Chapter 1

SEARCHING FOR THE OPTIMAL DEFENCE EXPENDITURE

An Answer in the Context of the Greek–Turkish Arms Race

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Abstract This paper aims at evaluating the extent to which the defence expenditure of Greece and Cyprus given their arms race against Turkey in the context of the Integrated Defence Doctrine policy constitutes a burden feasible to bear. The evaluation takes place using an Optimal Control solution constrained by a model emphasising on Greek and Cypriot defence expenditure. Various experiments and scenarios have been tested

leading to the general conclusion that the defence expenditure in both allied countries seems to be driving their economies beyond capacity limits. This, however, by no means justifies the one sided disarmament policy currently followed by Greece, since the long–term armament programmes pursued by Turkey, the role of which in this arms race has been proven as leading, leave very small room to the Greek and Cypriot sides to reduce their defence expenditures.

Keywords: Optimal Control, Defence Expenditure, Arms Race, Relative Military Security

1. Introduction

Some people argue that the concurrent reduction in the defence programmes of Greece and Turkey during the recent past seems to raise hopes that the Greek–Turkish arms race may not be an endless procedure after all. The extent to which this optimistic view is justified depends on whether there is indeed a causal relationship between the unexpected Greek defence programme reduction, shortly after it had been approved in the country's parliament by an overwhelming majority, and that of Turkey, after the latest economic crisis. The aim of this paper, however, is not to answer this question since we do not know of any causality tests applicable to qualitative foreign policy issues. What we have decided to do, instead, is to consider the extent to which this arms race constitutes an excessive defence burden for Greece and Cyprus, especially after the implementation of the Integrated Defence Doctrine. We shall attempt to calculate, in addition, the optimal defence burden for the two members of this alliance under the constraints imposed by their economies. Finally, we shall consider the extent to which pursuing such optimal recipes leads indeed to collecting a substantial peace dividend, in the sense proposed by several sources in the literature. 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, as it is explained in section 3, after a brief literature overview has been provided in section 2. The fourth 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 minimised. Section 5 includes various policy considerations based on the results derived by the algorithm, while the conclusions derived are stated in the last part of this paper.

2. Literature Overview

The existence of an arms race between Greece and Turkey is a well established fact (Kollias and Makrydakis 1997), determined chiefly 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 analysed 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 debt has doubled within the decade of the 1990s to reach more than 5 billion dollars 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 (Kollias 1994, Kollias 1995 and Kollias 1996) and Antonakis (Antonakis 1996 and Antonakis 1997) have investigated the economic effects of defence expenditure upon the Greek economy.

It is obvious, therefore, that the defence expenditure constitutes a considerable burden for the economies of Greece and Cyprus, meaning that the next straightforward question would be to consider what the ideal defence burden would be. To this end, we have decided to resort to using optimal control analysis in order to specify the optimal defence expenditure levels of the two allies, a Nash equilibrium problem analysed in the context of the theory of alliances in its simplest form (Hartley and Sandler 1995).

3. The Algorithms

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:

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

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 $\Phi(x, r_k)$, for a decremental 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} and a maximum number of 500 Armijo iterations. 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–initialisation to a different feasible starting point was considered as an alternative.

Concerning the Penalty Function, the initial feasible point x_0 and the initial value of the penalty term, $r_0 = 10$, are the main parameters. Concerning the Armijo Line Search, several parameters have to be defined. The version of the Armijo Line Search that has been used to solve the Optimal Control problem, differs from the standard Armijo Line Search and it is applicable to any descent direction ϕ_k. This version is proposed and studied in (Polak 1997 and Vrahatis et al. 2000) and can be implemented in two versions depending on the input value of a parameter s. The procedure uses two parameters $\alpha, \beta \in (0, 1)$, defined by the user. Furthermore, the values for the maximum number of Armijo iterations required, $MIT = 500$, the desired accuracy, $\varepsilon = 10^{-3}$, and a parameter $m^* \in \mathbb{Z}$, complete the input parameters set of the algorithm, which is exhibited in pseudocode in Table 1.1.

The selection $s = 0$ is normally used with Newton–like algorithms, with $m^* = 0$ to ensure superlinear convergence. The selection $s = 0$ is not very good for first–order algorithms because, on average, it requires considerably more function evaluations than the selection $s = 1$. So, $s = 1$ is used in first–order algorithms.

If the objective function Φ is bounded from below the subprocedure in Table 1.2 is used to find an m_k satisfying Relations (b) and (c) of Step 5 of the algorithm. This subprocedure uses the last used step length $\lambda_{k-1} = \beta^{m_{k-1}}$ as the starting point for the computation of the next step (Polak 1997).

The validity of the results obtained has been double–checked using a modification of the Particle Swarm Optimization (PSO) method for

Table 1.1. The Interior Penalty Function Method, with Steepest Descent and Armijo Line Search.

