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Modelling the Effects of Defence Spending Reductions on Investment Using Neural Networks in the Case of Greece

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ABSTRACT

The end of the Cold War and of the East-West arms race along with the relaxation of international tensions and conflicts opened up the prospect of substantial reductions in military expenditures with beneficial economic spin-offs through the reallocation of resources that are devoted to defence to other, potentially more productive uses in the economy. The potential gains from reduced defence spending, the so called peace dividend, have recently been increasingly attracting the attention of researchers in this field. This study is an empirical investigation of the potential benefits of reduced military spending in the case of Greece. Greece is chosen as the vehicle of this empirical investigation mainly for two reasons. Firstly, it yearly allocates considerable human and material resources to defence despite serious and persistent economic problems. During the period 1960-1994 the Greek defence burden has invariably been higher than the NATO average. On average it was 5.5% of GDP compared to a NATO average of 3.8%. Secondly, with a per capita national income in 1993 of about \$8670 Greece, in terms of this traditional indicator of development, is placed among the developed nations of the world albeit probably in the lower half of the group being one of the poorest countries in NATO and the European Union. In order to assess the potential effects of defence spending reductions this paper uses neural networks, a field of research that has been rapidly expanding and has found many applications in economic studies. Results reported here indicate that yearly reductions in the defence burden would bring about as much as 5.9% average annual increases in investment as a share of GDP over the period 1995-2000.

1. INTRODUCTION

Following Benoit's (1973, 1978) seminal contribution, the economic effects of military spending have attracted considerable theoretical and empirical work (Grobar and Porter, 1989; Ward et al., 1995). In broad terms, on the basis of the generated empirical data, one may tentatively suggest that no consensus exists on the relationship between defence spending and economic growth. As Chowdhury (1991) and Kusi (1994) point out this relationship cannot be generalised across countries and over time. Defence spending can affect the economy through a number of theoretical channels. It may have Keynesian type aggregate demand stimulation effects and may also have microeconomic effects through changes in technology. On the other hand, as the results of many studies have shown, it may retard growth mainly through investment crowding-out. However, estimates of its impact on growth naturally differ since, among other things, they depend on the estimation method and sample size adopted, the specification of the model and the transmission mechanisms that are allowed for. On balance, empirical evidence indicates that even when positive spin-offs are allowed for, military spending has a growth retarding impact mainly due to investment crowding-out. The momentous changes of recent years, the end of the Cold War and of the East-West arms race along with the relaxation of international tensions and conflicts opened up the prospect of substantial reductions in military expenditures with beneficial economic spin-offs through the reallocation of resources that are devoted to defence to other, potentially more productive uses in the economy (Intrilligator, 1995; Chatterji and Forcey, 1992; Isard and Anderton, 1992; Fontanel, 1994). The potential gains from reduced defence spending, the so called peace dividend, have recently been increasingly attracting the attention of researchers in this field. Fontanel (1994) suggests that reductions in military expenditure have a three stage impact, namely the immediate short-run effects of the change in the structure of the final demand, then a transition process as resources are either transferred to different uses or left idle, and finally the longer term supply side effects of the new allocations of resources on the economy as a whole. However, whereas a number of economic models have been constructed to analyse and quantify the impact of military spending, there are few formal analyses of the economic effects of defence spending reductions. For example, in the case of France it has been reported that progressive disarmament has a weak positive effect on GDP mainly due to a reduction of the inflationary tensions and to appreciable increase in national investment (Fontanel, 1994). A slight improvement in the balance of payments, a limitation of inflationary tensions and additional growth have been reported in the case of the UK as well as a reduction in the GDP and a worsening of the jobs situation (Dunne and Smith, 1984; Barker et al., 1991). In the case of Greece, Balfoussias and Stavrinos (1996) report that the macroeconomic effects of alternative uses of economic resources employed in the military sector are positive but not very large. Among other things, defence spending reductions lead to higher domestic output and improvements in the balance of payments. This study is an investigation of the potential benefits of reduced military spending in the case of Greece, hoping to add further empirical evidence to the relevant peace dividend literature. The effects of defence spending reductions on investment in Greece are estimated using neural networks.

