}_G(1) - \dot{p}_C(1)\right) \;/\; \dot{p}_T(1) \quad < \quad \left(\dot{p}_G(2) - \dot{p}_C(2)\right) \;/\; \dot{p}_T(2) \qquad (7a)$$

Bearing in mind that RS_{CG} as it is expressed by (6) and (7) measures the relative security of Cyprus, it is evident that (7a) holds true in the following three cases:

(a) If $\dot{p}_T(1) > \dot{p}_T(2)$, holding $\dot{p}_G$ and $\dot{p}_C$ constant, as shown by equations (6) and (7).

(b) If $\dot{p}_C(1) > \dot{p}_C(2)$, holding $\dot{p}_G$ and $\dot{p}_T$ constant, since F_{TC} in equation (5) will fall.

(c) If $\dot{p}_G(1) < \dot{p}_G(2)$, holding $\dot{p}_C$ and $\dot{p}_T$ constant, since F_{TG} in equation (4) will rise, meaning that Turkish forces are expected to move towards Greece and away from Cyprus. This case underlines the importance of the Greek support in the Greek – Cypriot alliance, in the context of which, all population growth rates not included in one of the above cases entail a decline of the RS_{CG}, indicating a reduction of the relative security of Cyprus[9].

(d) If all rates fluctuate, the direction of change of the RS will depend on the outcome of equation (7a), that is, RS will rise if the second term of (7a) is greater than the first.

It is now evident that this relative security measure can be used to provide for a much more precise strategy payoff measure compared to the hypothetical payoffs used in the literature, as we indicated earlier in this section. Indeed, if the percentage changes included in the exponent of (6) are instead denoted as logarithmic first differences, then the exponent x of the relative security measure RS_{CG} in (7) may be expressed as follows**:**

$$x = [\ \ln(P_G / P_G(-1)) - \ln(P_C / P_C(-1))\ ] \,/\, [\ \ln(P_T / P_T(-1))\ ] \qquad (8)$$

where P_G, P_C and P_T stand for the populations of Greece, Cyprus and Turkey respectively.

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[9] We are thankful to professor A. Bountis of the University of Patras, Greece, for his contribution to our analysis on this issue.

Denoting by g, c, and t the corresponding Greek, Cypriot and Turkish population increases, as given in (8) above, i.e:

$$g = \ln (P_G / P_G(-1)) \quad (9)$$

$$c = \ln (P_C / P_C(-1)) \quad (10)$$

$$t = \ln (P_T / P_T(-1)) \quad (11)$$

Then, following Chiang (1984), x represents the algebraic solution of the following equation:

$$c * t^x - g = 0 \quad (12)$$

It is evident, therefore, that (12) provides the necessary theoretical framework within which a relative security coefficient may be developed and used to quantify the impact of the various strategies selected by the sides involved in an arms race.

The benefits of introducing such a measure and applying it using neural networks are clear:

(a) It provides for a means to measure the impact of an arms race on the security of the allies involved in a much more specific way compared to the arbitrary payoffs found in the literature so far. Using, therefore, the relative security coefficient described in this paper, one may proceed to cardinal measurement comparisons among various arms race scenarios, thus drawing useful conclusions on the impact of such a race on the member states of an alliance.

(b) This Relative Security coefficient, by emphasizing the role of demographic variables, is tailored to fit the case of specific categories of arms races, in which human resources play a dominant role, such as the one between Greece and Turkey.

It is important to remember, however, that the application of this relative security coefficient is not necessarily confined to cases of two - member alliances. In fact, the number of the member countries in an alliance does not impose any constraint, as long as one focuses on the relative security involving pairs of member countries each time, facing a common threat.

The relative security coefficient for the Greek-Cypriot alliance thus established represents the output of our network algorithm, using as input some of the leading determinants of the Greek-Turkish arms race (Stavrinos and Zombanakis 1998; Andreou and Zombanakis 2000), as well as the top performing variables during preliminary input significance exercises (Table 1). The input variables thus selected are the GDP as well as its share representing defence expenditure of the three countries involved. In addition, the GDP share of the non-defence spending in Greece and Cyprus have been employed in order to introduce the opportunity cost of defence and thus the dimension of the peace dividend in the analysis.

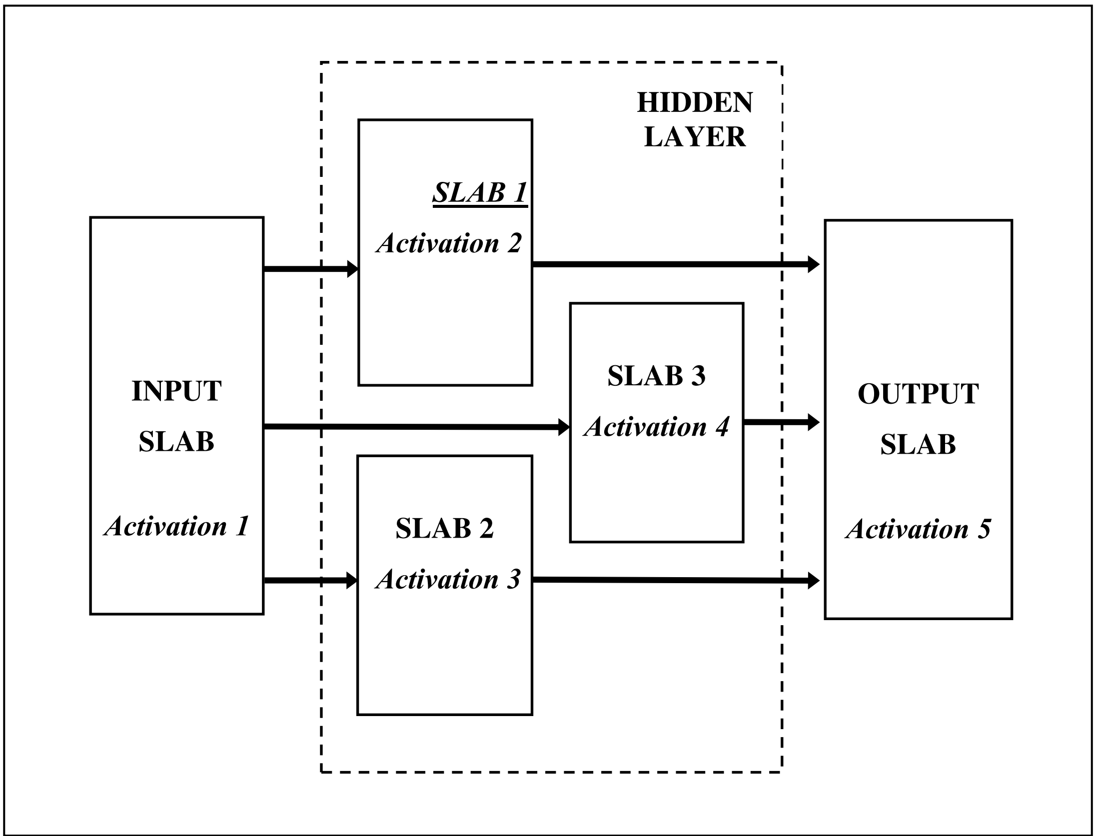
Table 1: Variables, data and sources

Code	Data Series	Source
GGDPCS	GDP of Greece, Constant Prices	Greek National Accounts
CGDPCS	GDP of Cyprus, Constant Prices	Cypriot National Accounts
TGDPCS	GDP of Turkey, Constant Prices	International Financial Statistics, IMF
GDEFCRS	Defence Expenditure of Greece (share of GDP)	SIPRI
CDEFCRS	Defence Expenditure of Cyprus (share of GDP)	SIPRI
TDEFCRS	Defence Expenditure of Turkey (share of GDP)	SIPRI
GNDEFCRS	Non-Defence Expenditure of Greece (share of GDP)	Greek National Accounts
CNDEFCRS	Non-Defence Expenditure of Cyprus (share of GDP)	Cypriot National Accounts

2.3 TECHNICAL BACKGROUND

This section is devoted to present briefly the methodology of artificial neural networks. By using this data driven approach in forecasting the impact of the arms race on the security of the allies, one may avoid the complications arising due to the use of intricate models involving non-linearities, where, for example, the empirical results are occasionally contradictory. This approach is based on developing a "machine" composed of a number of basic computational elements called neurons, connected to each other forming layers. A network is trained through general-purpose algorithms based on available data. The problem is reduced to the computation of weight neuron connections in a feed-forward network to accomplish a desired input-output mapping.

The learning phase can be viewed as a high dimensional, non-linear, system identification problem. In a feed-forward Multi-Layer Perceptron (MLP) links from each neuron in the k^{th} layer are being directed to each neuron in the $(k+1)^{th}$ layer. Inputs from the environment enter the first layer and outputs from the network are manifested at the last layer (Azoff 1994; Andreou and Zombanakis 2000).



architecture

The core architecture of our networks is the feed-forward MLP described above. Variations of this scheme were employed, such as the m-d-1 and m-d_1-d_2-1 topologies (m input nodes, one and two hidden layers respectively and one output) and a Multiply Activated (MA) one. The latter uses one hidden layer partitioned into three parallel sub-layers activated by a different function (Figure 1). All networks developed have one output neuron, which yields the next sample (predicted value) in the time sequence. The training algorithm used is the well-known Error Back Propagation with a momentum term (e.g. Rumelhart and McLelland 1986; Azoff 1994). The networks are trained to learn and then predict the behaviour of the time-series presented in specific patterns of data.

The networks used in the present paper were divided into three categories: The first one employs MLPs with a single hidden layer (category A), the second one includes MLPs with two successive hidden layers (category B) and the last one involves the Multiply Activated MLP (MAMLP – category C) described above. Different topologies, as regards the number of nodes within the hidden layers, were implemented. In addition, variations of learning schemes were adopted, lying on different activation functions (Table 2), such as:

Logistic sigmoid : $$f(y)=(1+\exp(-by))^{-1} \tag{13}$$

Hyperbolic tangent : $$f(y)=(1-\exp(-by))*(1+\exp(-by))^{-1} \tag{14}$$

Gaussian : $$f(y)=\exp\left(-x^{2}\right) \tag{15}$$

Gaussian complement : $$f(y)=1-\exp\left(-x^{2}\right) \tag{16}$$

where, $$y=\sum_{i=1}^{n} w_i x_i \tag{17}$$

and $x_i s$ denote the input values of a node, while w_is the real valued weights of edges incident on a node and n the number of inputs to the node from the previous layer. b is known as the steepness of equations (13) and (14).

The input layer is linear, while the output uses the sigmoid function.

Table 2: Neural network architectures, activation functions and encoding.

Network Architecture*	**Hidden Layer(s) Activation Function(s)**	**Code**
8-10-1	Logistic sigmoid	A(1)
8-10-1	Hyperbolic tangent	A(2)
8-14-1	Logistic sigmoid	A(3)
8-14-1	Hyperbolic tangent	A(4)
8-10-5-1	Logistic sigmoid	B(1)
8-10-5-1	Hyperbolic tangent	B(2)
8-15-8-1	Logistic sigmoid	B(3)
8-15-8-1	Hyperbolic tangent	B(4)
8-3-3-3-1	1st slab: Gaussian; 2nd slab: Hyperbolic tangent; 3rd slab: Gaussian complementary	C(1)
8-3-3-3-1	1st slab: Gaussian; 2nd slab: Gaussian complementary; 3rd slab: Hyperbolic tangent	C(2)
8-3-5-8-1	1st slab: Gaussian; 2nd slab: Hyperbolic tangent; 3rd slab: Gaussian complementary	C(3)
8-3-5-8-1	1st slab: Gaussian; 2nd slab: Gaussian complementary; 3rd slab: Hyperbolic tangent	C(4)

* "m-d-n" stands for m input nodes, d nodes in the hidden layer and n output nodes.
"m-d-p-n" stands for m input nodes, d nodes in the first hidden layer, p nodes in the second hidden layer and n output nodes.
"m-d-p-k-n" stands for m input nodes, d hidden nodes in the first slab (total hidden neurons subset) of the hidden layer, p hidden nodes in the second slab, k hidden nodes in the third slab and n output nodes.

Our data series consist of 33 annual observations, 25 of which were included in the training set and 8 in the testing set. The forecasting horizon was set to one step ahead. Performance was evaluated using well known and widely used error measures (see next sub-section), specifically the Normalized Root Mean Squared Error (NRMSE), the Correlation Coefficient (CC), the Mean Relative Error (MRE), the Mean Absolute Error (MAE) and the Mean Square Error (MSE). All these measures were evaluated on the testing set of data, that is, a set of pattern values that did not participate during the course of learning.

An important aspect examined in the present analysis is the determination of the significance ordering of the variables involved, that is, the selection of the variables that contribute more to the forecasting process. This task can be performed using the notions of input sensitivity analysis, described extensively in Refenes et al. (1995) and Azoff

(1994), based on which one can sum up the absolute values of the weights fanning from each input variable into all nodes in the successive hidden layer, thus estimating the overall connection strength of this variable. The input variables that have the highest connection strength can then be considered as most significant, in the sense of affecting the course of forecasting in a more pronounced way compared to others. Presenting the analytical technical background behind these notions is beyond the scope of this work, since the reader may refer to the sources stated above for further information.

2.3.1 System design and implementation

The given time series $x=\{x(t): 1 \leq t \leq N\}$ is divided into two sets: a training set $x_{train}=\{x(t): 1 \leq t \leq T\}$, and a test set $x_{test}=\{x(t): T < t \leq N\}$, where N is the length of the data series. The training phase presents the x_{train} set to the network repeatedly until a certain level of convergence is achieved based on some error criterion. The learning algorithm adjusts the weights in each repetition in order to minimize the diversion of the desired value from the predicted one.

The number of input neurons and the selection of the variables involved have been based on prior research on the topic, as stated in section 2, which has led to the choice of the input set which exhibits the highest performance in terms of prediction accuracy. We used several alternative configuration schemes, as regards the number of hidden layers and the nodes within each layer, in order, first to achieve best performance and second, to facilitate comparison between different network architectures (Table 2). Every input variable is associated with one neuron in the input layer.

Determining the number of hidden layers and neurons in each layer can often be a very difficult task and possibly one of the major factors influencing the performance of the network. Too few neurons in a hidden layer may produce bias due to the constraint of the function space, which results to poor performance as the network embodies a very small portion of information presented. Too many neurons on the other hand may cause overfitting of data on one hand and increase considerably the amount of computational time needed for the network to process data on the other, something that will not necessarily lead to convergence. We therefore have used a variety of numbers of neurons within one hidden layer, while in some cases a two-hidden-layer scheme was also developed in order to investigate whether performance is improved.

The number of iterations (epochs) presenting the whole pattern set during the learning phase is also very important. We have let this number vary during our simulations, since different network topologies, initial conditions and input sets, require different convergence and generalization times. The number of epochs our networks needed for convergence was 10,000, while the learning and momentum coefficients (Rumelhart and McLelland 1986; Azoff 1994) were kept constant at the positive values of 0.3 and 0.1 respectively. One should be very cautious though when using a large number of epochs, as the network may overfit the data thus failing to generalize. The problems of bias and data overfitting can be overcome by evaluating the performance of each network using a testing set of unseen patterns (testing phase). This set does not participate during the learning process (e.g. Azoff, 1994). If the network has actually learned the structure of the input series rather than memorizing it then it can perform well when the testing set is presented. Otherwise, if bias or overfitting is really the case, performance will be extremely poor on these “new” data values. Architecture selection is generally based on success during the testing phase, provided that the learning ability was satisfactory.

2.3.2 Performance evaluation

The CC measures the ability of the predicted samples to follow the upward or downward jumps of the original series. A CC value near 1 in absolute terms is interpreted as a perfect follow up of the original series by the forecasted one. A negative CC sign indicates that the forecasting series follows the same ups or downs of the original series with a negative mirroring, that is with a 180^o rotation about the time-axis. When the original series moves up, the forecasting moves down at the same time-period and vice versa.

The NRMSE indicates whether prediction is better than a simple mean forecaster. If NRMSE=0 then predictions are perfect; NRMSE=1 indicates that prediction is no better than taking x_{pred} equal to the x-mean.

MRE shows the accuracy of predictions in percentage terms expressing it in a stricter way, since it focuses on the sample being predicted, not depending on the scale in which the data values are expressed or on the units of measurement used. Thus, we are able to estimate prediction error as a fraction of the actual value, this making the MRE the more objective error measure among the three used.

MSE is reported in order to have the error condition met by the Back Propagation algorithm, while the MAE shows the divergence between actual and predicted samples in absolute measures. The above prediction error measures are given by the following equations:

$$\mathrm{NRMSE(n)} = \frac{\mathrm{RMSE(n)}}{\sigma_{\Delta}} = \frac{\mathrm{RMSE(n)}}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[x_{act}(i) - \overline{x}_{act,n}\right]^{2}}} \tag{18}$$

where,

$$\mathrm{RMSE(n)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[x_{pred}(i) - x_{act}(i)\right]^{2}} \tag{19}$$

$$\mathrm{CC} = \frac{\sum_{i=1}^{n}\left[\left(x_{act}(i) - \overline{x}_{act,n}\right)\left(x_{pred}(i) - \overline{x}_{pred,n}\right)\right]}{\sqrt{\left[\sum_{i=1}^{n}\left(x_{act}(i) - \overline{x}_{act,n}\right)^{2}\right]\left[\sum_{i=1}^{n}\left(x_{pred}(i) - \overline{x}_{pred,n}\right)^{2}\right]}} \tag{20}$$

$$\mathrm{MRE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{x_{pred}(i) - x_{act}(i)}{x_{act}(i)}\right| \tag{21}$$

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|x_{pred}(i) - x_{act}(i)\right| \tag{22}$$

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}\left(x_{pred}(i) - x_{act}(i)\right)^{2} \tag{23}$$

where $x_{act}(i)$ and $x_{pred}(i)$ the actual and predicted value when pattern i is presented,

$\overline{x}_{act,n}$, $\overline{x}_{pred,n}$ the mean value of actual and predicted samples of length n

and n is the total number of patterns.

2.4 POLICY SIMULATIONS

The RS coefficient seems to be quite successful in predicting the impact on the relative security of Cyprus with reference to Greece, in the context of an arms race between the two allies on one hand and Turkey on the other, using the input variables described earlier. As indicated in Table 3, the error figures during the training phase reveal a very satisfactory performance.

In general, performance after training was very successful as indicated by the Correlation Coefficient (CC), while the Normalized Root Mean Squared Error (NRMSE) indicates that predictions were by far better than the simple mean forecaster (NRMSE equal to 1). The deviation between actual and predicted samples, as indicated on the basis of the Mean Relative Error (MRE), the Mean Absolute Error (MAE) and the Mean Square Error (MSE) is negligible. As a result, the ability of the networks to generalize the knowledge embodied through the learning process during the testing phase is considerably high, as assessed on the basis of the corresponding errors for the out-of-sample data. More specifically, the forecasting performance during the testing phase is quite successful in CC terms, which in certain networks, like C(2), C(3) and C(4) reached an approximate 84-89% follow up of the original series.

Regarding prediction accuracy, the MSE, MRE and MAE error indicators exhibit low values in all networks, while the NRMSE figures indicate a slightly inferior behavior compared to a simple mean predictor in most of the cases, with the exception of A(2) and all networks constituting the C category. The network that yields the most accurate predictions regarding all error measures used is C(2) (Figure 2), while the predictions of the rest C-category networks are also quite satisfactory. Finally, concerning the rest two network categories, only one network, namely A(2) presented a forecasting performance which can be considered as equally successful.

Table 3: Forecasting performance and error figures

Network	Training Phase				
	NRMSE	MSE	CC	MRE	MAE
A(1)	0.0613	0.00430	0.9980	0.0642	0.0445
A(2)	0.0340	0.00130	0.9994	0.0393	0.0258
A(3)	0.0644	0.00470	0.9978	0.0713	0.0479
A(4)	0.0354	0.00140	0.9994	0.0372	0.0258
B(1)	0.0619	0.00430	0.9980	0.0636	0.0426
B(2)	0.0236	0.00120	0.9994	0.0332	0.0211
B(3)	0.0738	0.00620	0.9972	0.0800	0.0592
B(4)	0.0183	0.00030	0.9998	0.0176	0.0124
C(1)	0.0113	0.00010	0.9999	0.0103	0.0066
C(2)	**0.0070**	**0.00005**	**1.0000**	**0.0057**	**0.0041**
C(3)	0.0037	0.00001	1.0000	0.0032	0.0025
C(4)	0.0125	0.00010	0.9999	0.0095	0.0075
Network	**Training Phase**				
	NRMSE	**MSE**	**CC**	**MRE**	**MAE**
A(1)	1.0871	0.6909	0.7594	0.4779	0.4453
A(2)	0.9425	0.5194	0.7526	0.5309	0.4613
A(3)	1.0683	0.6672	0.7537	0.5006	0.4536
A(4)	1.0518	0.6467	0.7589	0.4901	0.4523
B(1)	1.1511	0.7746	0.7604	0.4908	0.4642
B(2)	1.2462	0.9079	0.7598	0.5322	0.5282
B(3)	1.1167	0.7290	0.7638	0.4305	0.4115
B(4)	1.1554	0.7805	0.7588	0.5357	0.5151
C(1)	0.7650	0.2264	0.8795	0.3689	0.2993
C(2)	**0.6858**	**0.2183**	**0.8854**	**0.3338**	**0.2217**
C(3)	0.8352	0.3683	0.8486	0.3806	0.4389
C(4)	0.8511	0.2889	0.8367	0.3785	0.3199

Before we move to examining how the relative security of the two allies may be affected in the context of alternative arms race scenarios, we turn to investigate the leading determinants of the relative security between Cyprus and Greece, facing the possibility of a Turkish threat. Input sensitivity analysis was performed for all networks used, following the learning phase, with the summation of weights corresponding to each input node (variable) presented in Table 4 in descending order.

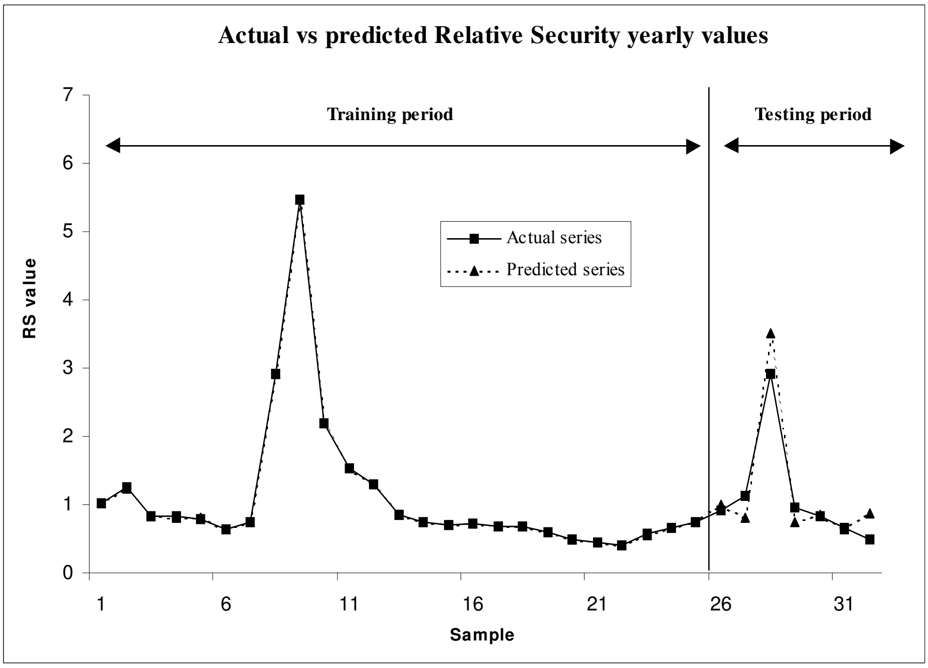


Figure 2. Actual versus predicted values of the Relative Security (RS) coefficient using an 8-3-3-3-1 MAMLP neural network architecture.