Step 1	**Start** with an initial feasible point x_0, i.e. a point that satisfies all the constraints of the objective function $\Phi(x, r_k)$ of Eq. 1, and an initial value of the penalty term, $r_0 > 0$. **Set** a counter $n = 0$.
Step 2	**Set** the values for the Armijo Line Search: MIT ; $\alpha, \beta \in (0,1)$; $s \in \{0,1\}$; $m^* \in \mathbb{Z}$, and ε. **Comment:** Start of the minimization phase.
Step 3	**Set** $k = 0$.
Step 4	**If** $\|\|\nabla\Phi(x_k, r_k)\|\| \leqslant \varepsilon$ go to Step 8; **Else** compute a descent direction ϕ_k.
Step 5	**If** $s = 0$, set $M^* = \{m \in \mathbb{Z} \mid m \geqslant m^*\}$, and compute the stepsize (a) $\lambda_k = \beta^{m_k} = \arg\max_{m \in M^*}\{\beta^m \mid \Phi(x_k + \beta^m \phi_k, r_k) - \Phi(x_k, r_k) \leqslant \leqslant \beta^m \alpha \langle \nabla\Phi(x_k, r_k), \phi_k \rangle\}$; **Else** ($s = 1$) compute the stepsize $\lambda_k = \beta^{m_k}$, where $m_k \in \mathbb{Z}$ is any integer such that (b) $\Phi(x_k + \beta^{m_k}\phi_k, r_k) - \Phi(x_k, r_k) \leqslant \beta^{m_k} \alpha \langle \nabla\Phi(x_k, r_k), \phi_k \rangle$ and (c) $\Phi(x_k + \beta^{m_k - 1}\phi_k, r_k) - \Phi(x_k, r_k) > \beta^{m_k - 1} \alpha \langle \nabla\Phi(x_k, r_k), \phi_k \rangle$.
Step 6	**Set** $x_{k+1} = x_k + \lambda_k \phi_k$.
Step 7	**If** $k < MIT$, replace k by $k + 1$, and go to Step 4; **Else** go to Step 8.
Step 8	**Store** x_k as x^* and go to the next step. **Comment:** End of the minimization phase.
Step 9	Test whether x^* is the optimum solution of the original problem. **If** x^* is found to be optimum, terminate the process. **Else** go to the next step.
Step 10	**Set** $r_{n+1} = c\ r_n$, where $c < 1$.
Step 11	**Set** $n = n + 1$, take the new starting point as $x_0 = x^*$ and go to Step 3.

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

Table 1.2. The Stepsize Subprocedure

1.	**If** $k = 0$, set $m' = m^*$; **Else** set $m' = m_{k-1}$.
2.	**If** $m_k = m'$ satisfies Relations (b) and (c) of Step 5 of the algorithm, stop.
3.	**If** $m_k = m'$ satisfies (b) but not (c), replace m' by $m' - 1$, and go to Step 2.
	If $m_k = m'$ satisfies (c) but not (b), replace m' by $m' + 1$, and go to Step 2.

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 $\Phi(x, r_k)$, 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 Table 1.3.

Table 1.3. The Particle Swarm Optimizer for locating all the Global Minima

Step 1	**Set** a threshold $\varepsilon > 0$ and the number of desired minima, N.
Step 2	**Initialize** randomly the population, velocities and the parameters of PSO. Let $L = \emptyset$ be the set of found minima. **Set** the value of the maximum number of iterations, MIT, and a counter $IT = 0$.
Step 3	**While** (card$(L) \neq N$) and ($IT < MIT$) **Do**
Step 4	**Set** $IT = IT + 1$ and update PSO's inertia weight. **Find** the best particle of the swarm, x_{best}.
Step 6	**If** $\Phi(x_{best}, r) \leqslant \varepsilon$, isolate x_{best} and perform constrained local search around it. Add the solution found by the local search at the set L and add a new, randomly chosen, particle into the swarm. Apply *Deflation* or *Stretching* at the point x_{best} (see formulas below).
Step 7	**End While**
Step 8	**Print** all elements of the set L and other parameters.

According to the "Deflation" technique, a new function $\frac{\Phi(x,r)}{||x-x_{best}||}$ is substituted for the the original objective function $\Phi(x, r)$, where x_{best} is an isolated particle of the swarm. "Stretching" is a recently proposed

technique (Parsopoulos et al. 2001) and it is consisted of a two–stages transformation of the original objective function. Thus, instead of minimising the function $\Phi(x,r)$, another function, $H(x,r)$, which is given by the formulas below, is minimised:

$$G(x,r) = \Phi(x,r) + \frac{\gamma_1}{2}\,\|x - x_{best}\|\,\Big(\text{sign}(\Phi(x,r) - \Phi(x_{best},r)) + 1\Big),$$

$$H(x,r) = G(x,r) + \frac{\gamma_2}{2}\,\frac{\text{sign}\Big(\Phi(x,r) - \Phi(x_{best},r))\Big) + 1}{\tanh\Big(\mu(G(x,r) - G(x_{best},r))\Big)},$$

where $\gamma_1 = 10^4$, $\gamma_2 = 1$, and $\mu = 10^{-10}$.