Neural networks is a field of research which has enjoyed a rapid expansion in recent years and has found many applications in economic studies (Kuan and White, 1994; Bierens, 1994; Lewbel, 1994). Neural networks are essentially statistical devices for performing inductive inference. From the statisticians point of view they are analogous to non-parametric, non-linear regression models. The novelty about neural networks lies in their ability to model non-linear processes with few (if any) a priori assumptions about the nature of the data generating process. This is particularly useful in formal modelling of the economic effects of military expenditure where strong linear models have usually been used. In assessing the impact of defence spending reductions on investment in the case of Greece the following three scenarios are used:

A. a 1% yearly reduction in the defence burden
B. a 5% yearly reduction in the defence burden and
C. the defence burden remains unchanged at its mean value of the last five years

The present study is organised into five sections. In the next section the main issues associated with Greek military expenditure and its economic effects are surveyed. In section three neural networks are outlined and explained. In section four the results obtained for each of the three different defence burden reduction scenarios are presented and analysed. Finally section five summarizes and concludes.

2. AN OVERVIEW OF GREEK MILITARY EXPENDITURE

With a per capita national income in 1993 of $8670 Greece, in terms of this traditional indicator of development, is placed among the developed nations of the world albeit probably in the lower half of the group being one of the poorest countries in NATO and the European Union: nevertheless it is by far the richest nation in the Balkan region. Greece yearly allocates considerable human and material resources to defence despite serious and persistent economic problems (Kollias, 1995a). During the period 1960-1994 the Greek defence burden has invariably been higher than the NATO average. On average it was 5.5% of GDP compared to a NATO average of 3.8% (Table 2.1).

TABLE 2.1

Defence spending as a share of GDP in Greece and NATO 1960-1994

Year	Greece	NATO	Year	Greece	NATO
1960	4.9	4.4	1978	6.6	3.6
1962	4.0	4.7	1980	5.7	3.5
1964	3.6	4.4	1982	6.9	3.8
1966	3.7	4.2	1984	7.1	3.5
1968	4.7	4.3	1986	6.1	3.4
1970	4.8	3.9	1988	6.3	3.2
1972	4.6	3.8	1990	5.9	3.1
1974	5.6	3.7	1992	5.5	2.9
1976	6.9	3.7	1994	5.5*	2.5

Source: SIPRI Yearbooks.
* Estimates.

There is strong empirical evidence which indicates that the main cause of Greek military spending are external security considerations (Kollias, 1996, 1995b; Kapopoulos and Lazaretou, 1993). These include disputes with Turkey, another NATO member, as well as until recently the threat that the Warsaw Pact posed to Greek national interests. However, this threat, as Platias (1991) points out, was considered by Greek defence planners and analysts to be of secondary importance and possible only in the context of a wider East-West conflict. The officially declared Defence Doctrine of Greece identifies Turkey as the principal long term threat to Greek security and national interests (Platias, 1991; Kollias, 1996). A number of studies have empirically investigated the hypothesis of a Greek-Turkish arms race. Using causality analysis Majeski and Jones (1981) and Majeski (1985) for the period 1949-1975 report significant and reciprocal interaction between the two countries. On the other hand, econometric results reported by Georgiou (1990) do not support the hypothesis of a Greek-Turkish arms race (but see Kollias, 1994). Stavrinos (1992) reports findings that indicate the presence of one way instantaneous causality from Greek military expenditure to Turkish but not the reverse. Sezer (1991) notes that in the light of the ongoing Greek-Turkish disputes it is not surprising to observe that the mutual weapons build up between the two countries has been an almost permanent feature of their interaction at least since the Turkish invasion of Cyprus in 1974. Similarly, Kollias (1995b) notes that the presence of competing and conflicting interests between states more often than not results in armaments competition and that over the past decades both Greek and Turkish defence spending have to a certain extent been influenced by each other's military capabilities. Kollias (1995a, 1996) reports that empirical findings indicate that over the past three decades such expenditures in Greece have mainly been influenced by external security considerations. Similar findings are also reported by Kapopoulos and Lazaretou (1993). It is not surprising, therefore, to note that, compared to most other members of the western alliance, Greece has in the pursuit of national security invariably allocated more human and material resources to its defence (Tables 2.1 and 2.2).