The findings of our experiments seem to be very much in line with earlier research on this topic (Andreou and Zombanakis 2000). Indeed, all experiments agree that the share of defence in the GDP of Turkey is clearly the top determinant of the Greek-Cypriot relative security. In most cases the Greek and Cypriot GDP shares of non-defence expenditure are the next two most important determinants of the relative security between the two allies. This finding underlines the importance of the trade-off between defence and non-defence spending and the extent to which the sacrifice of the peace dividend as a result of this specific arms race is too important to be overlooked, a conclusion which seems to agree with most of the literature (e.g. Hartley and Hooper 1990; Gleditsch et al. 1996).

Table 4: Input significance analysis (percentage in parentheses)

NN	Input variables significance ordering (descending)							
	1st	2nd	3rd	4th	5th	6th	7th	8th
A(1)	TDEFCRS (24.12)	CGDPCS (16.76)	GNDEFCRS (14.08)	GDEFCRS (11.91)	GGDPCS (10.70)	CNDEFCRS (8.76)	TGDPCS (7.48)	CDEFCRS (6.20)
A(2)	TDEFCRS (21.65)	GNDEFCRS (17.69)	CGDPCS (14.49)	GDEFCRS (12.56)	CDEFCRS (11.40)	CNDEFCRS (8.75)	GGDPCS (8.33)	TGDPCS (5.13)
A(3)	TDEFCRS (22.21)	GNDEFCRS (17.49)	CGDPCS (15.84)	TGDPCS (10.03)	GDEFCRS (9.33)	CNDEFCRS (8.78)	GGDPCS (8.74)	CDEFCRS (7.58)
A(4)	TDEFCRS (23.11)	GNDEFCRS (16.37)	TGDPCS (11.52)	CGDPCS (11.51)	GGDPCS (10.51)	GDEFCRS (9.99)	CNDEFCRS (8.83)	CDEFCRS (8.17)
B(1)	TDEFCRS (25.43)	CGDPCS (17.56)	GNDEFCRS (13.74)	GGDPCS (10.56)	CNDEFCRS (9.65)	GDEFCRS (9.22)	TGDPCS (8.09)	CDEFCRS (5.75)
B(2)	TDEFCRS (22.50)	GNDEFCRS (14.70)	CGDPCS (14.26)	GDEFCRS (12.24)	GGDPCS (9.96)	CNDEFCRS (9.25)	CDEFCRS (8.89)	TGDPCS (8.18)
B(3)	TDEFCRS (20.51)	CGDPCS (19.38)	GNDEFCRS (11.51)	GGDPCS (11.35)	GDEFCRS (10.60)	CNDEFCRS (9.58)	TGDPCS (9.37)	CDEFCRS (7.71)
B(4)	TDEFCRS (18.53)	GNDEFCRS (15.19)	GDEFCRS (13.32)	CGDPCS (12.56)	GGDPCS (12.50)	CNDEFCRS (11.35)	CDEFCRS (9.90)	TGDPCS (6.66)
C(1)	TDEFCRS (25.10)	GNDEFCRS (15.44)	GGDPCS (14.11)	GDEFCRS (13.18)	CNDEFCRS (9.87)	CGDPCS (8.98)	CDEFCRS (7.47)	TGDPCS (5.85)
C(2)	TDEFCRS (20.67)	GNDEFCRS (19.64)	CNDEFCRS (12.26)	CGDPCS (11.26)	GGDPCS (10.92)	GDEFCRS (10.89)	TGDPCS (8.20)	CDEFCRS (6.17)
C(3)	TDEFCRS (19.82)	GNDEFCRS (15.41)	CNDEFCRS (12.36)	CGDPCS (12.25)	GDEFCRS (11.71)	GGDPCS (10.13)	CDEFCRS (9.35)	TGDPCS (8.97)
C(4)	TDEFCRS (19.52)	GNDEFCRS (16.45)	CNDEFCRS (11.99)	GDEFCRS (11.68)	CGDPCS (11.51)	GGDPCS (10.35)	TGDPCS (10.23)	CDEFCRS (8.27)

Having identified the leading determinants of the relative security of the two allies with reference to Turkey, we may now proceed to study the simulation results of the networks forecasts of our relative security measure in the context of various arms race scenarios. The forecasting horizon included in the testing phase of the networks reaches the year 2002 and the results obtained confirm the findings of the literature on arms races and the various strategy payoffs (e.g. Wolfson 1985). The advantage of our method, however, lies with the possibility offered to substitute measurable payoffs for hypothetical, arbitrary values, thus obtaining a more meaningful cardinal measurement of the results of an arms race in the context of the Integrated Defence Space Doctrine.

The scenarios selected are the usual ones involved in a typical arms race examined via game theory, or in the context of the "prisoner's dilemma" (e.g. Majeski 1984). We assign, therefore, increasing or decreasing future values to the GDP shares of defence expenditure of Greece and Cyprus on one hand and Turkey on another[10], thus referring to the following four scenarios, with the terms "reduction" and "escalation" suggesting a respective decrease or increase of the GDP share of defence expenditure of the country or countries involved: (i) Both sides escalate, (ii) Greece and Cyprus escalate and Turkey reduces, (iii) Turkey escalates and Greece and Cyprus reduce, and (iv) Both sides reduce.

Prediction of the future course of the RS coefficient in the context of the scenarios described above was performed using the C(2) network which achieved the highest forecasting performance during all earlier simulations.

As the prediction results in Table 5 indicate, RS behaves as expected, according to the theoretical basis stated earlier. The best outlook is provided in the case in which both sides choose to reduce tension by contracting their defence expenditure, as this is described by the GDP ratio of military expenditure, a finding to be expected bearing in mind the peace dividend for both sides as described in the literature (Balfousias and Stavrinos 1996; Ozmucur 1996). In this case, the Greece-Cyprus relative security coefficient RS for the five years forecasted assumes an average value of 4.82, the highest of all scenarios. The second best option, however, seems to be the case in which both sides resort to an arms race, this providing for an average 5 year RS forecasted value of 4.55. The advocates of the "si vis pacem para bellum"[11] doctrine, however, will be delighted to observe that the year 2002 value of the RS coefficient in this scenario is practically equal to the corresponding value of the case in which both sides select the reduced defence spending policy. This finding is very interesting, since it underlines the importance of the arms race on the security of the alliance members.

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[10] The choice of the defence expenditure as a share of the GDP rather than the level of the military expenditure itself is widely used in the literature and aims at introducing, to a certain extent at least, the question of sustainability of the defence burden by relating it to the total output of an economy.

[11] The Latin for "if you want peace prepare for war"

Table 5: Case scenarios predictions on the Relative Security (RS) coefficient

Scenario	Year	Predicted RS
All countries escalate	1998	1.4469
	1999	2.4368
	2000	4.0670
	2001	6.1940
	2002	8.5902
Cyprus and Greece escalate, Turkey reduces	1998	1.6812
	1999	2.3682
	2000	2.9593
	2001	3.5439
	2002	4.1159
Turkey Escalates, Cyprus and Greece Reduce	1998	0.7649
	1999	0.6195
	2000	0.3689
	2001	0.1808
	2002	0.0675
All countries reduce	1998	1.6406
	1999	3.0701
	2000	4.6800
	2001	6.4924
	2002	8.2233

The cases in which one of the two parties emphasizes military spending, while the other reduces, also appear to be very interesting. Indeed, the average RS value for the five-year period forecasted is 2.93 in the case in which Greece and Cyprus increase their GDP share of defence expenditure, while Turkey reduces it. This conclusion is very much in line with both the established theoretical framework (e.g. Hartley and Sandler 1995), as well as elementary reasoning, given that the RS reflects the relative security of the Greek-Cypriot side.

It is also interesting to point out that the RS figures in all scenarios increase together with the time horizon, with the exception of those derived in the fourth scenario, namely the one in which Turkey escalates while Greece and Cyprus limit their defence expenditure. In this case the average of the RS figures, which decline with time up to 2002, does not exceed 0.4, a very low value for the security of the two allies, as expected. The graphical description of the results referring to all four scenaria as discussed above is shown in Figure 3.

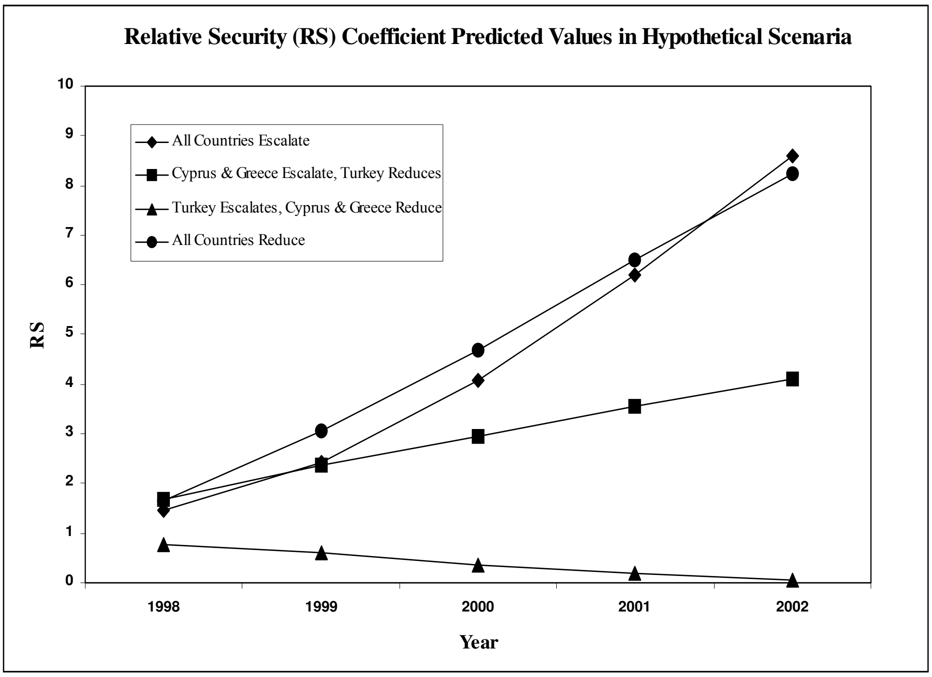

Figure 3. Predicted values of the Relative Security (RS) coefficient for hypothetical scenaria, using an 8-3-3-3-1 MAMLP neural network architecture.

2.5 CONCLUSIONS

The aim of this paper has been to contribute to the cardinal measurement of an arms race impact upon the security of two allies involved in such a race against a potential adversary. The analysis refers to the co-operation between Greece and Cyprus in the area of national security, something that has already been materialized in the context of the so-called Integrated Defence Space Doctrine. Our efforts have focused on supplementing the available literature on arms races by suggesting the introduction of a payoff relative security coefficient, emphasizing the dominant role of human resources in this case and measuring the impact on the military security of the two allies as a result of an arms race against a third party, namely Turkey.

The main conclusion drawn after a variety of scenarios have been tried is that the short and medium term relative security of Cyprus and Greece is maximized when both sides involved in the arms race reduce their defence expenditures, while the arms race scenario appears as a second-best choice. When it comes to the long-run, however, it is interesting to see that the Greece-Cyprus relative security index assumes its maximum value in the context of an arms race between Greece and Cyprus on one hand and Turkey on the other. This finding supports the view of those who believe that despite the peace dividend (Balfousias and Stavrinos 1996), Greece has no choice but to follow up the ambitious 25-year Turkish armaments programme. Finally, the results of the "Turkey escalates-Cyprus and Greece reduce" scenario are discouraging due to their lowest relative security values and, consequently, their poor contribution to peace promotion, something that must be taken to consideration by the one - sided disarmament policy followers.

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INTERIM 2

"Si vis pacem para bellum"
(if you desire peace prepare for war)
Roman saying

It seems, therefore, that the Romans were right when they claimed that those who desire peace must prepare for war. This was, obviously, a strictly empirical finding attained centuries earlier before the world knew anything about defence economics, Richardson models, game theory or Nash equilibrium which are nowadays used simply to reach this very straightforward conclusion.

The coincidence of theory and practice in this case leads to the following two very important considerations: The first one suggests that defence economics is by no means what some people refer to as "the painful elaboration of the obvious". On the contrary, theoretical structures like the ones mentioned in the previous paragraph provide the means to firmly support the Roman views on the trade-off between war and peace. They, moreover, contribute to proving that those who lament over a wasted peace dividend do not know or, what is even worse, do not want to know the value of military security as an investment for peace[12].

The second one is much more specific, as it refers strictly to the way in which Turkey seems to convert theory into practice, being a devoted follower of the Roman views on the subject. This focus of the Turks to the Roman dogma is not unreasonable. In fact, it seems that Turkey feels threatened in more ways than one, as it has been

[12] There are numerous sources on the issue of the peace dividend, both theoretical and applied in the case of various countries. A useful source in this case would be the book by Gleditsch et al. (eds.) "The Peace Dividend", North Holland, 1996 that includes studies for both Greece and Turkey.

involved in a number of crises, to a large or a lesser extent, especially during the past decade: The Gulf War during the beginning of the nineties and its current version in 2003 have both underlined the threat of a Kurdish State, especially during a period in which the U.S. realizes that it can not count on Turkey for its long-term strategies, at least to the extent that it used to do before the JDP (Justice and Development Party) won the November 2002 elections. The instability in Georgia and Armenia in the north-east border and the tension occasionally prevailing between Turkey and Syria over territorial disputes can only contribute to this feeling of insecurity. Finally, the relations of Turkey with Greece offer a wide variety of occasions for friction between the two countries in a number of issues like the Turkish territorial ambitions in the broader Aegean Sea theatre and the Cyprus issue. It is only natural therefore, that Turkey should aim at interfering in all these cases in a manner that not only would appease its fears concerning its territorial status quo, but would also favor its strategic ambitions. To do so it has always been pursuing a very consistent defence procurement policy, even during financially rough times. This consistency has been repeatedly underlined by the long-term procurement programmes of the Turkish armed forces, to which the domestic defence industry contributes a substantial share[13]. And even in cases in which unforeseen difficulties might arise, like the major earthquake in 1999 and the recent economic and political crisis, the projects involved in these programmes are never cancelled. They are simply postponed for a number of years.

As a result, Turkey has paid its focus on security matters rather dearly given the disappointing performance of its economy, especially during the recent past[14]. In fact, the steady growth of its huge external debt has been sustained thanks to the scandalous

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[13] The current long-term defence procurement programme of the Turkish armed forces has a 30-year time horizon. It expires in 2025 and involves purchases of the order of 150 billion U.S. dollars. For details on this issue the authorized reader may consult Pavlopoulos (2000).

[14] Inflation rate in terms of consumer prices is of the order of 50% for the last few years while the Turkish lira market rate depreciates versus the U.S. dollar at rates ranging between 50% and 100%. The associated "persistently high real levels of interest rates", states the latest OECD Economic Outlook, "are making the debt sustainability criterion difficult to meet, given the very large amount of short-term debt that either has to be rolled over, or has been issued on a floating-rate basis. The high proportion of the debt that is now denominated in or linked to foreign currencies also leaves the debt burden susceptible to exchange-rate changes". The same OECD source points out in addition that "the currently high country risk premium will become an obstacle to growth. Another source of downside risk is bank lending to the corporate sector, as non-performing loans continue to rise and put pressure on banks' capital. A significant deterioration in the labor market, with adverse effects on income distribution, remains a major threat to consumption dynamics".

generosity of the IMF, which grants Turkey one loan after another just upon request[15]. Yet, the SIPRI figures point out that the average growth rate of the country's economy for the last thirty years or so, although not negligible, is lower than the corresponding defence expenditure figure[16]. These choices of Ankara are even more impressive if one considers that they reflect the top importance, which it attaches to its defence procurement programmes in times during which almost all NATO allies reduce their defence budgets.

The Greek views on this issue seem to be radically different. The time horizon of the procurement programmes, to which the domestic industry has been contributing a negligible percentage – at least before the privatization of the shipyard industry – does not usually exceed five years while they are always revised downwards on the grounds of hardly convincing excuses. In fact the most recent procurement programme of the Greek armed forces had been curtailed to reach about half its original budget, only two years after earning the approval of the parliament. The government claimed that it thus hoped to reallocate some of these funds to support its social policy and to finance some of the infrastructure projects of the 2004 Olympic games[17]. We feel that this is a rather weak argument considering the policy followed at least for about a decade now. In fact, Kyriazis and Somakos[18] point out that back in 1996 the government opted for spending 1,350 billion drachmas in order to subsidize public enterprises, the managers of which seem to care more about employing the ruling party voters rather than pursuing strict business criteria. These subsidies, which were needed to finance the impact of the

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[15] The debt repayments due this year, which amount to 93 billion U.S. dollars, do not seem to be an impediment to the unobstructed flow of IMF loans to Turkey. The country, however, seems to have sacrificed the 6 billion dollar aid package, following its refusal to allow U.S. troops to use its territory in order to create a northern front during their recent invasion against Iraq.

[16] The defence expenditure figures published in SIPRI do not include the generous contribution of the Defence Industry Support Fund (DISF).

[17] On March 29, 2001 the government used these excuses not only to reduce the defence budget for the period 2002–2004 by one trillion drachmas, but in addition, to postpone the Greek participation to the construction of the fourth generation "Typhoon" fighter and the purchase of a number of these planes, thus weakening the long-run defence potential of Greece. The most important adverse repercussion of this decision is undoubtedly the fact that Greece missed the chance to participate in the European defence industry more actively than ever. The reader, however, will be very amused to know that exactly two years later, in March 2003, the Greek defence minister declared his priorities concerning mergers and other forms of integration of the European defence industry, as well as the increase of the research and development funds!

[18] Kyriazis and Somakos (1999) "Greece and Turkey, Defence and Economy'' (in Greek) p.p. 32-33.

resulting diminishing returns and diseconomies of scale in these enterprises, exceeded the country's annual defence expenditure by about 70%. Needless to point out that this money was enough to buy 193 F-16s or 96 F – 15s, much more than what the Hellenic Air Force would ever dream of purchasing! It seems that the dividing line between politics and demagogy is sometimes too thin for certain people to see. Except, if they pretend not to see …[19]

We have strong reasons to believe that the second is more likely than the first. Those who preach the reduction of the Greek defence expenditure on the grounds that the economy has reached its capacity limits are engaged in first class sophistry, using arguments based on an apparent inverse relationship between defence expenditure and GDP rate of growth. We are sorry to point out, however, that a similar line of reasoning would support practically any form of correlation. Thus, for example, we have already mentioned the case of the Church subsidies in the north of Greece, which has resulted to an increase in the number of births in the area. We also know that following a set of environmental measures taken in the same area, the number of storks has increased spectacularly. The direct relationship, therefore, between the birth rate and the number of storks in the area indicates that storks bring babies!

The scientific translation of this argument is the following: The GDP growth is not the only independent variable that influences the demand for defence expenditure and in most of the cases in the literature, the relationship between the two is a direct one[20]. There are, however, other independent variables used in the literature, like those representing the benefits of an alliance membership or the threat faced which sometimes count much more. Thus, the substantial reduction of the GDP share of defence expenditure to an average of about 4.5% for the nineties compared to almost 6.5% of

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[19] On November 14, 2001, the new Greek defence minister announced that the GDP percentage of the defence expenditure is targeted to have fallen down to 4% by 2004. These options of the Greek government in favor of a unilateral disarmament policy vis-à-vis Turkey are reflected in the SIPRI figures (in constant prices and exchange rates) which indicate that in terms of military equipment expenditure between 1999 and 2001, Greece shows a reduction by 1.7%, 2.9% and 13.7%, for each of these three consecutive years. During this period, which included both natural and financial earthquakes for Turkey, the corresponding Turkish figures denote increases by 36.4%, 7.4% and 22.8% respectively. As a result the ratio of the Greek equipment expenditure over the corresponding Turkish figure has witnessed a sustained decline throughout this period, from 0.664 in 1998 down to 0.304 in 2001.

[20] For a very useful review on the subject see Hartley, K. and Sandler, T. (1995) *The Economics of Defence*. U.K.: Cambridge University Press.

the previous decade, did not lead to a rise of the GDP growth rates. In fact, the average GDP growth rate for the nineties witnessed a decline to 2.1% down from 2.4%, which was the corresponding figure in the eighties.

These are simple, straightforward arguments, which must be taken into consideration very seriously by decision-makers in Greece. As it is usually the case, the responsibility concerning the final decisions on defence expenditure, both quantitative and qualitative, lies on the politicians' shoulders, with economists and soldiers just proposing solutions. Prior experience suggests that politicians are usually in favour of defence expenditure cuts for obvious reasons while most economists tend to agree on this, leaving soldiers to be the only side pressing for defence spending increases. But even if we accept that decision-makers in Greece do not want to see the logic of increased defence expenditure, we feel that they should, at least, consult the public opinion on the subject as it appears in the daily press, given that polls seem to affect almost every political decision in our days. It is, thus, interesting to see that according to the latest (March 2003) results of an opinion poll conducted regularly throughout Greece on a quarterly basis more than 70% of the answers are in favour of increased defence spending given the external threat. We believe that this admittedly striking result is enough to eliminate all arguments brought forward by the advocates of defence expenditure reduction and especially that of vote maximizing!

In view of this considerable discrepancy of views we have thought that deciding on such a crucial matter demands resorting to our favorite line of argument, which makes extensive use of techniques of analysis. In fact, under the circumstances, the crucial question to answer concerns the so-called "optimal defence expenditure", namely the desired level of defence spending compatible with the capacity of the economy. This compatibility is secured by the introduction of a constraints structure represented by a typical econometric model emphasizing on defence expenditure. Calculating the optimal defence expenditure, however, may cause considerable confusion with reference to the nature of the constraints imposed, something which has become more than obvious during conferences in which we have presented earlier versions of the paper that follows. We must point out beyond any doubt, therefore, that the term "optimal" is used in the text to define the maximum GDP share of defence expenditure allowed by the capacity of the country's economy. It must, consequently, be interpreted as a strictly economic optimization which does not take any geopolitical or strategic matters into consideration, which is, admittedly, a very interesting task for further research. Given, however, that such matters should, and do, in fact, influence such decisions taking into account the increased volatility of the international geopolitical and strategic environment, the derived economic optimization results must be interpreted very carefully. More specifically, the optimal figures derived by our algorithm must be interpreted as representing defence expenditure figures that can be attained without any sacrifice in the form of a peace dividend, since they have been calculated under the constraints imposed by the economic system. Peace dividend considerations can be justified only to the extent that the defence spending figures exceed those suggested by our algorithm as financially optimal for reasons related to geopolitical and strategic considerations.