4. The Model

The constraint structure we use for the optimisation procedure is a small, highly aggregated model of seven equations representing the economies of Greece and Cyprus. The model is based on previous research on the topic (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 in 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 demand for defence expenditure for each of the two allies is represented as follows:

$$GDEFCRS = f(GGDPCS, GNDEFCRS, GBOP, DRDL, RS, TDEFCRS), \quad (2)$$

$$CDEFCRS = f(CGDPCS, CNDEFCRS, CBOP, USDCP, RS, TDEFCRS), \quad (3)$$

where *GDEFCRS* and *CDEFCRS* are the corresponding GDP shares of defence expenditure for the two allies. 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[1]. 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 literature in that 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). *GGDPCS* and *CGDPCS* is the Greek and Cypriot GDP at constant prices respectively, *GNDEFCRS* and *CNDEFCRS* represent the share of non–defence expenditure for the two countries, *GBOP* and *CBOP* represent the Greek and Cypriot balance–of–payments deficits, while *DRDL* and *USDCP* 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 Turkish GDP share of defence expenditure. 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:

$$RS = \exp(x), \tag{4}$$

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:

$$x = \frac{\dot{p}_G - \dot{p}_C}{\dot{p}_T}. \tag{5}$$

On the basis of Eqs. 4 and 5 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 $RS = 2.718$, 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 a bit more than what meets the eye: In fact, the role of the population rates of increase in the RS is not only associated with the increased manpower in the armed forces, a development which finds itself, anyway, in direct conflict with the concept of modern warfare. 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.

The GDP in the two countries is taken to be determined by a behavioural equation given that emphasis has been placed on the developments of the GDP as this is affected by a number of variables which are leading determinants of the demand for defence expenditure. Eqs. 6 and 7 describe growth in the two allied countries in terms of its main ingredients: accumulation of physical capital $GTIS$ and $CTIS$, 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 drachma 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:

$$GGDPCS = f(GNDEFCRS, GTIS, GBOP, DRDL), \tag{6}$$
$$CGDPCS = f(CNDEFCRS, CTIS, GBOP, USDCP), \tag{7}$$

where $GTIS$ and $CTIS$ 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, 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, be it favourable or adverse (Hartley and Sandler 1995)[2].

Since special attention has been awarded to the role of human resources in the arms race between the two sides, we have chosen to devote a behavioural equation to describe population developments in each of the two allies[3]. Thus, the Greek and Cypriot populations are taken to behave as follows:

$$GPOP = f(GGDPCS, GDEFCRS, GNDEFCRS, GCPIDR), \tag{8}$$
$$CPOP = f(CGDPCS, CDEFCRS, CNDEFCRS, CCPICP), \tag{9}$$

where $GCPIDR$ and $CCPICP$ are the Greek and Cypriot consumer price indices.

Eqs. 2 to 9 including the identity describing the relative security measure for the two allies make up the constraint structure under which the optimisation exercise will be undertaken.

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 listed below compose an error–correction model, with all coefficients bearing the expected signs and being significant to a 1% or 5% level while the explanatory power of all six equations is satisfactory. Due to the length of the estimation period a small number of dummy variables

has been used to tackle the effects of important exogenous disturbances, usually of political or social nature, introducing structural changes in the economy. All variables are expressed in terms of first differences and the RES terms indicating the residual item of the corresponding long–run version of each equation:

$$\begin{aligned} GGDPCS = {} & 0.022 + 0.100\ \log(GNDEFCRS(-1)) + 0.235\ \log(GTIS) - \\ & - 0.056\ \log(GBOP(-4)) - 0.062\ \log(DRDL) + \\ & + 0.476\ \log(GGDPCS(-1)) - 0.048\ RES(-1) - \\ & - 0.047\ DGGDP + 0.048\ DDIC, \end{aligned} \tag{10}$$

$$\begin{aligned} GDEFCRS = {} & - 0.029 - 4.872\ \log(GNDEFCRS) + 0.354\ \log(GGDPCS\text{(-2)}) + \\ & + 0.547\ \log(DRDL) - 0.295\ \log(GBOP(-1)) - \\ & - 0.010\ \log(RS(-1)) + 0.112\ \log(TDEFCRS) - \\ & - 0.147\ RES(-1) + 0.086\ DGDEF, \end{aligned} \tag{11}$$