TABLE 2.2

Military and civilian personnel as % of labour force

	1970	1975	1980	1985	1990	1991	1992	1993	1994*
Greece	6.2	6.5	6.1	6.1	5.8	5.9	5.7	5.8	5.9
Turkey	4.4	3.8	4.8	4.8	3.9	4.1	3.6	3.5	3.7
USA	5.3	3.4	2.8	2.9	2.6	2.5	2.3	2.1	2.0
Britain	2.9	2.5	2.2	1.9	1.7	1.7	1.6	1.5	1.4
Germany	2.3	2.5	2.4	2.3	2.6	1.9	1.8	1.6	1.5
Italy	2.9	2.5	2.3	2.4	2.2	2.2	2.1	2.2	2.1
NATO	3.2	2.5	2.4	2.4	2.2	1.9	1.9	1.8	1.7

Source: NATO
* Estimates

The economic effects of Greece's high defence burden is a subject that has recently been attracting attention. The available studies that have attempted to empirically evaluate and quantify these effects are not numerous and their results are not conclusive (Chletsos and Kollias, 1995; Kollias, 1993, 1994a, 1995c; Antonakis and Karavidas, 1990). Estimates of the economic impact of Greek military spending vary. On the one hand, Kollias (1995c) using the two-step Engle and Granger cointegration methodology for the period 1963-1990 reports a positive effect on GDP with a coefficient for the defence burden variable ranging from +0.071 to +0.108 in the short-run dynamic tests. On the other hand, studies have reported empirical findings which indicate that investment is displaced by such expenditures, and through it, growth is retarded. Antonakis and Karavidas (1990) report results indicating that the negative impact of defence spending on investment has in the period 1950-1985 resulted in an annual average loss in output growth rate of between 0.52% to 0.62%. Chletsos and Kollias (1995) also report an adverse effect on the share of gross fixed capital formation in GDP for the period 1974-1990. However, a positive impact on consumption expenditure is also reported but this seems to be offset once the feedback through investment is allowed for. A negative effect on savings and investment is also reported by Kollias (1994a) and through this displacement effect growth rates appear to have been slowed down. Using neural networks this study models the peace dividend effects on investment expenditure which are forecasted six time periods ahead (i.e.1995-2000) according to each of the three scenarios mentioned earlier.

3. MODELLING THE PEACE DIVIDEND EFFECTS USING NEURAL NETWORKS

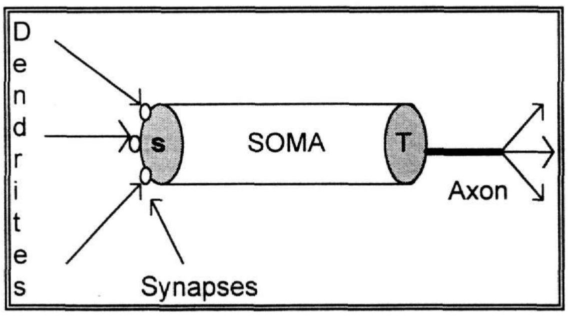
3.1. An Overview of Artificial Neural Networks

Artificial Neural Networks are essentially statistical devices for inductive inference. They have been developed over the past 25 years in an effort to understand and mimic the way in which the human brain performs learning and generalisation tasks. The most elemental device in the human brain is the neuron. The main composites of a neuron are the soma, the dendrites, and axon [see Figure 1(a)]. If we model the functionality of a neuron in terms of the electrical activity in the brain, the dendrites (connecting a neuron to other neurons in the brain) act as couriers of electrical stimuli into the neuron; the soma models the inherent resistance of the neuron; and the axon (connecting a neuron to other neuron in the brain) acts as a courier/modulator of signals out-of-the neuron into other neurons in the brain. Each neuron performs a simple operation: it receives signals (electrical stimuli) from other neurons through the dendrites; these signals are first amplified/de-amplified by the synapse and then summed up (**S**); if the total energy (the sum of all stimuli) exceeds the neuron's resistance (**T**) the neuron produces its own signal which is propagated forward to other neurons through the axon. Figure 1(b) gives a mathematical model of this operation.