As we have already pointed out, the contribution of techniques of analysis is decisive in the next chapter. In fact our algorithm performs an optimization under constraints that calculates the highest defence expenditure under the restrictions imposed by the economic system. We have performed such a constrained optimization exercise for both Greece and Cyprus with the structure of the economies of the two allies provided by a system of equations placing particular emphasis on defence expenditure. The latter has been built along the lines of a typical defence demand equation, which however, includes as a special feature the relative security coefficient introduced in chapter 2. We are confident that the reader will acknowledge the vital role of such a technique in this case in which there is ample room for subjective evaluations concerning the ideal level of defence spending.

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CHAPTER 3

CHAPTER 3

Optimal Versus Required Defence Expenditure

The Case of the Greek – Turkish Arms Race[*]

By

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3.1 INTRODUCTION

The recent rescheduling of the Turkish long-term defence procurement programmes following the economic crisis in the country and the reaction of the Greek authorities to reduce their own by about 25% has become the subject of extensive discussions. The issues involved in such discussions concern the possibility of a causal relationship between the developments in the two countries and the extent to which the two sides entangled, for ages now, in an expensive arms race, can afford a reduction of their defence expenditure. This leads to the next question, which involves the calculation of an "optimal" defence burden providing for maximum security in the face of an outside threat bounded by the constraints imposed by the economy.

The optimization will take into account the spillover effects enjoyed by Greece and Cyprus, especially after the implementation of the Integrated Defence Doctrine between these two allies. Finally, we shall consider the extent to which pursuing such an optimum leads to a substantial peace dividend. The answers will be provided in the context of an optimal control solution, using an Interior Penalty Function Method, with Steepest Descent and Armijo Line Search, after a brief literature overview has been

[*] First published in "Defence and Peace Economics", vol. 13, 4, 2002, pp. 329-347.

provided in section 2. The third part of this paper includes the description of the econometric model used by the algorithm as a constraints structure under which the penalty function is minimized. Section 4 includes various policy considerations based on the results derived by the algorithm, while the conclusions derived are stated in the last part of the paper.

3.2 LITERATURE OVERVIEW

The existence of an arms race between Greece and Turkey is a well-established fact (Kollias and Makrydakis 1997), determined, to a large extent, by demographic factors describing the Turkish rather than the Greek economic and demographic environment (Andreou and Zombanakis 2000). The extent to which mutual reduction of defence expenditure would lead to a substantial peace dividend has been extensively analyzed for both the Greek-Turkish case (Balfoussias and Stavrinos 1996, Ozmucur 1996, Kollias 1997), as well in a more general context referring to the cost in terms of growth (Deger 1986, Ward et al. 1991, Buck et. al.1993, Looney 1994 and several authors in Hartley and Sandler 1990). In fact, the cost of an arms race, especially on the foreign sector of what is commonly termed a "small, open economy" is rather expensive since military expenditure, is highly import-demanding, leading to foreign borrowing which exerts an adverse impact on both the domestic and the foreign sector (Stavrinos and Zombanakis 1998). Especially after the full implementation of the Integrated Defence Doctrine between Greece and Cyprus, the GDP shares of military expenditure by the two allies have exceeded 6% in certain cases, while the military debtin current U.S. dollars has doubled during the 1990s to reach more than 5 billion at the end of 2000, representing about 16% of the total General Government external debt of the country, according to provisional Bank of Greece data. Kollias (1994, 1995 and 1996) and Antonakis (1996 and 1997) have investigated the economic effects of defence expenditure upon the Greek economy.

Defence expenditure constitutes a considerable burden for the economies of Greece and Cyprus, raising questions about the ideal defence burden. A convenient way to tackle such issues is using a constrained optimization analysis, which requires minimizing the deviations of the endogenous variables of an economic system from their respective target values subject to the constraints imposed by the economy (e.g. Chow 1975, Levy 1992). The method thus leads to determining the ideal or optimal values for those variables, to the extent, of course, that these are attainable. It is important to stress that the derived values for defence expenditure shall be characterized as optimal in the strict economics sense without involving any constraints of strategic or tactical nature, an issue beyond the scope of this paper. The optimal control analysis, therefore, will specify the defence expenditure that the two allies are able to afford in the context of the theory of alliances in its simplest form (Hartley and Sandler 1995).

3.3 THE MODEL

The constraint structure we use for the optimization procedure is a small, highly aggregated model of seven equations representing the economies of Greece and Cyprus. The model is based on previous research (Stavrinos and Zombanakis 1998), placing emphasis on the defence expenditure side, while variables expressing the Turkish side are taken as exogenous. The majority of the variables are expressed in terms of GDP percentages aiming at concentrating on the growth effects of the priorities assigned to defence policy. Such effects became more pronounced in cases like the Turkish invasion of Cyprus in 1974 and the Greek-Turkish crises in 1982 and 1987. As a first step, all the variables in the stochastic equations have been expressed in natural logs and tested for integration. The data series used are listed in Table 1.

3.3.1 The Demand for Defence Expenditure and the Security Function.

The demand for defence expenditure for each of the two allies, namely Greece and Cyprus, is represented as follows:

$$GDEFCRS = f\,(GGDPCS, GNDEFCRS, GBOP, DRDL, RSC_G, TDEFCRS) \quad (1)$$

$$CDEFCRS = f\,(CGDPCS, CNDEFCRS, CBOP, DLCP, RSC_G, TDEFCRS) \quad (2)$$

where GDEFCRS and CDEFCRS are the corresponding GDP shares of defence expenditure for the two allies.

Table 1: Variables and data sources

Code	Data Series	Source
GGDPCS	GDP of Greece, Constant Prices	Greek National Accounts
CGDPCS	GDP of Cyprus, Constant Prices	Cypriot National Accounts
GTIS	Greek Government Total Investment Expenditure (share of GDP)	Greek National Accounts
GDEFCRS	Defence Expenditure of Greece (share of GDP)	SIPRI
CDEFCRS	Defence Expenditure of Cyprus (share of GDP)	SIPRI
TDEFCRS	Defence Expenditure of Turkey (share of GDP)	SIPRI
GNDEFCRS	Non-Defence Government Expenditure of Greece (share of GDP)	Greek National Accounts
CNDEFCRS	Non-Defence Government Expenditure of Cyprus (share of GDP)	Cypriot National Accounts
GBOP	Greek Balance – of – Payments Deficit (share of GDP)	Greek National Accounts
CBOP	Cypriot Balance – of – Payments Deficit (share of GDP)	Cypriot National Accounts
DRDL	Drachma / U.S. Dollar Exchange Rate	Bank of Greece
DLCP	U.S. Dollar / Cypriot Pound Exchange Rate	I.F.S.
GCPI	*Greek Consumer Price Index*	I.F.S.
CCPI	*Cypriot Consumer Price Index*	I.F.S.
GPOP	Greek Population Growth	I.F.S.
CPOP	Cypriot Population Growth	I.F.S.

Military expenditure is usually reported in current prices in local currency terms. For most purposes of economic analysis, however, it is the share of military expenditure to GDP - the military burden - that is of most interest because it reflects the relative priority given by the state to military demands and because it measures the relative burden or resource costs[21]. Its calculation does not depend on the choice of a specific price index, since it is the ratio of two measures in current domestic currency. It is a pure number that can be compared over time and across countries and it is by now extensively used in empirical investigations. There is, however, caution expressed in the

[21] See Goertz and Diehl (1986), and Herrera (1994), for the comparison of different approaches in measuring military allocations.

literature since measuring the military spending and the other variables in the model as shares or proportions of GDP can be misleading and may introduce biases in the measurement of certain coefficients (Chan 1985). Assuming inflation rates roughly equal for defence and non-defence activities, omitting the price variable does not introduce any biasing results[22]. GGDPCS and CGDPCS is the Greek and Cypriot GDP at constant prices respectively, GNDEFCRS and CNDEFCRS represent the share of non-defence expenditure in the GDP of the two countries, GBOP and CBOP represent the Greek and Cypriot balance-of-payments deficits as a share in their respective GDP, while DRDL and DLCP stand for the two countries respective currency rates against the US dollar. Notice that the price variable is not included in these functions, due to the lack of import substitution in the two countries, a problem which renders the demand for defence equipment almost completely price inelastic. The threat variable in both cases is TDEFCRS, which represents the share of defence expenditure in the Turkish GDP. Finally, special attention should be drawn to the spillover variable: One might be tempted to argue that a suitable spillover variable would be the military burden of the NATO countries except Greece and Turkey. We feel, however, that since our aim is to concentrate on the Greek-Cypriot alliance as this is expressed through the Integrated Defence Doctrine, what is required is an alternative measure tailored to fit this particular case. We have chosen, therefore to use a measure of relative security as a result of the two countries' alliance. This is applicable to cases in which the role of the substantial difference in human resources endowments between the two sides involved in an arms race is decisive (Andreou and Zombanakis 2001). The measure of this relative security coefficient is given by[23]:

$$RSC_G = \exp[x] \tag{3}$$

[22] See Hartley and Sandler (1995) p.61. Data on prices of Greek and Cypriot defence equipment – usually importables – is not available. To the extent that such imports are reported in the balance of payments, import prices of the appropriate SITC category do not exhibit significant differences compared to the rest of the categories.

[23] The RSC_G is a relative security measure particularly tailored to fit cases like the Greece / Cyprus conflict against Turkey. In cases like this the population rates of increase in the two sides play a leading role and this index is designed to emphasize on this specific point, as it is explained in the text. The target set for the RSC_G in this optimization procedure is that population developments on the Greek / Cypriot alliance side counterbalance the Turkish generous population rates of increase, a rather demanding target one must admit. If this is the case, then the numerator must equal the denominator of x yielding a value of unity, the log of which is 2.718. For a detailed explanation on this relative security measure see Andreou and Zombanakis 2001.

where x stands for the ratio of the difference between the Greek and Cypriot population rates of change over the corresponding Turkish figure, as follows:

$$\text{where} \qquad x = \left(\dot{p}_G - \dot{p}_C\right) \ / \ \dot{p}_T \tag{4}$$

On the basis of (3) and (4) one may be tempted to argue that the ideal alliance target for a balance between the two sides concerning security would be a value of RSC_G = 2.718, once x assumes the value of unity. Under the circumstances, however, this is a prohibitive restriction, meaning that the applied side of the matter calls for a more realistic constraint. It must be borne in mind, however, that this relative security coefficient composed of the population characteristics of the two sides involved in an arms race includes more than meets the eye: In fact, the role of the population rates of increase in the RSC_G is not only associated with the possibilities to increase manpower in the armed forces, something which does not necessarily agree with the recipes of modern warfare tactics. It is also linked with the continuous and pressing demands of Turkey for increase of its vital space justified by the population explosion in the country. We feel, therefore, that, given the particularity of the Greek-Turkish arms race, which is affected to a large extent by population developments in the countries involved, the RSC_G identity can serve as a security function entering the allies' utility function[24].

3.3.2 The Output Equation.

The GDP in the two countries is determined on the basis of a behavioral equation rather than an identity, given that the optimization procedure requires that emphasis is placed on the shares of the various GDP components in it. Equations (5) and (6) describe growth in the two allied countries in terms of its main ingredients: accumulation of physical capital as investment in Greece and Cyprus, GTI and CTI respectively, non-defence expenditure, net imports of goods and services as an indication of the external constraint imposed on the growth rate of the economy. Finally, the local currency exchange rate is included given that it has been a very popular policy instrument for the period under study. Thus the GDP in both countries is taken as determined as follows:

[24] See, for example, Bruce (1990).

GGDPCS = f (GNDEFCRS, GTI, GBOP, DRDL) (5)

CGDPCS = f (CNDEFCRS, CTI, GBOP, DLCP) (6)

where GTI and CTI stand for the GDP shares of total investment expenditure in Greece and Cyprus. It must be borne in mind that given the trade-off between non-defence and defence expenditure (Benoit 1978), the latter can be thought of as implicitly introduced in these functions to account for the direct effects of military spending on growth in the form of spin-offs, either favorable or adverse (Hartley and Sandler 1995)[25]. Thus, equations (9) and (12) presented in Table 2 simply underline the importance of the various output components in the GDP of each country, as well as the leading role of the international exchange rate, a policy instrument traditionally used by the economies of the two allies.

3.3.3 The Population Equation

Since we have already underlined the importance of human resources in the Greek - Turkish conflict (Andreou and Zombanakis 2000 and 2001), we have chosen to devote a behavioral equation to describe population developments in each of the two allies[26]. Thus, the Greek and Cypriot populations are taken to behave as follows:

GPOP = f (GGDPCS, GDEFCRS, GNDEFCRS, GCPI) (7)

CPOP = f (CGDPCS, CDEFCRS, CNDEFCRS, CCPI) (8)

where GCPI and CCPI are the Greek and Cypriot consumer price indices. The estimated equations (11) and (14) for the two allies described in Table 3 draw attention to the role of both non-defence expenditure and the consumer price index in determining population growth (Ehrlich and Lui 1997). The consumer price index is included in the function in order to introduce the budget constraint imposed on low - income families that cannot afford to contribute to the population growth.

Table 2. Model equations for Greece (t-values)

[25] General surveys of the effects of military expenditure on growth and development are given in Renner (1991), Isard and Anderton (1992), Pivetti (1992), Mintz and Stevenson (1995), and Ward et al. (1995), among others. For comprehensive bibliographies in English see Klein et al (1995), and Hartley and Hooper (1990).

[26] For a very useful review on the subject we resorted to Ehrlich and Lui (1997).

	EQ.9 (GGDPCS)	EQ.10 (GDEFCRS)	EQ.11 (GPOP)
C	0.022 (3.281)	-0.029 (-2.553)	0.001 (1.371)
GNDEFCRS		-4.872 (-17.598)	0.012 (1.837)
GNDEFCRS(-1)	0.100 (1.931)		
GTIS	0.235 (6.350)		
GBOP(-1)		-0.295 (-4.859)	
GBOP(-4)	-0.056 (-1.878)		
DRDL	-0,062 (-1.635)	0.547 (8.289)	
GGDPCS			0.026 (2.286)
GGDPCS(-1)	0.476 (4.869)		
GGDPCS(-2)		0.354 (2.102)	
GCPI(-2)			-0.0003 (-4.927)
RSC_G (-1)		-0.010 (-2.327)	
GDEFCRS(-3)			-0.005 (-2.001)
GPOP(-1)			0.635 (6.606)
TDEFCRS		0.112 (2.197)	
RES(-1)	-0.048 (-1.984)	-0.147 (-1.904)	-0.113 (-3.054)
DGGDP	-0.047 (-5.416)		
DDIC	0.048 (5.994)		
DGDEF		0.086 (9.881)	
DGDEMO			0.006 (5.547)

3.3.4 Comments on the Equation Estimates

Equations (9) to (14) as listed in Tables 2 and 3, and the relative security measure for the two allies given by the combination of (3) and (4) make up the constraint structure under which the optimization exercise will be undertaken.

Table 3. Model equations for Cyprus (t-values)

	EQ.12 (CGDPCS)	EQ.13 (CDEFCRS)	EQ.14 (CPOP)
C	0.052 (9.331)	0.024 (1.521)	-0.004 (-0.614)
CNDEFCRS	0.227 (2.953)	-16.595 (-26.348)	
CNDEFCRS(-4)			0.055 (1.889)
CBOP	-0.515 (-6.520)		
CBOP(-1)		-0.367 (-2.037)	
DLCP	0.250 (3.189)	-0.455 (-2.578)	
CGDPCS			
CGDPCS(-2)			0.065 (1.823)
CGDPCS(-3)	0.372 (2.197)		
CCPI			-0.016 (-4.026)
RSC_G (-2)			-0.014 (-1.538)
CDEFCRS(-3)			
CPOP(-1)			
TDEFCRS		0.418 (3.320)	
RES(-1)	-0.164 (-7.383)	-0.704 (-5.442)	-0.382 (-8.645)
DCGDP	0.130 (10.071)		
DCINV			0.031 (5.275)
DCDEF		0.210 (8.222)	
DCDEMO			-0.118 (-10.175)
TIME			0.004 (8.886)

All series have been found to be I(1), that is, stationary in their first differences, on the basis of the ADF test, while the estimation period undertaken ranges between 1960 and 2000. The short-run estimates presented in Table 4 comprise an error-correction model, with all coefficients bearing the expected signs and accompanied by their t values in parentheses, while the explanatory power of all six equations is satisfactory.

Table 4: Equation diagnostics and A.D.F. values for the residuals of their long-run versions

CODE NAME	R^2	D.W.	S.E.	A.D.F.*	J-B	ARCH	F(Pr)
EQ.9 (GGDPCS)	0.88	2.39	0.016	-2.84	0.77	0.09	(0.76)
EQ.10 (GDEFCRS)	0.98	1.87	0.025	-2.59	0.66	0.27	(0.60)
EQ.11 (GPOP)	0.81	1.86	0.002	-3.33	1.54	0.64	(0.42)
EQ.12 (CGDPCS)	0.84	2.02	0.033	-2.76	1.70	0.32	(0.57)
EQ.13 (CDEFCRS)	0.97	1.60	0.060	-3.98	0.04	0.87	(0.35)
EQ.14 (CPOP)	0.91	1.41	0.012	-2.06	1.17	0.30	(0.58)

*All A.D.F. tests indicate that the series are I(0) at a 1% level except equation 14 which describes the behaviour of the Cypriot population in the case of which is I(0) at a 5% level. The J-B (Jarque-Bera statistic) shows that the errors are normally distributed while the ARCH figures for autoregressive conditional heteroskedasticity are not significant.

Finally, given the length of the estimation period, the dummies used in the equations tackle the effects of crises between Greece and Turkey or the influence of exogenous disturbances of political or social nature that introduce structural changes in the economies of the two allies[27]. Thus, DCDEMO is used to capture the dramatic change in the Cypriot population after the 1974 invasion while DGDEMO includes the exogenous disturbance of the Greek population after the massive inflow of refugees from Turkey during the mid-sixties and the substantial increase in the number of illegal immigrant workers mainly from Albania and Bulgaria during the beginning of the nineties. DGDEF and DCDEF are used to capture revisions in the long-run defence programmes of Greece and Cyprus or lump sum purchases, which are settled through bilateral agreements and are not reflected in the external accounts of the two countries. The procurement of the Type-209 submarines from HDW by the Greek Navy during the beginning of the seventies, the so-called purchase of the century involving the procurement of a large number of Mirage fighters during the mid-eighties, its revision after the change of the Greek government at the beginning of the nineties and the procurement of the S-300 antiaircraft missiles by Cyprus during the end of the nineties are typical examples. DGGDP and DCGDP represent the effects of certain exogenous disturbances on the economies of the two allies like the three devaluations of the

[27] See Hartley and Sandler (1995) p.61.

drachma in 1983, 1985 and 1996 and the pressure upon the Cypriot economy after the 1974 shock. Finally, DDIC and DCINV capture the prolonged social and political instability in Greece and Cyprus caused by the dictatorial regime between 1967 and 1974.

All variables are expressed in terms of first differences with the RES terms indicating the residual item of the corresponding long-run version of each equation. The A.D.F. tests for these terms along with selected diagnostics are also included in Table 4.

3.3.4.1 The Demand for Defence Expenditure

The resulting estimated equations for Greece (eq. 10) and Cyprus (eq. 13) listed in Tables 5 and 6 describe the picture of their alliance against Turkey along the lines indicated in the literature. The trade-off between defence and non-defence expenditure is underlined in the cases of both Greece and Cyprus while the spill and threat variables seem to be important determinants of their defence expenditure. Finally, the long time lag required for the income variable to affect military spending is expected given the long-term horizon of the various defence procurement programmes that represent a considerable part of military spending in the two allied countries. The income inelasticity of defence expenditure in both equations underlines one of the major issues that this paper points out, namely the necessity to adhere to the defence-expenditure programmes undertaken. The negative sign of the balance-of-payments coefficient in both cases designates the external constraint imposed on the defence-procurement programmes, a constraint reinforced by the exchange-rate effect, the coefficient in all cases indicating an inelastic response of the defence expenditure to these variables. Attention is required when interpreting the difference in the sign of the exchange - rate coefficient between the Greek and the Cypriot cases that is due to the inversion of the parity fraction in the case of Cyprus.

3.3.4.2 The Output Equation

Equations (9) and (12) represent the Greek and Cypriot output growth respectively in terms of their main components and the domestic currency exchange rate against the

U.S. All estimates bear the expected sign and are statistically significant with a marginal exception in the case of the exchange rate in (9). This point, together with the low elasticity derived in both equations are related to the controversy associated with the effects of a domestic currency devaluation on the rate of growth (Zombanakis 1998) while attention, once more, is drawn to the difference in the sign of the exchange - rate coefficient between (9) and (12). The considerable time-lag in the case of the external constraint in the Greek case is related to the lengthy time period involved between an external trade transaction and its settlement with the conversion of the foreign exchange proceeds or payments to domestic currency, given that foreign exchange restrictions apply for a major part of the estimation period.

3.3.4.3 The Population Equation

The estimation of the two population equations (11) and (14) has faced a number of difficulties mainly due to the poor data quality, especially in the case of Cyprus, in which the 1974 invasion has introduced a major disturbance in the population pattern of growth. All coefficients, however, are statistically significant and bear the expected sign. The constraint imposed on population growth due to the standard of living is approximated by the consumer price index the reaction to which turns out to be quite significant, however highly inelastic in both cases. Finally, devoting funds to non-defence activities seems to contribute to the population increase while this is not the case for defence expenditure, at least in the case of the equation for Greece. Introducing defence spending in the Cypriot version of the equation did not produce any meaningful results and was, consequently excluded.

3.3.4.4 The Constrained Optimization

The description of the historical data on the basis of the model seems to be quite satisfactory following a dynamic simulation. Given this set of equations as a constraint structure, the optimization problem is formulated by requiring the minimization of a “welfare function” the arguments of which are the squared deviations of the endogenous variables from their respective targets. These targets are set in the context of a number of scenarios while the policy instruments used are the GDP shares of defence expenditure in the two allied countries. Given that the importance assigned to each of these endogenous variables may differ depending on each policy-maker's hierarchy ordering and priorities, we have decided to perform the constrained optimization introducing these priorities in the welfare function in two different ways: The first is to assign equal weights to all endogenous variables introducing a cardinal hierarchy ordering in terms of determining a target value for each endogenous variable which reflects the emphasis placed on either property or human resources. The second is to allow this emphasis to be reflected in the weights rather than the target values of the endogenous variables, an approach which focuses on the ordinal aspect of the hierarchy ordering. While the equations above have been estimated for the period between 1960 and 2000, the optimization exercise concentrates on the last eleven years, namely 1990 to 2000, in order to avoid the adverse repercussions of a large number of structural reforms, mostly of political nature, affecting Greece and Cyprus during the previous three decades.

The technique we employ for solving the Optimal Control problem is an Interior Penalty Function Method, with Steepest Descent and Armijo Line Search. This has been used for the minimization phase as follows:

$$\Phi(x, r_k) = f(x) - r_k \sum_{j=1}^{m} \frac{1}{g_j(x)}, \tag{15}$$

where $f(x)$ is the sum of squared differences between the variables and their corresponding target values (i.e. the original objective function), $g_j(x)$, $j=1,...,m$, are the constraints of the proposed model, and r_k is the penalty parameter. The repeated application of an unconstrained minimization technique to the function $\Phi(x)$, for a decremented sequence of values of the penalty parameter r_k, leads to convergence of the corresponding solutions to the solution of the original (constrained) problem, with feasibility standing for each one of the intermediate solutions.