$$\begin{aligned} GPOP = {} & 0.001 + 0.026\ \log(GGDPPC) + 0.012\ \log(GNDEFCRS) - \\ & - 0.0003\ \log(GCPIDR(-2)) - 0.005\ \log(GDEFCRS(-3)) - \\ & - 0.113\ RES(-1) + 0.635\ \log(GPOP(-1)) + 0.006\ DGDEMO, \end{aligned} \tag{12}$$

$$\begin{aligned} CGDPCS = {} & 0.052 + 0.227\ \log(CNDEFCRS) - 0.515\ \log(CBOP) + \\ & + 0.250\ \log(USDCP) - 0.164\ RES(-1) + 0.130\ DCGDP, \end{aligned} \tag{13}$$

$$\begin{aligned} CDEFCRS = {} & 0.024 - 16.595\ \log(CNDEFCRS) + 0.372\ \log(CGDPCS(-3)) - \\ & - 0.455\ \log(USDCP) - 0.367\ \log(CBOP(-1)) - \\ & - 0.014\ \log(RS(-2)) + 0.418\ \log(TDEFCRS) - \\ & - 0.704\ RES(-1) + 0.210\ DCDEF, \end{aligned} \tag{14}$$

$$\begin{aligned} CPOP = {} & - 0.004 + 0.065\ \log(CGDPPC(-2)) + 0.055\ \log(CNDEFCRS(-4)) - \\ & - 0.016\ \log(CCPICP) - 0.382\ RES(-1) + 0.031\ DCINV + \\ & + 0.004\ TIME - 0.118\ DCDEMO, \end{aligned} \tag{15}$$

$$\begin{aligned} RS = {} & \exp\Bigg(\Big[\Big(\log(GPOP) - \log(GPOP(-1))\Big) - \Big(\log(CPOP) - \\ & - \log(CPOP(-1))\Big)\Big] \Big/ \Big[\log(TPOP) - \log(TPOP(-1))\Big]\Bigg). \end{aligned} \tag{16}$$

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 the squared deviations of the

endogenous variables from their respective targets as these are set in the context of a number of scenarios. The policy instruments used are the GDP shares of defence expenditure in the two allied countries, while all targets have been assigned equal weights. Despite the fact 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 assign equal weights to all seven of them aiming at dealing with the optimal control problem in its most generalized version. 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, both economic and political, affecting Greece and Cyprus during the previous three decades.

5. Policy Considerations

The analysis which follows is based on prior work on this issue (Andreou and Zombanakis 2000) which points out that the importance of human resources in the arms race between Greece and Turkey must be acknowledged. This means that there are three possible strategies which may be followed concerning the emphasis placed on resources: Two strategies emphasising on just 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 RS, a very ambitious target indeed! Emphasis on property resources, in its turn 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 1994). 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[4], 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 esca-

late and Turkey reduces), 3 (Turkey escalates and Greece and Cyprus reduce) and 4 (Both sides reduce).

5.1. Arms Race: Both Sides Escalate (Scenario 1)

It seems that for the decade under consideration, the average optimal Greek and Cypriot GDP share of defence expenditure in the context of the arms race between Greece and Turkey stands to about 3.5%. This is a very reasonable figure to a large extent comparable with 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, 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 RS, 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 to 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, aiming at pointing out the resources devoted to defence over and above what the constrained optimisation procedure indicates: These deviations may be regarded, in other words, 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 RS 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.

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

This scenario assumes offensive tactics from the part of the alliance, this driving the relative security factor RS 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 property 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.

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

As it is 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 to 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, this 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 shown very clearly in the context of this scenario, as it has been the case in scenario 2: Indeed, resorting once more to the "reference" strategy which reflects reality clearer than any of the others, since it is relieved of any form of emphasis on either resource category, one can observe that the optimal values suggested for the GDP shares of defence expenditure of both allies, as well as for the relative security factor RS 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 RS by only 23% against 40% to 50% of the remaining strategies tested.

5.4. 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 up 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 it is 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, it is compelled to devote to defence spending shares as high as 6.0% of its GDP. It is finally comforting to observe that, in an environment of mutual disarmament policies from 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 by about 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.

6. Conclusions

The analysis presented thus far leads to the following interesting conclusions:

1 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 scenaria and strategies tested. This excessive spending measures the cost suffered by the alliance members due to the Greek–Turkish arms race and may 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.

2 The optimal values proposed by the algorithm are exclusively determined by the policy followed by Turkey, irrespective of the reaction from the part of Greece and Cyprus, a finding that confirms the leading role of Turkey in this arms race and supports the conclusions of earlier work on this issue.

3 Placing emphasis on property 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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Notes

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

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

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

4. 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.

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