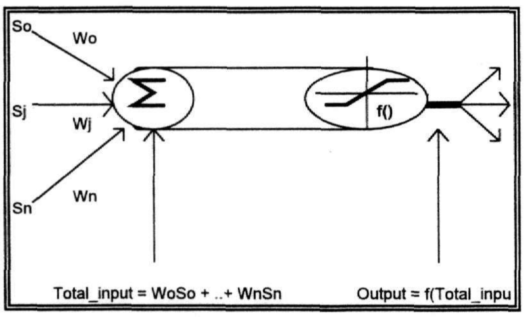
FIGURE 1

Neurons as biological devices and their mathematical abstractions

(a) Neuron as a Biological Abstraction



(b) Mathematical model of Neurons

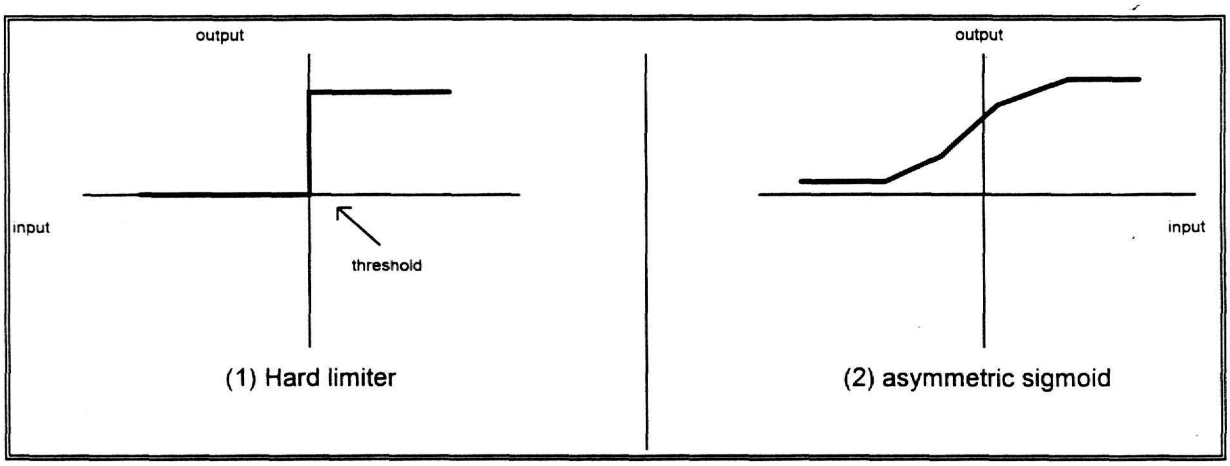


The input signals are represented by S_j, and the amplification/de- amplification process at the synapses is represented by W_j. The total input is therefore the dot product $\sum_n w_i s_i$. Essentially, the output of a neuron is a nonlinear transformation of the weighted sum of its total input. Several non linear transformations are plausible. Figure 2 shows the two most commonly used transforms, further explained in equations (1) and (2). The most commonly used nonlinear transform function is the asymmetric sigmoid as defined in equation (2).

Neural Networks typically consist of many simple neuron-like processing elements that are grouped together in layers (see Figure 3). Each neuron at the input layer represents an independent variable (e.g. A, B, C, D) and the neuron at the output layer represents the dependent variable (e.g. Y). Hidden layers represent intermediate nonlinear transforms.

FIGURE 2

Common nonlinear transfer function: a) hard limiter; b) asymmetric sigmoid asymptotic at (0, 1)