For the unconstrained minimization phase of the algorithm, we employ a widely used method, namely the Steepest Descent technique with Armijo Line Search, allowing the solution an accuracy of 10^{-3}, while the maximum number of iterations was set to 500 for all the loops of the algorithm. This maximum number of iterations proved to be enough for obtaining the solution in almost all experiments. In certain cases, however, in which the solution could not be detected after these iterations, re-initialization to a different feasible staring point was considered as an alternative. The validity of the results obtained has been double-checked using a modification of the Particle Swarm Optimization (PSO) method for locating all the global minima of an objective function (Parsopoulos and Vrahatis 2001). This involves setting a threshold, beyond which particles of the population bearing lower function values are isolated. Following that, stretching (Parsopoulos et al. 2001) or deflation is performed at this point in order to repel the rest of the swarm (population) from moving toward it. Finally, a local search is performed in its neighborhood, thus detecting a local minimum. Applied to the function $\Phi(x)$, the modified PSO resulted in several local minima of the objective function as well as the global one which, has been compared to the one obtained by the Steepest Descent algorithm. The main aspects of this algorithm are shown in the pseudo-code listings of the following two subsections.

3.3.4.4.1 Pseudo-Code 1: Interior Penalty Function Method With Steepest Descent and Armijo Line Search

Step 1

Set initial values:

$r_0 = 10$ (Penalty term's initial value)

stop_crit1, stop_crit2 = 0 (stopping criteria)

iter1, iter2 = 0 (iteration counters)

MaxIt = 500 (maximum iterations)

x_0 (initial feasible, randomly taken, approximation of the solution)

$x_{last} = x_0$ (auxiliary parameter)

$x_{old} = x_0$ (auxiliary parameter)

$r = r_0$ (penalty term variable)

$acc = 10^{-3}$ (desired accuracy)

$h_0 = 1$ (Initial step for the minimization phase)

Step 2

WHILE (*stop_crit1* = 0) AND (*iter1* < *MaxIt*) DO

> ***Step 2.1***
>
> Set *iter1* = *iter1*+1, *iter2* = 0.

Step 2.2

(Starting Gradient Descent phase of the algorithm *)*

WHILE ($stop\_crit2 = 0$) AND ($iter2 < MaxIt$) DO

Step 2.2.1

Set $h = h_0$, $iter2 = iter2 + 1$ and $x_{new} = x_{old} - h\ \nabla\Phi(x_{old}, r)$.

Step 2.2.2

(Perform Armijo Line Search to find the optimal step size *)*

WHILE ($\Phi(x_{new}, r) - \Phi(x_{old}, r) > -0.5\ h\ ||\nabla\Phi(x_{old}, r)||^2$) DO

Set $h = 0.5\ h$.

Re-calculate $x_{new} = x_{old} - h\ \nabla\Phi(x_{old}, r)$.

END WHILE (* End of Armijo Line Search *)

Step 2.2.3

IF $||\nabla\Phi(x_{new}, r)|| \leq acc$ THEN

$stop\_crit2 = 1$

ELSE

$x_{old} = x_{new}$

END IF

END WHILE (* End of Gradient Descent phase *)

Step 2.3

IF $||x_{new} - x_{last}||_\infty \leq acc$ THEN

$stop\_crit1 = 1$

ELSE

$r = 0.1\ r$

$x_{last} = x_{new}$

$x_{old} = x_{new}$

$stop\_crit2 = 0$

END IF

END WHILE

Step 3

Print the final solution x_{new} and the rest statistics (total iterations, Armijo iterations etc.).

3.3.4.4.2 Pseudo-Code 2: Particle Swarm Optimization Method

Step 1

Set a threshold $\varepsilon > 0$ and a number of desired minima, N.

Step 2

Initialize randomly the population, velocities and the parameters of PSO. Set the set of found minima, $L = \varnothing$.

Step 3

Set the maximum number of iterations, *MaxIt*, and the counter $iter = 0$.

Step 4

WHILE card(L) $\neq N$ AND $iter < MaxIt$ DO

Step 4.1

Set $iter = iter + 1$ and update PSO's inertia weight.

Step 4.2

Find the best particle, x_{best}, of the swarm and check its value $\Phi(x_{best})$.

Step 4.3

IF $\Phi(x_{best}) \leq \varepsilon$ THEN

Isolate x_{best} and perform local search around it and add the corresponding solution to L.

Add a new particle, randomly chosen, into the swarm.

Apply *Deflation* at x_{best} by substituting the function $\Phi(x)$ with $\frac{\Phi(x)}{\| x - x_{best} \|}$ or apply *Stretching* by substituting $\Phi(x)$ with

$$\mathrm{H(x)} = \mathrm{G(x)} + \frac{\gamma_2}{2}\frac{\mathrm{sign}\left(\Phi(x) - \Phi(x_{best})\right) + 1}{\tanh\left(\mu\left(G(x) - G(x_{best})\right)\right)}$$, where

$$G(x) = \Phi(x) + \frac{\gamma_1}{2} \| x - x_{best} \| \left(\mathrm{sign}(\Phi(x) - \Phi(x_{best})) + 1\right)$$ and $\gamma_1 = 10000$, $\gamma_2 = 1$, $\mu = 10^{-10}$.

END IF

END WHILE

Step 5

Print all elements of L and other desired parameters.

Thus, the solutions were verified and then used for conclusions extraction.

<u>3.3.4.4.3 Fixed versus variable weighting scheme</u>

Multiplying a term of the quadratic penalty function with a weight $w>1$, steepens the function at the direction of the corresponding variables, without, however, changing the nonlinear constraints implied by the model. This may result in optimal values that lie closer to the target values, for these variables. The same effect may be achieved, if the target values are properly increased.

Let x_i be the variable under consideration. Then, the first partial derivative of the penalty function $\Phi(x, r_k)$ in x_i is defined as

$$\frac{\partial \Phi}{\partial \mathrm{x_i}} = \frac{\partial f}{\partial \mathrm{x_i}} - \frac{\partial}{\partial \mathrm{x_i}}\left(r_k \sum_{j=1}^{m} \frac{1}{g_j} \right), \tag{16}$$

where $f(x) = \sum_{j=1}^{m} (x_j - t_j)^2$ is the sum of the squared differences of the variables and their corresponding target values. Thus, after the multiplication with w,

$$\frac{\partial f}{\partial \mathrm{x_i}} = 2w(x_i - t_i) \tag{17}$$

If, instead of multiplying by w, an offset a is added to the target value of x_i, then

$$\frac{\partial f}{\partial \mathrm{x_i}} = 2\left(x_i - \left(t_i + a\right)\right) \tag{18}$$

These two forms of the first partial derivative of f, are equal if

$$x_i = t_i - \frac{a}{w-1} \tag{19}$$

If the above relation does not hold, then the effect may be different in each case, depending on the constraints. This explains the variation in the optimal values, depending on the weight w and the offset a used in each case.

3.4 POLICY CONSIDERATIONS

The analysis that follows is based on prior work on the conflict between Greece and Turkey, pointing out the importance of human resources in the arms race between the two sides (Andreou and Zombanakis 2000). This means that there are three possible strategies that may be followed concerning the emphasis placed on resources. Two strategies emphasise human or property resources alone and a third one, using both property and human resources simultaneously. Emphasis on human resources is described by setting the Greek population rate to increase by about 1.5% to 2%, and the corresponding Cypriot figure to remain close to zero. This difference in the population growth rates of the two allies will thus be equal to the Turkish population growth rate, keeping the two conflicting sides in a balance according to the relative security criterion RSC_G, a very ambitious target indeed! Emphasis on property resources, capital equipment in particular, is expressed by setting the GDP growth rates of the two allies to 5%. All three strategies must then be compared to a neutral, "reference" strategy in the sense that it does not stress the importance of either property or human resources. Each of these strategies, in its turn, involves four possible scenarios as it is usually the case in a typical arms race examined via game theory, or in the context of the "prisoner's dilemma" (Majeski 1984). We assign, therefore, increasing or decreasing future values to the GDP shares of defence expenditure of Greece and Cyprus on one hand and Turkey on another[28], thus referring to the following four scenarios, with the terms "reduction" and "escalation" suggesting a respective decrease or increase of the GDP share of defence expenditure of the country or countries involved: 1 - Both sides escalate, 2 - Greece and Cyprus escalate and Turkey reduces, 3 - Turkey escalates and Greece and Cyprus reduce and 4 - Both sides reduce[29].

3.4.1 Arms Race: Both Sides Escalate (Scenario 1)

In case that both conflicting sides, i.e. Greece and Cyprus on one hand and Turkey on another, pursue escalation tactics the average optimal Greek and Cypriot GDP share of defence expenditure stands at about 3.5% for the decade under consideration. This is a very reasonable figure to a large extent, although slightly higher, compared to the corresponding figures of most EU and NATO members. The fact remains, however, that this figure for the two allies reaches as high as 6.0% to 6.5% in certain cases, depending on the time profile of their armament programmes. It is interesting to point out,

[28] The choice of the defence expenditure as a share of the GDP rather than the level of the military expenditure itself is widely used in the literature and aims at introducing, to a certain extent at least, the question of sustainability of the defence burden by relating it to the total output of an economy.

[29] The one-sided reduction of defence expenditure by either side hardly reflects an arms race environment and is simply included to adopt the picture to the theoretical framework of a simple arms race environment (e.g. Hartley and Sandler 1995).

however, that the optimal defence expenditure figure, as a percentage of GDP, is remarkably stable on the average at about 3.4% to 3.6% for both allies, irrespective of strategies chosen. However, the average alliance relative security, as this is measured by RSC_G, for the period under consideration obtains its highest optimal value when preponderance of human resources alone is assumed. This means that maximising the GDP share of defence expenditure alone, by itself, is not the only recipe for security maximisation, especially in the case of the Greek-Turkish arms race, in which the role of human resources is leading.

The deviations of the optimal values derived by the algorithm from their respective actual observations are a further interesting point to observe. It is important to stress at this point that the values derived are “optimal” only from the economics point of view that is compatible to the constraints imposed by the model. Such values, therefore, are expected to differ compared to the corresponding actual values which can be considered as “de facto optimal” since their choice involves, in addition, geopolitical and strategic criteria that do not enter our constraints structure. Thus, the difference between the two aims at pointing out the resources devoted to defence over and above what the constrained optimisation procedure indicates and may be regarded as the cost suffered as a result of the arms race in which Greece and Cyprus are involved against Turkey. The first point to make concerns the main issue, which is the GDP shares of defence expenditure for the two allies. It seems that the Greek economy exceeds the optimal defence burden by about 25% on the average irrespective of the strategy followed. The excess defence expenditure with respect to the suggested optimal in the Greek case reaches close to 30% on the average for the period under review, when emphasis is placed on property resources. This is to a large extent, expected since it reflects the high cost of transforming the defence mechanism from a manpower-intensive complex to a defence mechanism focusing on small-numbered efficient forces armed with very expensive modern equipment, given the constraint imposed by the Greek economy. On the contrary, average defence overspending is slightly higher than 10% in the case of Cyprus, for all strategies involved, indicating that the Cypriot GDP share of defence spending is close to its optimal level. The extent to which this is a policy option or, instead, a result of a supply constraint remains to be seen as a matter of further research. It is important to concentrate, finally, on the security level as this is measured by RSC_G

and attained by employing various strategies, in the context of the arms race scenario: To begin with, it seems that in all cases and as a result of defence overspending, the average actual security performance considerably exceeds the optimal. This finding also suggests that in the context of the ongoing arms race, the optimal security level required for the alliance leaves a great deal to be desired if emphasis were placed on property, rather than human resources. In fact, given the heavy structural reform cost of transforming the forces of the alliance into efficient, small-scale, well-equipped units on one hand, and the constraint of the alliance economies on the other, the average optimal security performance of the alliance deviates from the corresponding actual figure considerably. This deviation may be considerably restricted if the strategy concentrates on human resources, which, however, happens to be the strong point of the Turkish side (Andreou and Zombanakis 2001). Bearing, therefore, these considerations in mind, we feel that property resources must be awarded special attention despite the cost involved, simply because Greece and Cyprus are expected to suffer a considerable disadvantage in the field of human resources in the long run. This view seems to be shared by the Greek Ministry of Defence which has embarked in a long-term plan aiming at making the Greek armed forces strongly capital intensive by adopting the modern but expensive dogma which places emphasis on effectiveness through speed, flexibility and sophisticated equipment (Greek Ministry of Defence, 2000).

3.4.2 Offensive Alliance Tactics: Greece and Cyprus Escalate while Turkey Reduces (Scenario 2)

This scenario assumes offensive tactics on the part of the alliance, this driving the relative security factor RSC_G to considerably higher levels compared to the arms race scenario previously analysed, particularly if emphasis is placed on property resources, while the average optimal GDP share of defence expenditure barely exceeds 3.5% for both allies. It is most interesting to observe with reference to the policy considerations, as these are derived on the basis of the “reference” strategy, that the optimal values derived for both the relative security factor and the GDP shares of defence expenditure for the two allies are identical to those derived according to the fourth scenario of mutual disarmament by both the allies and Turkey which we shall consider below. This means that the reduction of defence expenditure by the Turkish side is the decisive element that affects the decision of the allied side concerning its military spending and, consequently, the performance of the model in terms of optimal values. On the contrary, the extent to which the Allies will move to disarmament policies or not plays no role whatsoever.

In cases of offensive tactics from the part of the alliance while, in parallel Turkey reduces its defence expenditure, the average optimal deviations from their corresponding actual for Greece are all of the order between 26% and 28%, indicating no substantial difference between strategies in the case of Greece while the corresponding Cypriot figures range between 12% and 17%. Turning, finally, to the relative security measure, and given the reducing policy of the Turkish side, the optimal relative security measure when preponderance is awarded to property resources is considerably close to the actual level attained by the alliance, a result more or less expected as shifting to capital rather than human resources seems to be part of the modern warfare strategy in view of the considerable decline in the Greek population rate, a feature of a large number of modern advanced economies. Attaining this specific target by placing emphasis on property resources is facilitated by the concurrent defence-reducing policy from the part of Turkey.

3.4.3 Defensive Alliance Tactics: Greece and Cyprus Reduce while Turkey Escalates (Scenario 3)

As expected, the relative security factor is lower in this case compared to the scenario previously analysed, as a result of the defence expenditure reduction from the part of the alliance in parallel to the offensive Turkish tactics. The average GDP shares of defence expenditure, which are suggested as optimal, however, are remarkably fixed at about 3.5% for both allies, with maximum figures not exceeding 6.5% for Greece and about 6.0% for Cyprus. This simply means that as long as Turkey follows offensive defence policies, the two allies do not have any room for defence expenditures reduction. It seems, indeed, that the mobilisation of both categories of resources still does not seem to contribute to better defence performance, meaning that the economies are already close to their optimal defence expenditure levels.

The outstanding role of Turkey in its arms race against Greece and Cyprus is indicated very clearly in the context of this scenario, as it has been the case in scenario 2. To show this, one needs to resort once more to the "reference" strategy that reflects reality clearer than any of the others, since it is relieved of any form of emphasis on either resource category. We can thus observe that the optimal values suggested for the GDP shares of defence expenditure of both allies, as well as for the relative security factor RSC_G are identical to those derived in the case of the first scenario, according to which both sides escalate. It is evident, therefore, once again that the role of Turkey in the arms race against Greece and Cyprus is to dictate the intensity of this race, leaving the opposite side no room to mitigate this influence.

Concerning deviations between actual and optimal values, the escalation of the Turkish defence activity accompanied by reducing tactics from the part of the alliance seems to lead to attaining optimal Greek defence expenditure figures which are inferior to the corresponding actual by about 23% to 27% on the average. The lowest deviation is observed in cases in which no particular emphasis is placed on either human or property resources, an outcome that seems natural considering the context of this scenario. The corresponding Cypriot figures, however, appear quite low, lower than 10% in certain cases, indicating that the GDP defence expenditure is possibly close to what the economy can take. As a result of the policy followed by the two allies, the superiority of the use of property resources is obvious in this case as well, in which the optimal value attained falls short with respect to the actual RSC_G by only 23% against 40% to 50% of the remaining strategies tested.

3.4.4 Mutual Disarmament Agreement: Both Sides Reduce (Scenario 4)

No matter how unrealistic this scenario appears, one must consider it for the sake of a complete analysis. It seems natural that diverting resources away from defence expenditure to alternative, non-defence activities reduces the optimal values suggested by the algorithm for certain observations, even if the average optimal GDP shares of defence expenditure remain close to 3.5% for both allies. In fact, this is the only scenario examined thus far in which placing emphasis on both property and human resources allows the Greek economy to restrict the maximum annual defence burden to 5.5% instead of 6.5% which has been the case thus far. This should be regarded as a blessing given the absence of a Turkish threat, since it suggests that the economy is allowed to pursue its defence programme, with fewer resources devoted to it, as stated by assumption. This, of course, allows for a considerable peace dividend for the Greek economy. Unfortunately, this does not seem to be the case for Cyprus which, even in this case,is compelled to devote to defence spending shares as high as 6.0% of its GDP[30]. It is finally comforting to observe that, in an environment of mutual disarmament policies on the part of Greece and Cyprus on one hand and Turkey on the other, the relative security factor between the two allies can reach rather high values on certain occasions, particularly if property resources are mobilised.

From the point of view of deviations between actual and optimal values, the mutual reduction scenario appears to be the least costly, for the Greek side at least, when emphasis is placed on human resources, in the case of which the optimal value of the GDP share of defence expenditure is some 22% lower than the corresponding actual. This being the least demanding scenario, since it involves mutual disarmament policies from both the allies and Turkey, does not require expensive, property-resource tactics to face an arms race. It is considered, therefore, reasonable that it points towards human resources as the least costly solution. Cyprus, on the other hand, seems to be indifferent in this case, between shifting to property or human resources, with the corresponding average deviations being of the order of about 11%. Despite this “preference” towards human resources in the context of a mutual disarmament scenario, it appears that the relative security is best attained when emphasis is given to property resources, an expensive but efficient and competitive strategy.

3.4.5 A Variable-Weight Scheme

The optimal control algorithm we have used allows for the option of expressing the emphasis placed on certain variables not only by means of a specific target value selection but, in addition, by increasing the weight assigned to the deviation of the variable requiring emphasis from its target value. We have thus decided to try this alternative by assigning a double weight to the variables representing the Greek and

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[30] In the case of Cyprus, such peak optimal values are influenced by the only major revision of the defence procurement programme during the period under consideration which involved the purchase of a considerable number of Exocet and Aspide missiles as well as that of a large number of G3 rifles to replace the National Guard weapons, sometime during 1992.

Cypriot population in order to indicate our emphasis on human resources. Preponderance of property resources, on the other hand, is demonstrated by a double weight on the GDP variable of the two allies.

It is interesting to see that the optimal values for the GDP share of the Greek and Cypriot defence expenditure are somewhat higher compared to those obtained by expressing emphasis via target selection, without, however, reaching the actual defence expenditure figures attained on certain occasions in the past. It is important to point out, therefore, that the picture concerning optimal defence expenditure remains broadly the same in this experiment as well, despite the fact that the optimal values obtained on the basis of the variable-weighting scheme are less restrictive compared to those under the fixed-weighting scheme. One may thus simply argue that according to the variable-weighting scheme the peace dividend approximated by the differences between the optimal and the actual defence expenditure figures for the two allies appears to be somewhat less costly. It is much more important to point out that in both the fixed and the variable weighting schemes the major problem for the two allies, as this is revealed through the “reference” strategy, is the leading role of Turkey in this arms race. This role is always underlined since the intentions of Turkey to escalate or reduce its defence expenditure seem to dictate the corresponding moves to Greece and Cyprus in all cases.

The results of the constrained optimization procedure for the fixed and the variable-weighting schemes are listed in Table 5 for Greece and Table 6 for Cyprus.

Table 5: Constrained optimization results: optimal defence expenditure / GDP for Greece (extreme values and mean)

SCENARIOS	STRATEGIES					
	HUMAN RES.		PROPERTY RES.		REFERENCE*	
	Fixed Weight	Variable Weight	Fixed Weight	Variable Weight	Fixed Weight	Variable Weight
ALL ESCALATE	2.2 – 6.3 3.5	3.8 – 4.9 4.3	1.4 – 5.9 3.3	3.4 – 4.8 4.3	1.9 – 6.5 3.6	3.8 – 5.2 4.5
GR & CY ESCALATE TR REDUCES	1.4 – 5.8 3.4	3.6 – 4.7 4.2	1.5 – 6.3 3.4	3.9 – 4.7 4.2	1.5 – 6.1 3.4	3.4 – 4.7 4.1
GR & CY REDUCE, TR ESCALATES	1.8 – 5.7 3.4	3.4 – 5.0 4.2	1.6 – 6.1 3.5	3.7 – 4.6 4.3	1.9 – 6.5 3.6	3.8 – 5.2 4.5
ALL REDUCE	2.3 – 6.4 3.4	3.9 – 4.8 4.2	1.6 – 6.1 3.4	3.6 – 4.8 4.7	1.5 – 6.1 3.4	3.4 – 4.7 4.1

* The Reference strategy is characterized by complete absence of any form of emphasis on either of the two resource categories.

3.5 CONCLUSIONS

The analysis presented above leads to the following interesting conclusions:

i. Both the Greek and the Cypriot economies are compelled to devote a substantial percentage of their GDP to defence expenditure, about twice as high as the corresponding GDP share in most EU or NATO countries, in the context of all scenarios and strategies tested. This is a burdensome policy option for the two allies given that their economies can only allow about half or, at most, two thirds their actual spending as the optimisation algorithm indicates. Their actual defence expenditure figures, therefore, can be considered as reflecting their preferred positions taking into consideration, in addition to the budget constraint, geopolitical and strategic ones that do not enter our constraints structure. One may, thus, argue that this excessive expenditure measures the costs suffered by the alliance members due to the Greek - Turkish arms race and can be taken to approximate the peace dividend involved. An immediate consequence of excessive defence expenditure is that the relative security coefficient describing the alliance security status versus Turkey is much higher compared to its optimal values.

Table 6: Constrained optimization results: Optimal defence expenditure / GDP for Cyprus (extreme values and mean)

SCENARIOS	STRATEGIES					
	HUMAN RES.		PROPERTY RES.		REFERENCE*	
	Fixed Weight	Variable Weight	Fixed Weight	Variable Weight	Fixed Weight	Variable Weight
ALL ESCALATE	1.8 – 5.7 3.6	3.5 – 4.3 4.0	2.1 – 5.8 3.6	3.5 – 4.6 4.3	1.8 – 6.1 3.6	3.5 – 5.0 4.1
GR & CY ESCALATE TR REDUCES	1.1 – 5.4 3.6	3.3 – 4.2 3.8	1.7 – 5.8 3.6	4.0 – 4.5 4.2	1.4 – 5.6 3.5	3.1 – 4.5 3.8
GR & CY REDUCE, TR ESCALATES	1.6 – 6.1 3.8	3.1 – 4.5 3.5	2.1 – 5.5 3.7	3.8 – 4.5 4.1	1.8 – 6.1 3.6	3.5 – 5.0 4.1
ALL REDUCE	1.5 – 5.9 3.6	3.6 – 4.3 4.0	1.7 – 5.8 3.6	3.7 – 4.6 4.0	1.4 – 5.6 3.5	3.1 – 4.5 3.8

* The Reference strategy is characterized by complete absence of any form of emphasis on either of the two resource categories.

ii. The optimal values proposed by the algorithm are exclusively determined by the policy followed by Turkey, irrespective of the reaction on the part of Greece and Cyprus. This is a finding that confirms the leading role of Turkey in this arms race and supports the conclusions of earlier work on this issue pointing out that Turkey possesses a weapon of momentous importance in its conflict against Greece and Cyprus, namely that of financial warfare which may lead the economies of its adversaries to their limits.

iii. Placing emphasis on capital resources seems to yield optimal values, which are closer to the actual ones. This finding leads to the conclusion that preponderance of property resources over human resources, a feature of modern warfare philosophy, may be justified given that it yields optimal values which are, in most cases, closer to those actually attained, indicating an expensive, however desirable policy, to the extent that the high actual GDP shares of defence expenditure are considered necessary.

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INTERIM 3

INTERIM 3

"The distribution of power is the major determinant of strategy"
Thoukidides

The Internet site of the Greek Ministry of Defence is not exactly very descriptive when informing the user about the Integrated Defence Doctrine. It appears, anyway, that this doctrine is a vital component of the National Defence Strategy in its revised form, as this has been expressed on the basis of the new dogma[31] that places emphasis on speed and flexibility of small, well-trained units equipped with latest technology weapons. The reader is reminded at this point that the decision to emphasize on technology rather than manpower has been dictated by the adverse demographic developments in Greece and the persistence of the authorities on curtailing the country's defence budget. Concerning the Greek National Defence Strategy, this dictates the deterrence of the threat mainly from the part of Turkey and, to a lesser extent, from a number of other sources in conjunction with a tension de-escalation policy. It is rather straightforward, therefore, that such a dogma describes a defensive strategy beyond any doubt, designed to maximize the efficiency of the Greek Armed Forces when facing any external threat. To cope with their task the Greek Armed Forces must be reliable and

[31] The Greek Ministry of Defence determines the National Defence Strategy by formulating the guidelines that describe the use of the defence resources of the country, the design and development of its defence structure as well as the decision-making process on defence matters. The National Defence Strategy forms part of the Greek National Strategy, which aims at promoting the Greek interests in the international environment.

determined to retaliate rapidly and effectively, something which requires defence sufficiency, flexibility of reaction and control, and coverage of the Integrated Greece-Cyprus Defence Doctrine.

What the Greek government does by pursuing the logic of defence sufficiency is to exercise a form of constrained optimization in the following sense: It aims at providing the means in terms of property and human resources, adequate to avert any external threat, by mitigating, in parallel, the adverse repercussions of an arms race, to the best possible extent. The focus on cost-benefit issues is an essential part of this logic which is safeguarded by the introduction of latest technology defence systems that contribute to the defence policy as force multipliers. Concerning flexibility of reaction, the Defence Dogma dictates that it is a necessary condition to face any form of crisis. To do so, the Greek Armed Forces must be prepared to offer a wide variety of options, which will attain all targets in the Aegean, the North and Cyprus, in the context of the Integrated Defence Doctrine. The essence of the latter is that an attack against the Republic of Cyprus shall be considered as an attack against Greece in the sense of the so-called extended deterrence. It follows, therefore, that the reaction from the part of Greece to any such assault will not necessarily be restricted to the Cyprus area, bearing in mind the military disadvantage in terms of distance that Greece will be facing in such a case. On the contrary, any such reaction shall cover the broader reference area of the Doctrine (Aegean, North of Greece and Cyprus) and shall focus on any part of the assaulting country's sovereignty, at a carefully selected place and time.

At least in paper, therefore, the Integrated Defence Doctrine sounds a very impressive dogma indeed! Yet a number of people argue that in terms of substance this formal declaration has added very little to the defence philosophy of the two allies as this had been conceived and exercised between mid seventies and mid eighties, long before this formal statement. Moreover, one cannot help noticing that the ambitious targets of this doctrine can hardly be pursued in practice given the relative weight of the two allies in the international political and strategic environment. Still more people question the way in which the costs and benefits of such an alliance, be it political, strategic or economic, have been allocated between the two participants.

The extent to which these arguments stand to reason is far too intricate a matter for this book to tackle, nor are we qualified to question or praise the efficiency of the

Integrated Defence Doctrine. What we can do, however, is use our knowledge and conclusions of our study on this case so far, in order to offer some answers to certain aspects of this alliance. To be more specific, given the importance of human resources in the conflict between Greece and Turkey and using the relative security coefficient that underlines this importance, we have compared the benefits in relative security terms that the two allies derive. This comparison, which clearly favors Greece, offers some room for a proposal concerning the allocation of costs and benefits between the two allies. We feel that this proposal will contribute to the efficiency of the Integrated Defence Doctrine and make it much more substantial than just a theoretical structure based to a considerable extent on wishful thinking.

CHAPTER 4

CHAPTER 4

Optimal Versus Required Defence Expenditure Revisited

The Case of the Greek – Cypriot Alliance

By

Andreas S. Andreou, Konstantine E. Parsopoulos, Michael N. Vrahatis and George A. Zombanakis

4.1 INTRODUCTION

The scope of this paper is to supplement our earlier work on the issue concerning the Greek-Cypriot Integrated Defence Doctrine. The term describes a purely defensive dogma the scope of which is to face any form of offensive action against one or both of the allies. It aims, in addition, at defending the strategic and political interests of the two allies in the Aegean Sea and the broader East Mediterranean area in an environment of an arms race against Turkey (Hellenic Ministry of Defence 2000). Given the complexity and multi-disciplinary aspect of this issue we restrict ourselves to focusing on a very interesting aspect of the topic that has not been considered in the literature thus far. What we examine, more specifically, is the relative security contribution of Greece and Cyprus to their alliance and the benefits that each side derives in that respect. The background theory supporting our research is presented in section 2, while the model modifications are discussed in section 3. The results of our experiments and the conclusions derived are given in sections 4 and 5 respectively.

4.2 LITERATURE OVERVIEW[32]

The economics aspect of the Greek-Cypriot alliance has already been considered in the first part of our research (Andreou et al. 2002), while the background theory has been provided by Andreou and Zombanakis (2000 and 2001). These papers make extensive use of advanced techniques of analysis to prove the existence of an arms race between Greece and Turkey and to underline the importance of human resources in it. The leading role of human resources in this case has justified the introduction of a relative security measure to evaluate the extent to which Greece contributes to the defence of Cyprus in the context of the "Integrated Defence Doctrine". This relative security measure, which relies on the population growth rates of both allies and Turkey, has assumed the role of a spill variable as suggested by the conventional theory of alliances (Hartley and Sandler 1995).

The research mentioned above, however, has focused exclusively on the contribution of Greece to the security of Cyprus, an issue that has assumed particular importance in view of the Cyprus full EU membership and the anticipated reactions from the part of the new Islamic government of Turkey since early November 2002[33]. What remains to be seen, however, is the extent to which Cyprus may be able to contribute to the security of Greece in the context of their alliance. This is an issue that has acquired increasing importance during the recent past, given the restrictions imposed on the defence equipment purchases of Greece by the Conventional Forces in

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[32] The references cited in this section have been restricted to the bare minimum given that a comprehensive overview of the relevant literature has already been presented in Andreou et al. (2002), on which the present research has been based.

[33] "The landslide victory of the Justice and Development Party (JDP) in the 3 November 2002 elections marked the beginning of a new era in Turkish politics, with potentially profound repercussions for domestic and foreign policies. Both its opponents and supporters perceive the JDP as having an Islamic agenda. Although in the short term it is likely to concentrate on consolidating its grip on power rather than trying to erode the secular principles enshrined in the Turkish constitution, there are already signs that the Turkish establishment - led by the military - is mobilizing to restrict the JDP's room for maneuver and undermine its authority by targeting the JDP leader, Recep Tayyip Erdogan" (IISS 2002).

Europe (CFE) Treaty[34], and the additional burden imposed on the country's economy due to its commitments with NATO and the Euroarmy[35].

Table 1. Variables, data and sources

Code	Data Series	Source
GGDPCS	GDP of Greece, Constant Prices	Greek National Accounts
CGDPCS	GDP of Cyprus, Constant Prices	Cypriot National Accounts
GTIS	Greek Government Total Investment Expenditure (share of GDP)	Greek National Accounts
GDEFCRS	Defence Expenditure of Greece (share of GDP)	SIPRI
CDEFCRS	Defence Expenditure of Cyprus (share of GDP)	SIPRI
TDEFCRS	Defence Expenditure of Turkey (share of GDP)	SIPRI
GNDEFCRS	Non-Defence Government Expenditure of Greece (share of GDP)	Greek National Accounts
CNDEFCRS	Non-Defence Government Expenditure of Cyprus (share of GDP)	Cypriot National Accounts
GBOP	Greek Balance – of – Payments Deficit (share of GDP)	Greek National Accounts
CBOP	Cypriot Balance – of – Payments Deficit (share of GDP)	Cypriot National Accounts
DRDL	Drachma / U.S. Dollar Exchange Rate	Bank of Greece
DLCP	U.S. Dollar / Cypriot Pound Exchange Rate	I.F.S.
GCPI	*Greek Consumer Price Index*	I.F.S.
CCPI	*Cypriot Consumer Price Index*	I.F.S.
GPOP	Greek Population Growth	I.F.S.
CPOP	Cypriot Population Growth	I.F.S.

[34] The CFE Treaty imposes a roof on the purchases of the participant countries regarding tanks, armored vehicles, artillery, helicopters and fighter planes. The Treaty also provides for a roof on the armed forces personnel of the countries involved. It is important to remember that Turkey has never signed this treaty.

[35] The extent to which the NATO and Euroarmy commitments burden the Greek defence budget can be realized by considering that the cost of just one of about ten programmes required, namely that of the procurement of 10 to 12 transport aircraft (C17 Globemaster or Airbus 400M) amounts to roughly 1.8 billion dollars.

4.3 THE MODEL MODIFICATIONS

To assess the contribution of Cyprus to the security of Greece we have used the coefficient employed in our research thus far (Andreou and Zombanakis 2001) adjusted to measure the relative security of Greece with reference to Cyprus (data variables are listed in Table 1). This means that the formula of the relative security measure required in this case will be:

$$RSG_C = \exp[x] \tag{1}$$

$$\text{where} \quad x = \left(\dot{p}_C - \dot{p}_G\right) / \dot{p}_T \tag{2}$$

and RSG_C represents the relative security of Greece with reference to Cyprus and $\dot{p}_C$, $\dot{p}_G$ and $\dot{p}_T$ stand for the Cypriot, the Greek and the Turkish population growth rates respectively. Introducing (1) in the demand for defence expenditure function for Greece used by Andreou et al. (2002), we come up with the following form:

GDEFCRS=f(GGDPCS, GNDEFCRS, GBOP, DRDL, RSG_C, TDEFCRS, DGDEF) (3)

where GDEFCRS is the Greek GDP share of defence spending, GGDPCS is the Greek GDP at constant prices, GNDEFCRS represents the share of non-defence expenditure in the Greek GDP, GBOP stand for the Greek balance-of-payments deficit as a GDP share, while DRDL denotes the drachma exchange rate against the US dollar. The threat variable is TDEFCRS, which represents the share of defence expenditure in the Turkish GDP. Finally, DGDEF captures all revisions in the long-run defence programmes of Greece or lump-sum purchases settled through bilateral agreements without appearing in the external accounts of the country (e.g. the procurement of the Type-209 submarines from HDW by the Greek Navy during the beginning of the seventies and the so-called purchase of the century involving the procurement of a large number of Mirage fighters during the mid-eighties, its revision after the change of the Greek government at the beginning of the nineties). All series have been found to be I(1), that is, stationary in their first differences on the basis of the ADF test while the explanatory power of all six equations is satisfactory. The short-run estimates presented in Tables 2 and 3 comprise an error-correction model, with all coefficients bearing the expected signs and accompanied by their t-values in parentheses[36].

Table 2. Model equations for Greece (t-values in parentheses)

	GGDPCS	GDEFCRS	GPOP
C	0.022 (3.281)	-0.029 (-2.553)	0.001 (1.371)
GNDEFCRS		-4.872 (-17.598)	0.012 (1.837)
GNDEFCRS(-1)	0.100 (1.931)		
GTIS	0.235 (6.350)		
GBOP(-1)		-0.295 (-4.859)	
GBOP(-4)	-0.056 (-1.878)		
DRDL	-0,062 (-1.635)	0.547 (8.289)	
GGDPCS			0.026 (2.286)
GGDPCS(-1)	0.476 (4.869)		
GGDPCS(-2)		0.354 (2.102)	
GCPI(-2)			-0.0003 (-4.927)
RSG_C (-1)		0.010 (2.327)	
GDEFCRS(-3)			-0.005 (-2.001)
GPOP(-1)			0.635 (6.606)
TDEFCRS		0.112 (2.197)	
RES(-1)	-0.048 (-1.984)	-0.147 (-1.904)	-0.113 (-3.054)
DGGDP	0.047 (-5.416)		
DDIC	0.048 (5.994)		
DGDEF		0.086 (9.881)	
DGDEMO			0.006 (5.547)

The key feature of the constraints structure in our optimization exercise can be traced in the equation describing the Greek demand for defence expenditure. In fact, the direct relationship between the defence expenditure of Greece and the country's relative security denotes the shift of the Greek defence policy to its new doctrine as a result of its negligible – sometimes even negative-birth rates. This strategy revision places the emphasis of the defence procurement programmes on quality, advanced technology and

[36] For a detailed evaluation of the constraints structure see Andreou et al. (2002).

modernization of the structure of the Greek armed forces in order to make up for the population deficiency.

Table 3. Model equations for Cyprus (t-values in parentheses)

	CGDPCS	CDEFCRS	CPOP
C	0.052 (9.331)	0.024 (1.521)	-0.004 (-0.614)
CNDEFCRS	0.227 (2.953)	-16.595 (-26.348)	
CNDEFCRS(-4)			0.055 (1.889)
CBOP	-0.515 (-6.520)		
CBOP(-1)		-0.367 (-2.037)	
DLCP	0.250 (3.189)	-0.455 (-2.578)	
CGDPCS			
CGDPCS(-2)			0.065 (1.823)
CGDPCS(-3)		0.372 (2.197)	
CCPI			-0.016 (-4.026)
RSC_G(-2)		-0.014 (-1.538)	
CDEFCRS(-3)			
CPOP(-1)			
TDEFCRS		0.418 (3.320)	
RES(-1)	-0.164 (-7.383)	-0.704 (-5.442)	-0.382 (-8.645)
DCGDP	0.130 (10.071)		
DCINV			0.031(5.275)
DCDEF		0.210 (8.222)	
DCDEMO			-0.118 (-10.175)
TIME			0.004 (8.886)

In addition to the shift from human to capital resources, emphasis is placed on the close co-operation and co-ordination of the actions of all three branches of the armed forces, their rapid reaction to threat accompanied by an increase of fire volume and efficiency (Hellenic Ministry of Defence 2000). This change in the defence dogma is a necessary, however expensive solution calling for increased spending on modern defence equipment and extensive training and restructuring of the existing units. In such a case, and according to equations (1) and (2), it will be inevitable that the burden of counterbalancing the Turkish population increases must fall on the Cypriot side. This will in fact be the only way to raise RSG_C which thus assumes the role of a spillover variable in the sense employed in the literature, replacing conventional variables like, for example, the military burden of the NATO countries except Greece and Turkey.

4.4 EMPIRICAL RESULTS

The optimization algorithm used is the one we employed in our earlier research involving an Interior Penalty Function Method, with Steepest Descent and Armijo Line Search (Vrahatis et al. 2000, Parsopoulos and Vrahatis 2001 and Parsopoulos et al. 2001). It is important to remind that the constraints structure introduced in this algorithm is of purely economics nature, aiming at specifying the defence expenditure that the two allies are able to afford in the context of the theory of alliances. The literature background described in section II provides the framework within which our analysis will develop, as follows:

a. There is an arms race between Greece and Turkey.
b. The role of human resources is very important and it turns against Greece and Cyprus and in favor of Turkey.

Given the above, we shall employ one reference or baseline scenario that involves a dynamic simulation of the model without any policy measures taken by either side. Two policy scenarios will be introduced according to which either Greece or Cyprus undertakes the burden of counterbalancing the Turkish advantage in terms of human resources. This will require a number of demographic policy measures taken by either ally that are expected to lead to raising its rate of population growth. In such a case and according to equations (1) and (2) the security alliance target for Greece may be set as $RSG_C = 2.718$, once x assumes the value of unity. The same target may be assigned for RSC_G that reflects the relative security of Cyprus with reference to Greece as it is used in the Cypriot demand for defence expenditure equation. Thus, the optimization problem is formulated by requiring the minimization of a “welfare function” the arguments of which are the squared deviations of the endogenous variables from their respective targets, as these reflect the assumptions of the two policy scenarios. The weights assigned to all endogenous variables are equal to unity, while the policy instruments used are the GDP shares of defence expenditure in the two allied countries.

The results obtained by the optimization procedure are very interesting and reflect the choices of the Greek armed forces as these are expressed through the recent dogma change. Indeed, the benefits in terms of security that Greece derives out of its alliance with Cyprus are multiple compared to those that Cyprus derives out of this alliance (Figure 1). Since, however, the demographic developments in Cyprus (Government of Cyprus 2001) are much more promising compared to those of Greece (Hellenic Republic 2001) this conclusion is not as preposterous as it appears at a first glance. This is a benefit that allows Greece to concentrate on advanced defence equipment and technology rather than manpower, an obviously expensive alternative, as the relevant defence expenditure figures indicate (Figure 2). Indeed, the average optimal value derived by the model approaches 4.5%, about one percentage point higher than the corresponding optimal defence expenditure levels calculated in our earlier research (Andreou et al. 2002). This margin is not at all negligible bearing in mind that it could buy Greece an extra 60 F-16s or about 30 F-15s, a fighter plane rejected a few years ago on the grounds of a very high price.

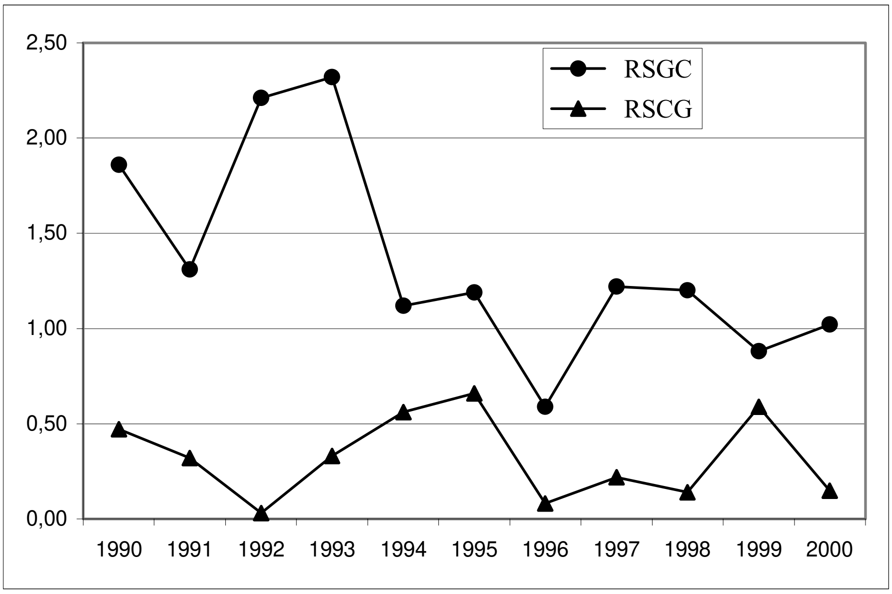

Figure 1. Relative Security of Greece (RSG_C) and Cyprus (RSC_G) (optimal values)

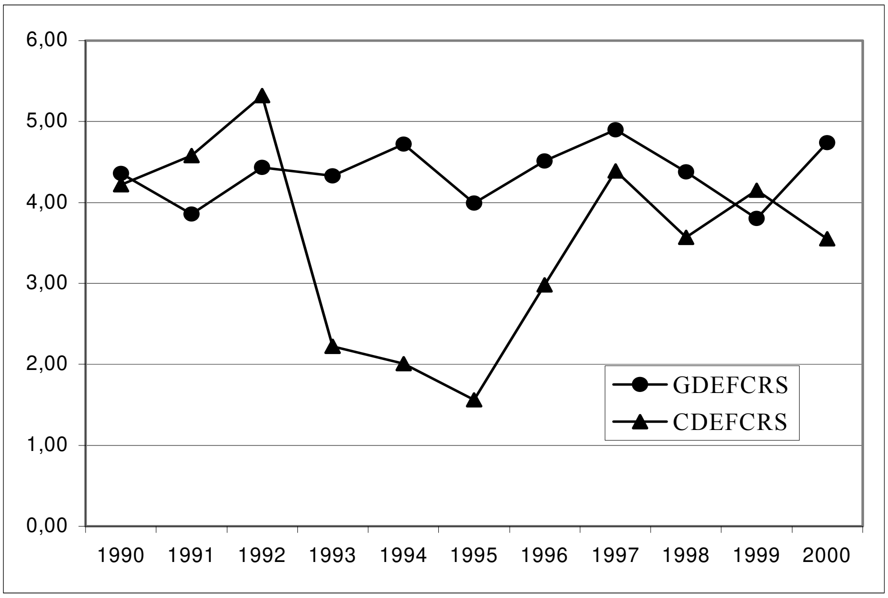

Figure 2. Defence Expenditure of Greece (GDEFCRS) and Cyprus (CDEFCRS) (optimal values in terms of GDP shares)

A further interesting finding is that this average optimal defence expenditure deviates from its target value, as this is set by the Greek authorities in the context of an arms race, by less than 40% compared to a more than 50% average deviation in the Cypriot case (Figure 3). An important consequence of these substantial deviations figures is that the attainable average relative security in Greece deviates from its desired target of unity by only about 25% as opposed to 42% in the case of Cyprus (Figure 4).

The defence expenditure deviation figures are considerably lower when measuring the gap between actual and optimal values (Figure 5), which amounts to an average of just 7.5%, and 18.5% in favor of the actual defence expenditure in Greece and Cyprus respectively. It seems reasonable to argue that these figures can be taken to approximate the peace dividend following a conversion from defence to non-defence expenditure in the economies of the two allies (Intriligator, 1996).

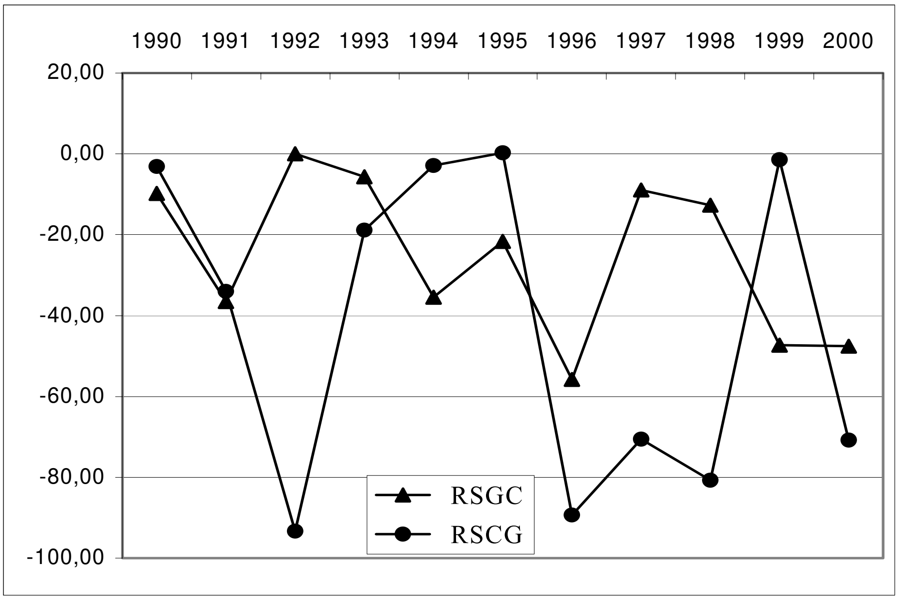

Figure 3. Relative Security deviations (%) of Greece (RSG_C) and Cyprus (RSC_G) (optimal with respect to target values)

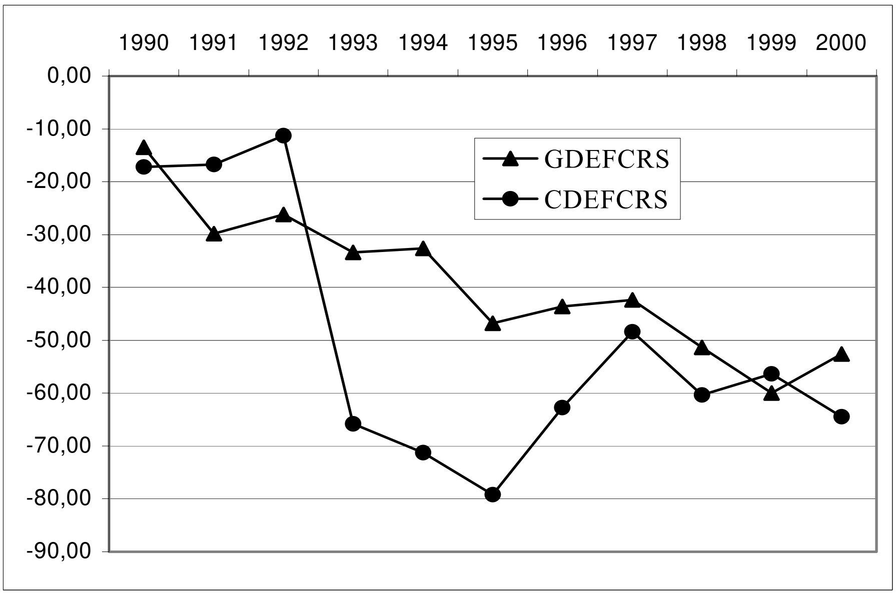

Figure 4. Defence Expenditure deviations (%) of Greece (GDEFCRS) and Cyprus (CDEFCRS) (optimal with respect to target values)

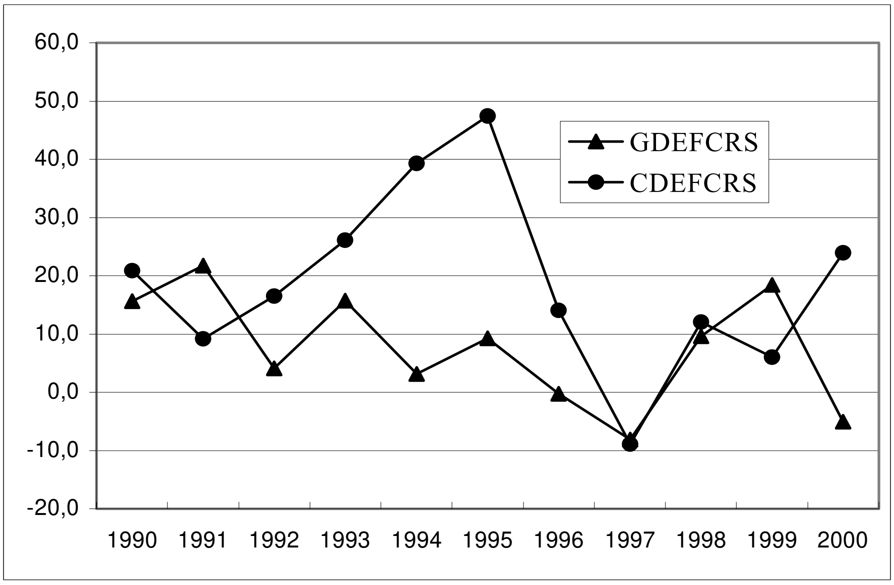

Figure 5. Defence Expenditure deviations (%) of Greece (GDEFCRS) and Cyprus (CDEFCRS) (actual with respect to optimal values)

It is important to remind once more that the values derived are "optimal" only from the economics point of view that is compatible to the constraints imposed by the model. Such values, therefore, are expected to differ compared to the corresponding actual values which can be considered as "de facto optimal" since their choice involves, in addition, geopolitical and strategic criteria that do not enter our constraints structure. Thus, the difference between the two aims at pointing out the resources devoted to defence over and above what the constrained optimization procedure indicates and may be regarded as the cost suffered as a result of the arms race in which Greece and Cyprus are involved against Turkey.

The final interesting conclusion concerns the choice of the ally that will be more successful in undertaking the human resources policy of the allies in view of the Turkish superiority as regards population developments. All our experiments lead to the conclusion that the relative security of both allies is maximized if Cyprus undertakes the task of counterbalancing the population developments that turn the relative security indices in favor of Turkey (Table 1). This is rather straightforward given the better demographic performance of Cyprus in comparison to Greece and bearing in mind the structure of the relative security indices that rely exclusively on the demographic developments of the two sides. In case, however, that Cyprus undertakes the burden of counterbalancing the relative security gap against Turkey, then the actual defence expenditure of Greece is allowed to deviate from its optimal values by almost twice as much compared to the baseline figures mentioned before. The explanation in this case once again confirms the reasoning behind the change in the defence dogma since the human resources dimension is allowed to Cyprus to cope with, while Greece shifts to the more expensive solution of emphasis on technology and modern equipment.

Table 4. Human Resources (HR) policy effectiveness by individual ally

HR Policy Assigned to:	RSC_G	RSG_C	GDEFCRS	CDEFCRS
Greece	0.28	1.31	4.37	3.39
Cyprus	0.41	1.35	4.12	3.61

Under the circumstances, therefore, it might be worthwhile to consider the possibility that the well-known international trade recipe of comparative advantage might improve the efficiency of the Integrated Defence Doctrine. Bearing in mind our results, a suggestion may be to assign the alliance needs in terms of capital resources development and modernization to Greece, while Cyprus may be assigned to cope with the human resources in terms of manpower requirements of both allies.

4.5 CONCLUSIONS

The results discussed above may be summed up as follows:

i. The returns in terms of relative security that Greece derives as a result of its alliance with Cyprus are considerably higher compared to the benefits of its ally.

ii. The resulting average peace dividend measured as the deviations of the actual from the optimal defence expenditure values for the two allies does not exceed 10% and 20% for Greece and Cyprus respectively.

iii. Raising the relative security coefficient that relies exclusively on human resources is a task that will be better undertaken by Cyprus, given its better demographic performance in comparison to its ally. This will enable Greece to shift resources to capital equipment, technology and modernization of its armed forces, something that will counterbalance the weakness of both allies in the area of population developments vis-à-vis Turkey. This expensive task, however, faces a number of additional constraints imposed by the Conventional Forces in Europe (CFE) Treaty and the increased defence requirements of the NATO and the Euroarmy, not necessarily coinciding with the Greek national defence priorities.

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INTERIM 4

INTERIM 4

Two enemy nations may be engaged in battles for years striving for victory. However, it only takes one decisive day to indicate the winner.
Sun Tzu, "The Art of War"

It appears, therefore, that the law of comparative advantage works in this case as well! It is recommended that Greece focus on providing the capital equipment by investing in research and development, purchasing latest technology systems and modernizing the existing stock of weapons. Cyprus, on the other hand, will be required to provide the manpower indispensable to man this equipment in the most efficient way.

We feel, however, that one or two words of caution are necessary in this case: The first issue concerns the way in which Cyprus may contribute in terms of manpower. The conclusions drawn in the previous chapter concerning the alliance burden sharing between Greece and Cyprus are based on their population growth rates. The fact remains, however, that in terms of absolute figures Cyprus is too weak to face a large part of the personnel requirements of both allies, given that the number of male Cypriots which join the armed forces every year does not exceed a few thousand. This means, therefore, that Cyprus will only be in a position to contribute to the alliance manpower needs if it resorts to professionalism, over and above the compulsory military service which is a must for reasons similar to those applying for Greece and analyzed in Interim 1, earlier on. The second word of caution refers to the Greek case. The recommendation that Greece focuses on the provision of the equipment that will support the function of the alliance does not, by any means, imply that the importance of the human element is to be neglected. The recommendation which concerns combining a professional army with a compulsory military service addresses both allies and leaves absolutely no room for cheap politics which imply that the two systems are substitute solutions. In fact, professionalism and compulsory service must complement one another in a way that combines thorough knowledge of modern technology with high morale. Since we have already discussed the reasoning behind this argument extensively earlier on in this book, we do not feel that we should expand on the extent to which the undoubtedly high skills of professional forces can ever be a substitute to the enthusiasm of conscripts. We can only point out that our current geopolitical and strategic environment does not enjoy the delicate, however, effective balance of powers it did during the Cold War era. To make things worse, and unlike what some people love to support[37], tension in the area that concerns the Greek-Cypriot alliance is far from easing given the recent Middle East crisis. This widespread volatility in the international setting, therefore, leads to underlining the importance of strong armed forces on both national and international levels. Thus, the initiative taken by Germany, France, Belgium and Luxemburg with regard to a European defence mechanism, which could function in a manner independent of the NATO structure has become the cause of serious reconsiderations that concern the extent to which national defence budgets should be curtailed. As regards Greece, the country has to face a considerable extra burden imposed on its economy by a number of defence programmes required to support its alliance commitments, which means that the government has no option but to increase the funds allocated to defence activities. This proves that not only is the relaxed attitude of the Greek government concerning external threat not justified, but, in addition, the statements made concerning reductions of the defence budget do not reflect the true picture.

History teaches that demagogy of this extent can entail a significant national cost. Greece has paid the cost of demagogy very dearly, starting with the Peloponnesian War (431-404bc.), through to the National Revolution in 1821 and the Asia Minor Ethnic Disaster in 1922. Conversely, Greece reaped the benefits of not succumbing to demagogy in the early twentieth century, when the government devoted a large sum of

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[37] See for example, the IMF latest report (February 13, 2003), following the mission's visit to Athens

money, despite the hysteria of the opposition leaders, to support the Hellenic Navy, a very wise move considering the results of the 1912–1913 Balkan Wars.

The post-Copenhagen summit period is a crucial one for the geopolitical and strategic interests of Greece and Cyprus. It is a period during which the international environment currently under considerable revision will play a much more important role compared to the past and during which nothing can be taken for granted not even the Cyprus full EU membership, leaving, therefore, absolutely no room for demagogy!

The following chapter aims at underlining the increased role of the international factors and the complexity of one of the problems faced, namely that of Cyprus.

In such cases, however, in which political uncertainty prevails, decision-makers and policy proponents usually face serious difficulties when approaching significant, real-world systems, the main one being the choice of the appropriate analytical tool that would reflect the complexity of such international geopolitical systems. Moreover, given the problems associated with the availability and reliability of data and the difficulties encountered when formulating a mathematical model, we feel that efforts to communicate and understand a particular system as well as to propose policies must rely on natural language arguments in the absence of formal models. This is why we have decided to treat the Cyprus issue by using the technique of Fuzzy Cognitive Maps which is particularly suitable for modeling political problems and supporting a decision-making process. The following chapter explains how this method is combined with Genetic Algorithms thus creating a hybrid model reflecting the complication of the Cyprus issue. Since the “cut-off date” of the paper that follows has been the first day of the US – UK operations against Iraq, the reader will notice that the forecasting ability of the algorithm used has been very satisfactory on the basis of the scenarios employed. These consider, among other variables, the extent to which an environment of intensity might prevail on the island, the possibilities of a viable solution of the Cyprus issue, as well as the reactions of the Greek and Turkish Cypriots following the full EU accession of Cyprus.

CHAPTER 5

CHAPTER 5

The Cyprus Puzzle and the Greek – Turkish Arms Race: Forecasting Developments Using Genetically Evolved Fuzzy Cognitive Maps*

By

Andreas S. Andreou, Nicos H. Mateou and George A. Zombanakis

5.1 INTRODUCTION

During the Copenhagen summit conference on December 12 to 14, 2002, the 15 EU member sates decided on the enlargement of the Union by granting accession in May 2004 to ten new members, namely Poland, The Czech Republic, Slovakia, Hungary, Estonia, Latvia, Lithuania, Slovenia, Malta and Cyprus. The acceptance of the latter has been, formally at least, unconditional with reference to the solution of the Cyprus problem, with the summit declaration favoring further negotiations for a united Cyprus. In fact the declaration expresses satisfaction as the Greek and Turkish Cypriots are committed to continue their negotiations aiming at reaching an agreement until the end of February 2003. In case an agreement has not been reached by that date, then the "acquis communautaire" will be suspended for the north part of the island until the Cyprus issue has been resolved.

It is only straightforward, therefore, that failure to reach an agreement will deprive the Turkish Cypriots from an initial €273 million which the European Council has decided to pump to the north as part of a special development program which will allow it to catch up with the rest of the island. Such a failure, moreover, will doom the north,

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half the population of which is first – or second – generation settlers from Turkey, to continue to depend heavily on aid from Ankara. Ironically, it is the Turkish Cypriot authorities that insist on a loose confederate system with the two communities remaining independent sovereign states and their populations physically separated. Massive demonstrations in the north during late December 2002, however, have made it clear that the Turkish Cypriot population does not share its authorities' views on the subject.

The UN Secretary General has attempted to resolve the issue by submitting the so–called Annan Plan in November 2002, proposing a Swiss canton system. The government of Cyprus has agreed to accept the Annan Plan as a basis for a final settlement, despite the risk that the burden added on the Cypriot economy by the underdeveloped north may lead to its failure to meet the Maastricht criteria and, consequently, to join the EMU and the Eurozone[38]. While the Turkish Islamic government, however, has publicly maintained that a settlement based on the Annan Plan is possible by the deadline set, the Turkish military bluntly told the government at the National Security Council meeting on 29 November that it would not be allowed to determine Turkish policy on Cyprus. Privately, military officials insist that the threat will be backed by force if necessary, since it believes that a strong military presence in northern Cyprus, where it currently has 30,000 troops, is vital to Turkey's strategic needs (IISS 2002). It is obvious, therefore, that there is a serious conflict of interests on the Turkish side and more specifically, between the government and the military as it concerns the settlement of the Cyprus issue in the context of the Annan Plan. Given that Cyprus has been already granted accession to the EU, the position of Turkey is rather delicate, as it has to compromise between the Turkish Cypriots interests and its own future as an EU candidate on one hand and its strategic interests on another.

[38] It is indicative that the Cypriot GDP amounted to $9.1 bn. for the period 1998–2001 while the corresponding figure for the North barely reached 10% of this figure (IISS 2002). The hesitant attitude of the Cypriot government vis-à-vis the Annan Plan, however, is due to more than what meets the eye, since it imposes indirect, however binding restrictions concerning the control of the Cypriot FIR and the weapons of the troops kept by Greece and Turkey on the island. Additional problems may arise concerning the approval of the Annan Plan by the concurrent referendums in the south and the north of Cyprus on March 30, 2003. The voters will be asked to approve or not a package of four crucial issues referring to the structure of the new Cypriot state, its constitution, the terms of the treaty between Cyprus, Greece, Turkey and the UK and the EU accession of Cyprus, all with a "yes" or "no".

Bearing the above developments in mind, therefore, one should start wondering to what extent the optimism expressed by the Greek side regarding the future of the Greek–Turkish relations is well founded. Indeed there has been a widespread impression that, following these latest developments, business between the two countries in the form of direct investment flows will be flourishing, with Greece being one of the leading supporters of the Turkish EU candidacy. Both countries have even applied to host the Euro 2008 football championship jointly! But above all the most striking conclusion drawn by those sharing this optimism is that the arms race between the two countries which for decades now devours considerable GDP shares in both countries (Andreou and Zombanakis 2000 and 2001) will be led to its end. And to make things even more preposterous, the Greek Ministry of Defence has proceeded to a one sided reduction of its defence procurement programme for a third time since 2001, while it has recently announced a further reduction of the compulsory military service term.

Given the contrast between this lackadaisical attitude from the part of the Greek authorities on one hand and the fundamental differences concerning the Cyprus issue between government and military in Turkey, this paper aims at forecasting the developments concerning the settlement of the Cyprus issue after the Copenhagen EU summit. What we plan to do, more specifically, is to evaluate the extent to which one should share the Greek optimism concerning the improvement of the Greek-Turkish relations and the subsequent reduction of tension that will lead in its turn, to the end of the arms race currently burdening the economies of both sides. Section 2 provides the technical background of this work. What it does, more specifically, is to explain how the use of Genetic Algorithms can contribute to the efficiency of Certainty Neuron Fuzzy Cognitive Maps (CNFCMs) in cases of crisis management and decision-making. The model that we use to represent the setting of the problem is presented in section 3. The combination of the two techniques contributes to the construction of our hybrid model that reflects the political and strategic setting as described in the Introduction. The next section deals with the various scenarios and the results forecasted following a number of simulation exercises while the final section of the paper presents the conclusions derived.

5.2 TECHNICAL BACKGROUND

Cognitive Maps (CMs) were introduced by Axelrod (1976) and were mainly used to support political decisions in international relations. A CM employs a technique based on qualitative reasoning and can be used by an individual decision-maker to study or interpret knowledge that involves many interacting concepts. These concepts are represented as nodes while directed arrows are used to show the causal relationships between them. Each arrow is characterized by a weight, a real value that indicates the degree of influence of the causal relationship between any two connected nodes. This representation, in which concepts are considered as variables of the system, gives a figure of nodes and arrows called “cognitive map”. Such a map may represent three different types of causal relationships underlining the links between them as well as the degree of influence between concepts and causal relationships:

- Positive (+) causality expressed by words like “promotes”, “enhances”, “is benefit to” etc. An increase / decrease of the causal relationship will cause an increase / decrease in both the “cause” and the “effect” variables.
- Negative (-) causality expressed by words like “retards”, “prevents”, “is harmful to” et c. In cases of a negative causal relationship an increase in the “cause” variable will result to a decrease of the “effect” variable.
- No effect (0) described as “no effect on”, “does not influence” et c.

To indicate, in addition, the intensity of the relationships between these variables one needs to employ a Fuzzy Cognitive Map (FCM), which has been developed by political scientists in order to analyze, predict and understand decisions imitating the cognitive process of human experts on various fields of expertise. Fuzzy Cognitive Maps (FCMs) are soft computing tools (Zadeh 1997a,b) that combine elements of fuzzy logic and neural networks. FCM theory was developed recently (Kosko 1986, 1992) as an extension of cognitive maps used for planning and making decisions in the fields of international relations, in modeling social systems and in studying political developments in the context of such systems. Strictly speaking, a FCM is a figure composed of nodes and edges, the former introducing the qualitative concepts of the analysis while the latter indicate the various causal relationships. Each concept node possesses a numeric state, which denotes the qualitative measure of its presence in the conceptual domain. Thus, a high numerical value indicates that the concept is strongly present in the analysis while a negative or zero value indicates that the concept is not currently active or relevant to the conceptual domain.

A FCM works in discrete steps (Kosko 1992). When a strong positive correlation exists between the current state of a concept and that of another concept in a preceding period, we say that the former positively influences the latter indicating this by a positively weighted arrow directed from the causing to the influenced concept. By contrast, when a strong negative correlation exists, it reveals the existence of a negative causal relationship indicated by an arrow charged with a negative weight. Two conceptual nodes without a direct link are, obviously, independent.

The activation level of the system nodes and the weighted arrows are each set to a specific value based on the experts believes. Afterwards the system is free to interact until the model:

- Reaches equilibrium at a fixed point with the values of the activation level remaining stable in the interval [-1 1] independently of time.
- Exhibits limit cycle behaviour, falling in loop of a specific period.
- Exhibits a chaotic behaviour.

In order to increase the reliability of the weight matrix Kosko (1986) suggested consulting more than one expert, while the experience of these experts has been rated with a value from 1 to 10. If S_i is the score of expert i and W_i is the weight matrix of the FCM defined by that expert, the final weight matrix is given by the following formula (Taber and Siegel 1987).

$$W = \frac{\sum_{i=1}^{N} S_i W_i}{\sum_{i=1}^{N} S_j} \qquad (1)$$

In 1997, the introduction of the Certainty Neuron Fuzzy Cognitive Maps (CNFCMs) (i.e. Tsadiras and Margaritis 1996, 1998), provided additional fuzzification to FCMs, by allowing for various activation levels of each concept between the two extreme cases, i.e. between activation or not. In other words, this combination of Fuzzy Logic (Zadeh 1992, Cox 1994) and Neural Networks (Kartalopoulos 1996) creates models that emulate reasoning and the decision-making process using fuzzy causal relationship. The flexibility of such models is improved by allowing for a variety of activation levels of each concept thus creating a Certainty Neuron Fuzzy Cognitive Maps (CNFCM).

More specifically, a function $f()$ coming from the area of expert systems was used to return the new certainty factor of a fact after receiving new evidence for, or against previous believes based on the present certainty factor.

The updating function of a CNFCM is the following:

$$A_i^{t+1} = f\left(S_i^t A_i^t\right) - d_i \; A_i^t \tag{2}$$

where

$$S_i^t = \sum_{\substack{j=1 \\ j \neq i}}^{n} A_j^t w_{ij} \quad , \tag{3}$$

A_i is the activation level of concept C_i at time $(t+1)$ or (t), equation (3) is the sum of the weighted influences that concept C_i receives at time step t from all other concepts, d_i is a decay factor (Tsadiras and Margaritis 1996), and

$$f_m(A_i^t, S_i^t) = \begin{cases} A_i^t + S_i^t(1 - A_i^t) = A_i^t + S_i^t - S_i^t A_i^t, if \; A_i^t \geq 0, S_i^t \geq 0 \\ A_i^t + S_i^t(1 + A_i^t) = A_i^t + S_i^t - S_i^t A_i^t, if \; A_i^t < 0, S_i^t < 0, |A_i^t|, |S_i^t| \leq 1 \\ A_i^t + S_i^t \Big/ \left(1 - \min\left(\left|A_i^t\right|, \left|S_i^t\right|\right)\right), otherwise \end{cases} \tag{4}$$

is the function used for the aggregation of certainty factors (Kosko 1992). The meaning of the above function is that the external influence can affect the activation of a concept just to a certain degree.

We propose the following modification to the third case of equation (4) as follows:

$$A_i^t + S_i^t \Big/ (1 - \min(A_i^t, S_i^t)), otherwise \tag{5}$$

to cover the undesired situation in which one of A_i^t and S_i^t equals to 1 and the other to –1 leading the denominator to zero.

Given the structure of a CNFCM as described above it is easy to see that its ability to combine the input supplied by domain experts together with its flexibility makes it a useful tool for analyzing tough political problems and suggesting plausible solutions in an environment of political uncertainty (Tsadiras and Margaritis 1997).

5.3 THE MODEL

The structure of this model (Table1, Figure 1) relies heavily on previous research on the Cyprus issue using Fuzzy Cognitive Maps and Genetic Algorithms (Mateou et al. 2003, Andreou et al. 2003) and has been built to reflect the political framework describing the Cyprus problem shortly before the Copenhagen Summit Conference, in December 2002[39].

Table 1. Description of the concepts

C1	Cyprus EU Full Accession
C2	Escalation of Tension
C3	Settlement of the Cyprus Issue
C4	Turkish - Cypriot Position
C5	Position of the Turkish Government
C6	The Cyprus Issue Solution Framework
C7	Position of Cypriot Government
C8	Position of the European Union
C9	Position of the Greek Government
C10	Reactions of U.S. – U.K.
C11	Invasion in Iraq

[39] Given that our revision has taken place after the end of the Copenhagen Summit Conference (CSC) we had an excellent opportunity to evaluate our model in terms of its applicability by simply comparing the results obtained in the form of conclusions after the (CSC) to the findings derived by the initial dynamic simulation exercise.

The construction of the model has been based on the method of questionnaires and interviews (Roberts 1976). According to this we have identified the important concepts or variables influencing our strategic target, i.e. the EU accession of Cyprus (C1) as well as the various causal links between them. This was a procedure, which has been based on input provided by a team of domain experts. These experts filled in a questionnaire concerning the causal relationships and the weights characterising them, i.e. the degree to which concepts influence each other, using a scale between -1 and 1, to indicate the direction and intensity of these relationships (Taber and Siegel 1987).

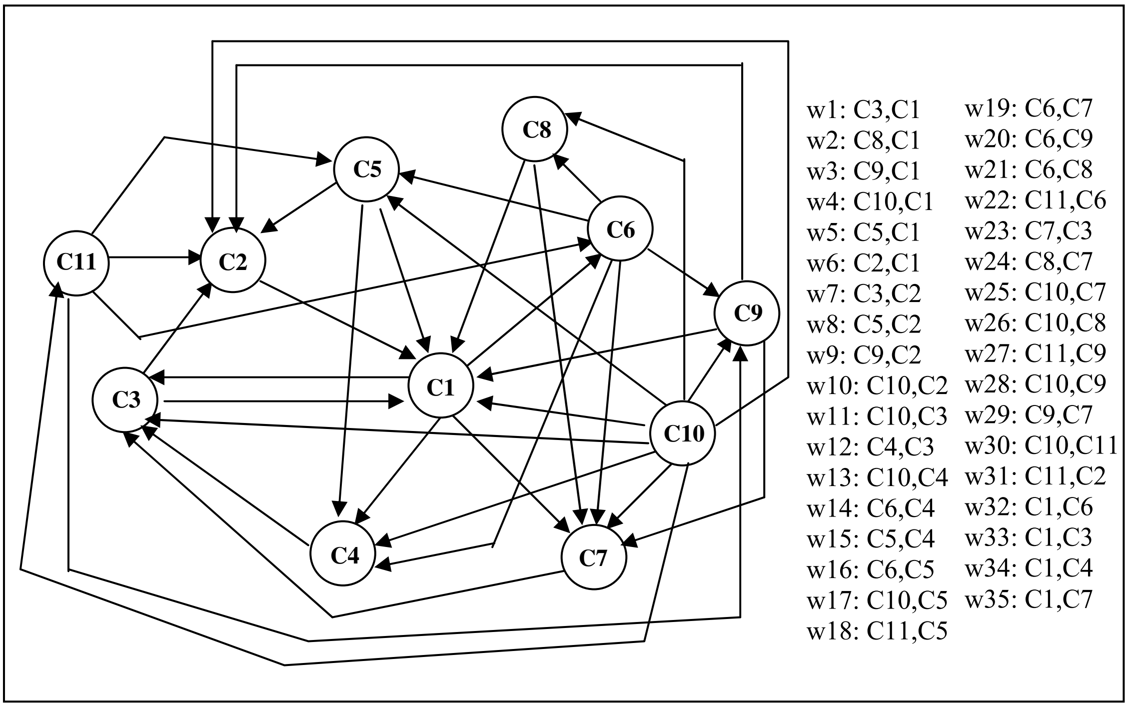

Figure 1. The Cyprus issue CNFCM model

Bearing in mind that fuzzy variables can be positive, zero, or negative and quantifying their magnitude as small, medium, or large (Kosko 1992) we can obtain six fuzzy-set values excluding zero:

- NL : Negative Large
- NM: Negative Medium
- NS: Negative Small
- ZE: Zero
- PS: Positive Large
- PM: Positive Medium
- PS: Positive Small

Using the above classification the experts constructed the initial fuzzy matrix used by the model as knowledge base, appearing in Table 2. This knowledge base has been built to describe the magnitude of each concept determining the initial equilibrium conditions of the model and facilitating the forecasting procedure.

The general model of Figure 1 was then built, in which the various concepts of the model interact with one other. The two leading or fundamental concepts of interest in this model are the EU accession of Cyprus's (C1), and the role of the UN through the submission of the Annan Plan (C6), with the answer to our crucial question concerning the relations between Greece and Turkey depending, to a large extent, on concept C2 representing an environment of tension on the island. The various weights are listed on the right-hand side of Figure 1 in a form that indicates the link from the initial to the terminal concept, with concepts separated by commas.

Promising as they may appear, the CNFCMs have two weak points: The first involves the invariability of the weights, which leaves only the activation levels to participate in the configuration of a political problem. The second lies with the inability of the method to model a certain political situation by performing all possible computational simulations following the change of a certain weight or group of weights. These problems are solved by combining CNFCMs with Genetic Algorithms (GAs) thus creating a hybrid model: The CNFCM part of the algorithm computes the final activation levels given the weights and relationships between concepts (see the Appendix for details on the computation process), while the GA part develops the weight matrix attempting to find the optimal set of weights that satisfy a predefined activation level for a specific concept. A hybrid model of this type, therefore, traces the degree of the causal relationships between the various concepts such that it can "force" them to be activated to a certain level. Hybrid models of this type are expected to contribute to the effectiveness of decision-making by defining, for each concept, the activation level achieved using a certain set of weights evolved by the GA (Goldberg 1989, Michalewicz 1994).

Table 2. Fuzzy model analysis

Concept	Fuzzy Values	Description
C1: Cyprus EU Full Accession	0.66 to 1	Cyprus EU Full Accession. Freedom of Authority Exercise Ranges Between Considerable and Complete.
	0.31 to 0.65	Cyprus EU Full Accession. Freedom of Authority Exercise Ranges Between Considerable and Inadequate.
	0 to 0.3	Cyprus EU Full Accession. No Solution to the Cyprus Issue.
	-0.32 to 0	Cyprus EU Full Accession Revised in Anticipation of a Pending Solution.
	-0.33 to –0.65	Cyprus EU Full Accession Suspended until a Final Solution.
	-1 to -0.66	Cyprus EU Full Accession Rejected. No Solution to the Cyprus Issue.
C2: Escalation of Tension	0.66 to 1	Tension Escalation. Warfare
	0.31 to 0.65	Large Scale Provocative Incidents
	0 to 0.3	Small Scale Provocative Incidents
	-0.32 to 0	Statements and Intensions to Actions Aiming at Reducing Tension.
	-0.33 to –0.65	Actions Aiming at Reducing Tension.
	-1 to -0.66	Stability on the Island.
C3: Settlement of the Cyprus Issue	0.66 to 1	Generally Acceptable Solution of the Cyprus Issue.
	0.31 to 0.65	Basis for Settlement of the Cyprus Issue.
	0 to 0.3	Talks Aiming at Reaching an Agreement on the Cyprus Issue.
	-0.32 to 0	Stagnation Concerning the Cyprus Issue.
	-0.33 to –0.65	Adverse Developments Concerning the Cyprus Issue. Dead end.
	-1 to -0.66	No Possibilities for Solution. Two Separate States on the Island.
C4: Turkish – Cypriot Position	0.66 to 1	Acceptance of Annan Plan After a Referendum.
	0.31 to 0.65	Acceptance of Annan Plan After Negotiations.
	0 to 0.3	Acceptance of Annan Plan as it Stands.
	-0.32 to 0	Rejection of Annan Plan After Negotiations.
	-0.33 to –0.65	Rejection of Annan Plan After a Referendum.
	-1 to -0.66	Rejection of Annan Plan as it Stands.

Table 2. Fuzzy model analysis (continued)

Concept	Fuzzy Values	Description
C5: Position of the Turkish Government	0.66 to 1	Acceptance of Annan Plan in Line with a Turkish – Cypriot Decision.
	0.31 to 0.65	Acceptance of Annan Plan After Negotiations.
	0 to 0.3	Acceptance of Annan Plan as it Stands.
	-0.32 to 0	Rejection of Annan Plan in Line with a Turkish – Cypriot Decision.
	-0.33 to –0.65	Rejection of Annan Plan After Negotiations.
	-1 to -0.66	Rejection of Annan Plan as it Stands.
C6:The Cyprus Issue Solution Framework	0.66 to 1	Full Approval of Plan.
	0.31 to 0.65	Satisfactory Plan.
	0 to 0.3	Negotiable Plan.
	-0.32 to 0	Adverse Elements in the Plan.
	-0.33 to –0.65	Unsatisfactory Plan.
	-1 to -0.66	Unacceptable Plan.
C7: Position of Cypriot Government	0.66 to 1	Acceptance of Annan Plan After a Referendum.
	0.31 to 0.65	Acceptance of Annan Plan After Negotiations.
	0 to 0.3	Acceptance of Annan Plan as it Stands.
	-0.32 to 0	Rejection of Annan Plan After Negotiations.
	-0.33 to –0.65	Rejection of Annan Plan After a Referendum.
	-1 to -0.66	Rejection of Annan Plan as it Stands.
C8:Position of the European Union	0.66 to 1	Cyprus Full Accession and Solution of the Cyprus Issue.
	0.31 to 0.65	Cyprus Full Accession. Further Talks for a Solution.
	0 to 0.3	Cyprus Full Accession. No Solution to the Cyprus Issue.
	-0.32 to 0	Cyprus Full Accession Pending Until Solution.
	-0.33 to –0.65	Cyprus Full Accession Postponed Anticipating Negotiations Results.
	-1 to -0.66	Cyprus Full Accession Fails.
C9:Position of the Greek Government	0.66 to 1	Acceptance of Annan Plan in Line with a Cyprus Government Decision.
	0.31 to 0.65	Acceptance of Annan Plan After Negotiations.
	0 to 0.3	Acceptance of Annan Plan as it Stands.
	-0.32 to 0	Rejection of Annan Plan in Line with a Cyprus Government Decision.
	-0.33 to –0.65	Rejection of Annan Plan After Negotiations.
	-1 to -0.66	Rejection of Annan Plan as it Stands.

Table 2. Fuzzy model analysis (continued)

Concept	Fuzzy Values	Description
C10: Reactions of U.S. – U.K.	0.66 to 1	Strong Pressure for a Solution and Support of Cyprus Full Accession.
	0.31 to 0.65	Discrete Pressure on Both Sides for Full Accession and Solution.
	0 to 0.3	Neutral Position. Distances Kept against Both Sides on the Island Regarding Full Accession and Solution.
	-0.32 to 0	Reduced Interest in a Solution Following Full Accession.
	-0.33 to –0.65	Reduced Interest in a Solution Before Full Accession.
	-1 to -0.66	Indifference Regarding Full Accession and Solution of the Cyprus Issue.
C11: Invasion in Iraq	0.66 to 1	Attack Against Iraq.
	0.31 to 0.65	Preparatory Stage for Assault.
	0 to 0.3	Considerable Chances for an Assault.
	-0.32 to 0	Small Chances for an Assault.
	-0.33 to –0.65	Remote Chances for an Assault.
	-1 to -0.66	No Possibilities for an Assault.

The essence of the Genetically Evolved Certainty Neuron Fuzzy Cognitive Map (GECNFCM) model lies with tracing the optimal weight matrix corresponding to a desired activation level for a given concept as computed by a simple CNFCM model (Andreou et al. 2003). More specifically, the GA evolves a population of individuals each of which consists of a weight matrix describing the degree of causal relationships between the concepts of Figure 1. The initial generation contains weights matrices with random values. The evolution of the individuals is performed with the help of the CNFCM model, which computes the final activation levels of the concepts using equations 3 to 5. The activation level of a certain concept in focus denoted by $A_{d,i}$ is used to calculate the fitness of each individual-weight matrix WM_i according to the following function:

$$\text{fitness}(WM_i)=1/(1\text{-abs}(A_{d,i} - \text{mean}_{50}(A_{a,i})) \quad (6)$$

where $A_{d,i}$ is the target (desired) value of the activation level for the concept in focus C_i and mean50($A_{a,i}$) is the mean value of the last fifty actual activation levels of concept C_i as these are computed by the CNFCM (t variable in equation (4)). It is clear from equation (6) that the closer to the target value this mean is, the more appropriate the weight matrix. In fact, the fitness function uses the average of the last fifty activation levels to take into consideration a possible final state of the model which presents limit-cycles, that is, a state in which the $A_{d,i}$ exhibit periodic fluctuations and do not stabilize at equilibrium values. Thus, if the activation level of the concept in focus reaches equilibrium then the corresponding weight matrix in this case can be considered more appropriate compared to another individual-matrix that has resulted to limit cycle behaviour.

The simulations conducted to test the functionality and predictability of our model were based on the following constant values for the variables involved: The population size has been set equal to 100 and the number of generations equal to 400. The weight values were initialised in the range [-1.0, 1.0] while the probability of applying the genetic operator of crossover was set to 0.25 and that of mutation to 0.01.The simulations that follow retrieve the final activation levels of the rest of the concepts, as well as the strength of the causal relationship between them. The analyst is thus given the means to proceed to tactical movements in his decision-making by varying the degree of such relationships taking into account the final activation levels that the model has suggested.

Table 3. Weight matrix according to the domain experts

W1 C3-C1	**W2 C8-C1**	**W3 C9-C1**	**W4 C10-C1**	**W5 C5-C1**	**W6 C2-C1**	**W7 C3-C2**	**W8 C5-C2**	**W9 C9-C2**
0.02	0.22	0.22	-0.11	-0.11	-0.19	-0.16	0.18	-0.16
W10 C10-C2	**W11 C10-C3**	**W12 C4-C3**	**W13 C10-C4**	**W14 C6-C4**	**W15 C5-C4**	**W16 C6-C5**	**W17 C10-C5**	**W18 C11-C5**
0.22	-0.16	-0.18	0.12	0.20	0.20	0.20	0.14	0.17
W19 C6-C7	**W20 C6-C9**	**W21 C6-C8**	**W22 C11-C6**	**W23 C7-C3**	**W24 C8-C7**	**W25 C10-C7**	**W26 C10-C8**	**W27 C11-C9**
0.2	0.2	0.16	0.02	0.19	0.16	0.14	0.16	0.01
W28 C10-C9	**W29 C9-C7**	**W30 C10-C11**	**W31 C11-C2**	**W32 C1-C6**	**W33 C1-C3**	**W34 C1-C4**	**W35 C1-C7**	
0.11	0.14	0.22	0.12	0.06	0.11	0.06	0.13	

Our model, using the weights depicted in Table 3 as these were defined by the experts, has reached equilibrium, as indicated in Figure 2, after 250 interactions (t variable in eq. (3) to (5)), thus calculating the new activation levels of the eleven concepts presented in Table 4.

Table 4. Activation levels (A_i) for the Baseline scenario

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
0.2	-0.25	0.32	-0.35	-0.58	0.49	0.38	0.52	0.58	0.32	-0.57

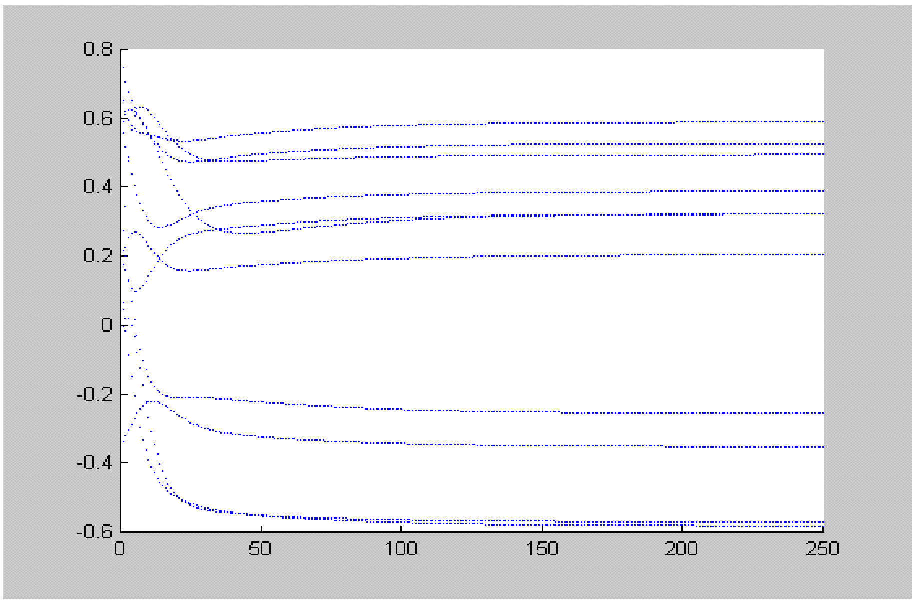

Figure 2. Stabilization of the model in equilibrium

It is very encouraging to point out that although the baseline simulation providing the initial equilibrium conditions of our model was performed before the CSC on December 12–14, 2002, it has nevertheless captured the dynamics of the Cyprus issue as follows:

i. The activation level (AL) of concept C1 representing the EU accession of Cyprus has stabilised to 0.2. Given that the range of possible values has been set between –1 and +1, and by looking at Table 2 denoting the ranges of the various ALs used in our fuzzy model analysis, this value lies within the range of PS (Positive Small), indicating the existence of a distinct possibility of EU accession without a settlement of the Cyprus issue. The results of the CSC of December 02 simply confirmed our forecast.

ii. Concept C2 is of considerable importance for the analysis, since it stands for the degree of tension on the island, assuming a simulated activation level of A_2=-0.25. This value together with the negative sign forecast the reduction of tension and the conciliatory attitude of the new Turkish government following the submission of the Annan Plan. Indeed, it seems that the Islamists do not insist on their predecessors' threats involving "unlimited reactions" in case of an accession before a settlement of the Cyprus issue.

iii. The commitment of the two sides to continue working for a settlement of the Cyprus issue until the end of February 2003 is reflected to a forecasted activation level of A_3=0.32 for the third concept C3 representing a solution to the Cyprus problem.

iv. The rejection of the Annan Plan, as proposed by both the Turkish-Cypriot authorities and the Turkish Government under the pressure of the Turkish National Security Council, is forecasted by the values assumed for the fourth and the fifth concepts respectively, i.e. A_4=-0.35 and A_5=-0.58. The validity of our forecasts concerning the inflexibility of the Turkish side has been verified during the CSC, when then UN Secretary envoy, Mr Alvaro De Soto, failed to arrange a new round of direct bilateral talks based on the Annan Plan, following a rejection by the Turkish Cypriot regime. By contrast, the attitude of the Cyprus government, which regards the Annan Plan as a sound basis for further talks, is very successfully forecasted by the model that yields a value of the AL for the relevant concept C7 equal to A_7=0.38. In fact, the Cyprus Government was ready to start negotiations during the CSC, a position supported by the Greek Government (C9), which is forecasted to favour a solution of the problem following negotiations, given that its AL is simulated to A_9=0.58.

v. Turning, finally, to the forecasted attitude of the international environment, the eighth concept that represents the position of the European Union assumes a baseline activation level of A_8=0.52. This is considered reasonable given that the EU favours both the accession of Cyprus and the continuation of the talks aiming at a settlement of the Cyprus issue. The moderate pressure exercised by the US and the UK on both sides on the island is reflected in an AL value of A_{10}=0.32 for this tenth concept, while available information thus far indicates a possibility to avoid an invasion in Iraq, at least until the submission of the UN experts report on the nuclear and biological arsenal of Iraq.

5.4 POLICY CONSIDERATIONS

Having thus established, following our CNFCM baseline simulation, the functionality of our model which reflects the complexity of the Cyprus issue in its pre-Copenhagen Summit Conference form, we can now proceed to examining a variety of possible policy scenarios. As it has already been pointed out, this task that will be performed using Genetic Algorithms and Scenario Analysis (Godet 1987, Bunn and Salo 1993), requires assigning our two leading targets, namely the EU accession of Cyprus and the solution of the Cyprus issue, a certain activation level that reflects the degree to which they are designed to attain, according to each scenario. Once this has been established, the algorithm will then provide the values required for the instrumental variables of the system, namely its activation levels and concept weights to attain the specific target set. The evaluation and interpretation of the results will be based on the predetermined range of possible values presented in Table 2.

Taking into account the picture, as it stands on a cut–off date, sometime in early January 2003, we have decided to consider the forecast for the following three possible scenarios:

Scenario A: The Optimistic Case

The optimistic outlook of the Cyprus issue provides for the following scenario: Cyprus becomes a full EU member while the Cyprus issue is resolved by allowing the Cypriot government a large number of degrees of freedom in order to implement its economic and social policy for the entire island. Our genetic algorithm requires that this framework is described by increasing the activation level of C1 to A_1=0.9, yielding in equilibrium mode (Figure 3) the optimal weight matrix depicted in Table 5, while Table 6 provides the corresponding ALs which verify the reliability of our model. Indeed, the AL of concept C1 that represents full EU accession converges from an initial 0.2 to 0.82, a figure that reveals that the Cypriot government has been allowed unconstrained freedom of movement in order to implement its economic and social policy for both communities on the island. Such an event, however, as the model indicated, will trigger tension on the island, given that the AL of the corresponding concept C2 rises to A_2=0.73. It is interesting to point out, however, that the Turkish Cypriot community will be eager to accept the "carte blanche" given to the Cypriot State (A_4= 0.8) since this arrangement will entail considerable welfare improvement following their full EU membership[40].

By contrast, the expected reaction of the Turkish side to such an arrangement is forecasted to be a straightforward rejection since the corresponding C5 assumes a strongly negative value (A_5=-0.62), thus generating a further source of tension between the two sides. Concerning the Annan Plan, the forecast concerning both the Cypriot and the Greek governments indicates that they will accept its final form following a referendum (A_7=0.77 and A_9=0.88), with the consensus of Athens (A_6=0.1).

The reaction of the international community is forecasted as a certain amount of pressure by the US and the UK (A_{10}=0.67) for a settlement of the problem, while the

[40] The reaction of the Turkish Cypriots is expected to contribute to promoting tension on the island and to complicate matters. In fact, Mehmet Ali Talat, head of the Turkish Cypriot opposition Republican Turkish February (IISS 2002).

position of the EU in this case, represented by an A_8=-0.65 might be a surprise to a certain extent. In fact, according to Table 2 such a figure corresponds to the possibility of suspension of the EU accession of Cyprus in anticipation of a final solution.

Table 5. GECNFCM optimal weight matrix for the Optimistic Case scenario

w1 C3-C1	**w2 C8-C1**	**w3 C9-C1**	**w4 C10-C1**	**w5 C5-C1**	**w6 C2-C1**	**w7 C3-C2**	**w8 C5-C2**	**w9 C9-C2**
0.89	0.04	0.91	0.38	-0.02	0.68	1	-0.18	0.41
w10 C10-C2	**w11 C10-C3**	**w12 C4-C3**	**w13 C10-C4**	**w14 C6-C4**	**w15 C5-C4**	**w16 C6-C5**	**w17 C10-C5**	**w18 C11-C5**
0.72	0.28	0.97	0.10	0.01	-0.2	-0.18	-0.59	-0.27
w19 C6-C7	**w20 C6-C9**	**w21 C6-C8**	**w22 C11-C6**	**w23 C7-C3**	**w24 C8-C7**	**w25 C10-C7**	**w26 C10-C8**	**w27 C11-C9**
-0.20	0.18	-0.52	0	0.80	-0.53	-0.23	0.88	0
w28 C10-C9	**w29 C9-C7**	**w30 C10-C11**	**w31 C11-C2**	**w32 C1-C6**	**w33 C1-C3**	**w34 C1-C4**	**w35 C1-C7**	
-0.76	0.69	-0.68	-0.36	-0.54	-0.14	0.73	0.66	

Table 6. Activation levels calculated with GECNFCM's optimal weights for the Optimistic Case scenario

C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**
0.82	0.73	0.87	0.80	-0.62	0.10	0.77	-0.65	0.88	0.67	-0.33

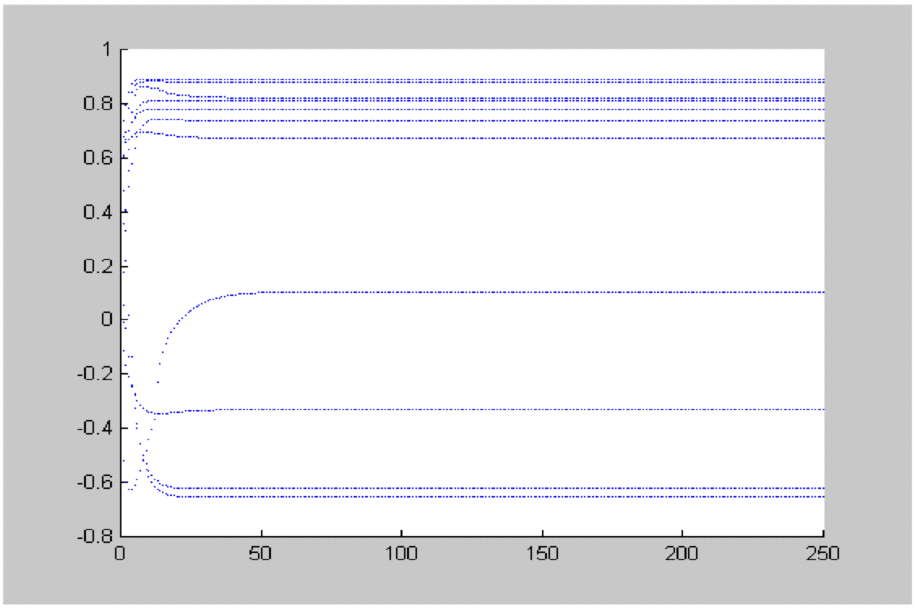

Figure 3. Optimistic Case (scenario 1): Equilibrium for A_1=0.9

Scenario B: The Complex Case

This scenario provides for a full EU membership, together with a settlement of the Cyprus issue such that the government is not allowed to implement its policy on the entire island. This scenario, therefore, requires that the initial AL of concept C1 be increased from 0.2 to 0.4. The model is shown to have reached equilibrium in Figure 4 with the calculated optimal weight matrix presented in Table 7 and the eleven concepts activated as indicated in Table 8.

Following the recalculation of weights by our genetic algorithm the model leads to an AL equal to A_1= 0.39. The reduced degrees of freedom allowed to the authority of the Cypriot government by the finalized version of the Annan Plan lead to the consensus of the Turkish Cypriot authorities and the subsequent tension reduction, since the AL of C2 reaches A_2=-0.42. It follows, therefore, that the referendum on the Turkish Cypriot side will lead to accepting the Plan (A_4=0.77), with the approval of the Turkish government (A_5=0.77), unlike the one conducted by the Cypriot government which is forecasted to reject it (A_7=-0.51). It is interesting to see that the Greek government might be inclined to accept an improved version of the Plan following a period of negotiations (A_9=0.45). The apparent contrast of positions between the Greek and the Cypriot government is not altogether that unexpected given the emphasis that the former places on the improvement of the relations between the EU and Turkey. Finally, the pressure from the US–UK is always strong (A_{10}=0.84), while the position of the EU is clearly in favor of a deferment of Cyprus's accession (A_8=-0.52), since the last thing it would ask for is another extra domestic problem to solve in the event of an unsatisfactory solution for one of its members involved in the Cyprus issue.

Table 7. GECNFCM optimal weight matrix for the Complex Case scenario

W1 C3-C1	**W2 C8-C1**	**W3 C9-C1**	**W4 C10-C1**	**W5 C5-C1**	**W6 C2-C1**	**W7 C3-C2**	**W8 C5-C2**	**W9 C9-C2**
0.43	0.23	0.91	0.61	-0.77	-0.26	-0.29	-0.94	0.22
W10 C10-C2	**W11 C10-C3**	**W12 C4-C3**	**W13 C10-C4**	**W14 C6-C4**	**W15 C5-C4**	**W16 C6-C5**	**W17 C10-C5**	**W18 C11-C5**
0.46	-0.67	0.71	0.61	0.95	0.51	-0.89	-0.99	-0.38
W19 C6-C7	**W20 C6-C9**	**W21 C6-C8**	**W22 C11-C6**	**W23 C7-C3**	**W24 C8-C7**	**W25 C10-C7**	**W26 C10-C8**	**W27 C11-C9**
-0.36	-0.60	0.65	0	-0.22	0.48	-0.25	0.31	0
W28 C10-C9	**W29 C9-C7**	**W30 C10-C11**	**W31 C11-C2**	**W32 C1-C6**	**W33 C1-C3**	**W34 C1-C4**	**W35 C1-C7**	
0.55	0.28	-0.03	0.11	0.75	0.41	-0.66	0.50	

Table 8. Activation levels calculated with GECNFCM's optimal weights for the Complex Case scenario

C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**
0.39	-0.42	0.67	0.77	0.77	-0.73	-0.51	-0.52	0.45	0.84	-0.7

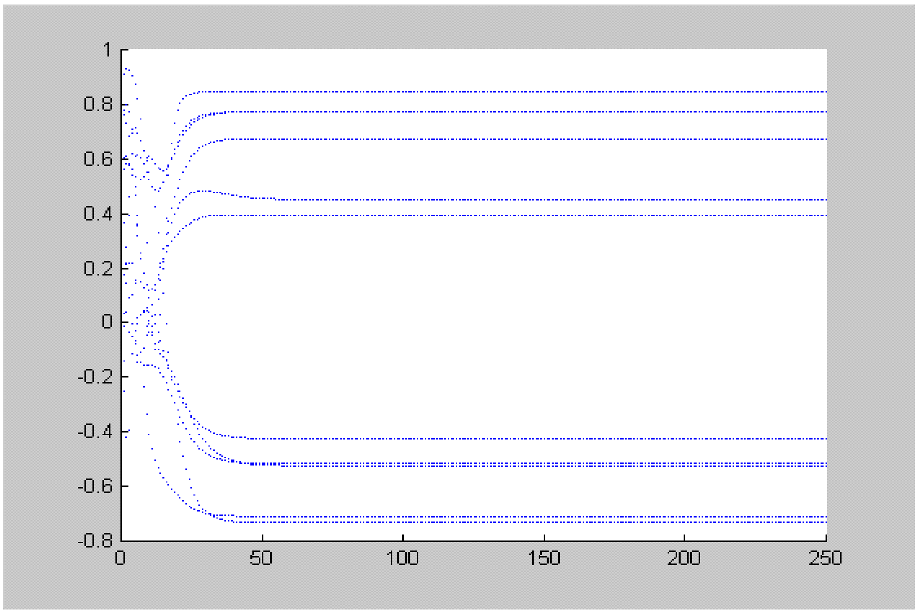

Figure 4. Complex Case (scenario 2): Equilibrium for A_1=0.4

Scenario C: The Pessimistic Case.

This scenario faces the possibility of a suspended EU full accession, despite the Copenhagen summit decision[41], in anticipation of a solution to the Cyprus issue by setting the activation level of C1 to A_1=-0.2, thus obtaining the optimal weight matrix depicted in Table 9 in equilibrium mode (Figure 5).

Table 9. GECNFCM optimal weight matrix for the Pessimistic Case scenario

W1 C3-C1	**W2 C8-C1**	**W3 C9-C1**	**W4 C10-C1**	**W5 C5-C1**	**W6 C2-C1**	**W7 C3-C2**	**W8 C5-C2**	**W9 C9-C2**
0.56	0.61	-0.69	-0.11	-0.95	-0.93	0.16	-0.47	-0.70
W10 C10-C2	**W11 C10-C3**	**W12 C4-C3**	**W13 C10-C4**	**W14 C6-C4**	**W15 C5-C4**	**W16 C6-C5**	**W17 C10-C5**	**W18 C11-C5**
0.33	-0.09	-0.55	0.83	0.9	-0.55	0.01	-0.04	0.3
W19 C6-C7	**W20 C6-C9**	**W21 C6-C8**	**W22 C11-C6**	**W23 C7-C3**	**W24 C8-C7**	**W25 C10-C7**	**W26 C10-C8**	**W27 C11-C9**
0.94	0.67	-0.92	0	0.44	-0.98	-0.57	0.8	0
W28 C10-C9	**W29 C9-C7**	**W30 C10-C11**	**W31 C11-C2**	**W32 C1-C6**	**W33 C1-C3**	**W34 C1-C4**	**W35 C1-C7**	
-0.25	-0.98	0.65	0.81	0.23	-0.58	0.65	-0.29	

[41] Indeed, despite the fact that Cyprus's EU accession has never been linked to the solution of the Cyprus issue by any means, the Helsinki Agreement signed in December 1999 (Paragraph 9b) states that before the ratification of the Cyprus EU accession, the Council will take into consideration all relevant factors concerning the Cyprus issue. Any possibility for a postponement, therefore, is expected to arise on these rounds, rather than as a result of a rejection in one of the member-states parliaments where such a rejection can only apply for all ten newly appointed members.

As shown in Table 10 the concept representing EU accession of Cyprus is activated almost to its target value (A_1=–0.13), while tension is expected to rise in this case as well (A_2=0.43) following the stagnation prevailing as it concerns the Cyprus issue. The general attitude facing the Annan Plan involves rejections by both the Greek (A_9=-0.55) and the Turkish (A_5=-0.25) government, the position of the former being considerably stronger, while the two sides on the island are hesitant to accept (A_4=0.03 for the Turkish Cypriots) or reject it (A_7=-0.02). These results explain the position of the EU, which favors postponement of the Cyprus's accession until conclusion of the talks (A_8=-0.26). The US–UK side, finally, keeps pressing for a solution (A_{10}=0.69), in anticipation of its invasion to Iraq which will require the use of a number of Turkish military air bases, a variable which is expected to carry increased weight in the bargain for a solution to the Cyprus issue[42].

Table 10. Activation levels calculated with GECNFCM's optimal weights for the Pessimistic Case scenario

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
-0,13	0,43	-0,01	0,03	-0,25	-0,45	-0,02	-0,26	-0,55	0,69	0,63

[42] "On the Turkish side, the deadline of 28 February 2003 means that Ankara is unlikely to come under effective pressure from the US to reach a settlement, as Washington is currently more concerned with placating, rather than antagonizing, Turkey in order to secure its support for a possible military campaign against Iraq early next year" (IISS 2002). This means that the pressure for concessions on the Cyprus issue is expected to fall on the Greek side.

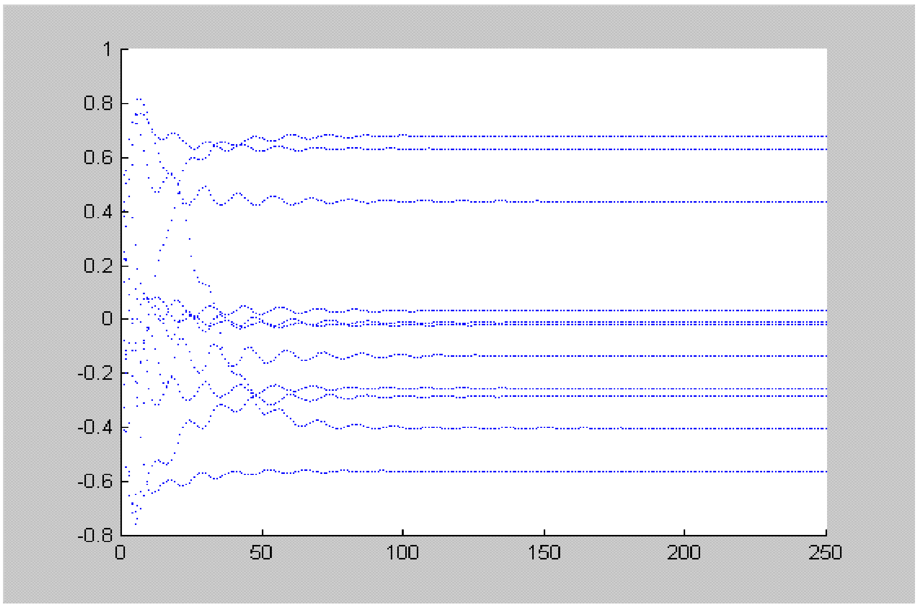

Figure 5. Pessimistic Case (scenario 3): Equilibrium for A_1=-0.2

5.5 CONCLUSIONS

It is straightforward, therefore, that under the circumstances there is very little room for optimism with regard to possibilities of a drastic tension reduction concerning the relations between Greece and Turkey. In fact, in all the cases analyzed, one or both sides will be strongly opposed to the proposed solution of the Cyprus issue on the basis of the Annan Plan. The prospects are even gloomier as a result of the extent to which the two sides affect the decisions taken by Cyprus itself. In the case of the Turkish military, in particular, the pressure which it exercises may comply with the Turkish Cypriot authorities' inflexibility; it is, however, in direct conflict to the aspirations of the overwhelming majority of the Turkish Cypriots, a position revealed by their massive demonstrations during late 2002 and early 2003. If one includes the conflict that has arisen between the Islamic government and the Turkish military after the November 2002 elections in Turkey, then our hybrid model simply confirms the prolongation of tension between the two sides as a result of the difficulties in reaching an agreement on the Cyprus issue.

Concerning the international environment, the Cyprus government must not rely on the decisions taken during the Copenhagen summit, until May 2004, the deadline for the approval of these decisions by the 15 EU parliaments. The forecasted lack of enthusiasm from the part of the EU concerning Cyprus full membership is related to the skepticism of certain member states that would prefer avoiding an extra burden to the various EU problems, preferring to postpone Cyprus's EU accession until the issue has been resolved. Regarding the pressure exercised by the US–UK for a quick solution in view of an invasion of Iraq, this will hardly contribute to smoothening the tension between the Greek and the Turkish side.

The hesitant attitude of the Cypriot state towards the Annan Plan may be due, among other things, to the enormous financial cost which it will bear in its effort to integrate the underdeveloped north. The prior experience of Germany on this issue raises serious concerns that this cost will be prohibitive for the economy of Cyprus, given its effort to comply with the Maastricht criteria and join the EMU and the Eurozone.

A direct conclusion of the above is that the relaxed attitude of the Greek government regarding the prospects of its relations with Turkey is far from being justified. Given the pronounced clash of interests on the Cyprus problem between the two sides on one hand and the intense domestic conflict concerning political decision-making in Turkey and on the Turkish–Cypriot side on another, the prospect of friction between Greece and Turkey will remain high. Consequently, the Cyprus issue, which we must be careful to regard as simply one of the problems concerning the Greek–Turkish relations, is expected to promote the arms race that burdens the economies of both sides in the foreseeable future.

5.6 UPDATE

We have completed this paper on March 20, 2003, Day One of the US–UK invasion to Iraq. This is a major international crisis, which we have considered in our model as affecting the Cyprus issue in more ways than one. In fact we are now in a position to evaluate the validity of our results and the predictability of our model, given that the developments concerning the Cyprus issue and the global political setting are currently at a very delicate phase.

What seems to be the case, therefore, is that the current developments with respect to the Cyprus issue and the associated international environment are very close to what we have called “the Complex Scenario”. Given that no solution has been attained by the end of February 2003, it appears that the Adhesion Act for the ten new members will be signed in Athens on April 16, 2003 and it will refer to the Republic of Cyprus as one entity. To what extent the EU will be willing to bargain the membership application of Turkey against the settlement of the Cyprus issue is a matter that remains to be seen.

According to our “Complex Case”, therefore, it seems that the solution of the Cyprus issue may be left up to the EU dynamics in the context of an “acquis communautaire”, possibly leading to accessing the north of the island along the lines of the German renunciation. This means that whatever this solution may be is certainly going to be a question of long-term character. We must point out once again, however, in the light of the latest developments that we still cannot share the optimism of the Greek side concerning its bilateral relations with Turkey. The distance between the “Complex Case” and what we have termed the “Pessimistic Case” is far too small to be neglected. A possible incorporation of the third version of the Annan Plan to the Adhesion Act, or even a rejection of all ten applications by a member-state parliament, as a reaction to the backing offered by some of the EU newly selected members to the US foreign policy are possibilities which the Greek side must seriously consider.

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EPILOGUE

EPILOGUE

Μάλλον γάρ πεφόβημαι τάς οικίας ημών
αμαρτίας ή τάς τών εναντίων διανοίας
(I would rather be concerned about our
own errors rather than our adversaries' plans)
Thoukidides

What we have done in this book is to examine certain key issues related to the Cyprus problem and the Greek–Turkish arms race and to provide answers to questions related to these issues. Our points and suggestions presented in this book are certainly not original. In fact, a large number of experts may have supported similar views now and then. We believe, however, that we have contributed a small step further in studying the relations between Greece and Turkey in the light of the Cyprus issue by using positive rather than normative analysis. Offering mathematical proofs to such issues beyond any reasonable doubt can entail a considerable number of benefits the least important being the time saved during the endless TV debates on the issue.

Using this straightforward reasoning, therefore, we have shown how important the role of human resources is in arms races in general and in the case of the Greek–Turkish conflict, in particular, in which Turkey obviously has the upper hand, given the demographic developments in the two countries. The relative security measure we propose is merely one extra way to show the importance of human resources in the arms race between the two sides. We have shown that no matter how paradoxical it may sound, the state of an arms race between Greece and Turkey is the only way in which peace can be safeguarded in the broader area of Cyprus and the Aegean, given the profound differences between the two sides, the role of each of which in this race, be it leader or follower, is clearly identified. The difference between the actual and the financially optimal defence expenditure for Greece and Cyprus which can be taken to approximate the peace dividend for the two partners, points out the excessive burden that the two countries must bear, given their commitments along the lines of the Integrated Defence Doctrine. This alliance, moreover, may prove much more fruitful if the two participants make use of their comparative advantage which dictates that Greece emphasizes on the procurement of equipment while Cyprus provides the manpower for both countries. The shift of the Greek defence doctrine towards flexibility, speed of action and modernization of equipment is certainly a good start. One should not forget, however, that this is an expensive solution and consequently it is not compatible with any defence budget cuts, given the fragility of the international equilibrium in the Middle East and the reaction of Turkey which remains a question mark following the U.S. - U.K. invasion and the post Saddam regime in Iraq. In fact, the Pentagon and the State Department, to a lesser extent, do not seem to be exactly pleased with the contribution of their traditional ally in the area, especially after the refusal of the parliament to allow the use of Turkish territory by US troops aiming at invading Iraq from the north. It seems that the extra cost in terms of both time and money which the allied forces suffered following the Turkish rejection of their demands has been subtracted from the admittedly generous US financial support to Turkey, although the latter did eventually collect a substantial fraction of this support. In fact there is a widespread opinion that Erdogan's political maneuvers in this case have been admirable as he manages so far to keep a delicate balance between his strong Islamic backing, the Turkish military and the alliance commitments of his country. The fact remains, however, that irrespective of the extent to which Erdogan's political balance will be fruitful, there is a distinct possibility that Turkey will invest on a more pronounced presence in the Aegean if not in Cyprus, even if this requires a more aggressive attitude from its part. History teaches that Turkey tends to export its domestic problems in the form of a variety of demands against neighboring countries. It follows, therefore, that in cases in which developments in the area turn against its strategic interests like, for example, the case of a US support to a Kurdish independent state, Turkey may shift its focus towards alternative targets in Cyprus and the Aegean theatre. In the opposite case, again, in which its position as a US ally is upgraded, it will feel strong enough to press for increased American backing to its demands against Cyprus and Greece. Consequently, whatever the gains or losses for Turkey may be during the post Saddam era, the possibilities of friction in Cyprus and the Aegean continue to remain high during a period of detrimentally relaxed euphoria of the Greek side.

A word of caution is required in this case: Both the Cyprus problem and the demands of Turkey in the Aegean Sea are issues which affect the relations between Greece and Turkey to a considerable extent, without, however, by any means being interdependent. In fact the Greek side has always rejected the logic of a package deal between the two countries. Concerning Cyprus, in particular, it seems that its EU full membership outlines a completely new strategic, political and socio-economic background very similar to the pre-Annan Plan era. What the Annan Plan proposed, in broad terms, has been a co-operation between Greece and Turkey on the island at the expense, at least to a very large extent, of its national sovereignty. What is more, the statements made by the UN Secretary praising the Greek and Cypriot side for their co-operation and support could reveal much more than what meets the eye. We believe that what it does, in fact, is to point to the Greek side as the weakest of the two, in the sense of being more liable to negotiations, given the Turkish firm position which leaves no room for bargaining. In that sense, the Cyprus EU full membership by leaving no such room, allows the "acquis communautaire" to provide the unique framework for a final solution of the problem through the integration of the Turkish-Cypriot community on the island. The generous flow of financial support directed to the North and the measures taken by the Cypriot government in April 2003 promoting unobstructed labor mobility and trade flows throughout the island are certainly expected to contribute to this end.

This does not mean, however, that we should all rely on the acquis communautaire and the international treaties for the settlement of our problems. Our recent experience based on developments in the Middle East points out to a very important message. In a strongly volatile political and strategic environment, which no longer enjoys the luxury of a delicate balance as a result of the Cold War, questions of legitimacy arise after any arbitrary political or military move, questions that the UN has proved that it cannot answer effectively. This automatically implies that establishing the legitimacy of any such move or action will be left to those who undertake it. And it seems that in such cases the stronger the armed forces of those who seek legitimacy of their actions, the more convincing their arguments are.