a) Hard Limiter

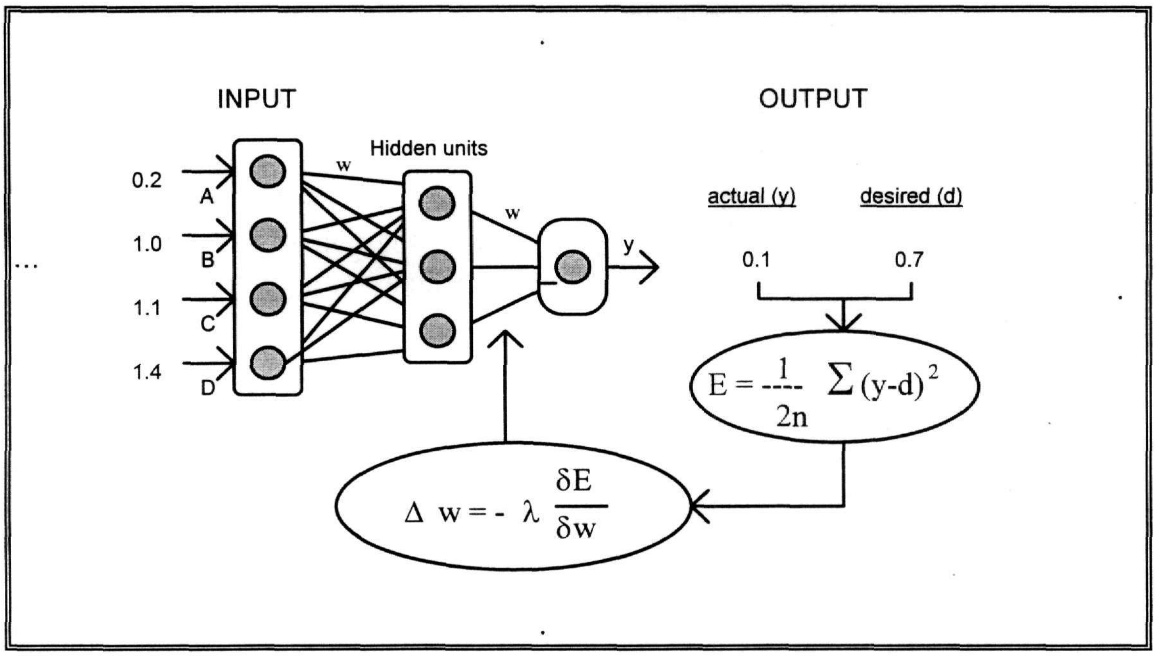
$$output = \begin{cases} 1 \text{ if total\_input} > \text{threshold} \\ 0 \text{ otherwise} \end{cases} \qquad (1)$$

b) Asymmetric Sigmoid

$$output = \frac{1}{1 + e^{-(total\_input)}} \qquad (2)$$

FIGURE 3

Fully interconnected network with one layer of hidden units



Before "training", the weights (w) are initialised with random values. Training the network to produce a desired output d when presented with an input vector i involves systematically changing the weights until the network produces the desired output (within a given tolerance). This is repeated over the entire training set. In doing so, each weight in the network, computes the derivative, with respect to the connection strength, of a global measure of the error in the performance of the network. Each connection strength is then adjusted in the direction that decreases the error. A plausible measure of how poorly the network is performing with its current set of weights is given by E in (3).

$$E = \frac{1}{2n} \sum_{i}^{n} (y_i - d_i)^2 \tag{3}$$

where n is the sample size, y_i is the actual output of the network for observation i, and d_i, is its desired output for the observation. In Figure 3 for example, we have a single observation with values (0.2, 1.0, 1.1, 1.4) for the variables (A, B, C, and D) respectively, the desired output is 0.7 ad the actual output (initially random) is 0.1. Learning is thus, reduced to a minimisation procedure of the error measure given in (3). This is achieved by repeatedly changing the weights by an amount proportional to the derivative $\partial E/\partial W$, denoted by δ_i:

$$\Delta W_{ij}(t+1) = -\lambda \delta_i y_i \tag{4}$$

The learning rate, λ (i.e. the fraction by which the global error is minimised during each pass) is kept constant at least for the duration of a single pass. In the limit, as λ tends to zero and the number of iterations tends to infinity, this learning procedure is guaranteed to find the set of weights that gives the Least Mean Square Error (LMS). The value of $\delta_i = \partial E/\partial W$ is computed by differentiating (3) and (2).

$$\delta_i = (d_i - y_i) f'(y_i) \tag{5}$$

The Least Mean Square Error procedure has a simple *geometric* interpretation: if we construct a multi-dimensional "weight-space" that has an axis for each weight and one extra axis called "height" that corresponds to the error measure. For each combination of weights, the network will have a certain error which can be represented by the height of a point in weight space. These points form a surface called the "error surface". For networks with linear output units and no hidden units, the error surface always forms a bowl whose horizontal cross-sections are ellipses and whose vertical cross-sections are parabolas. Since the bowl has only one minimum (perhaps a complete subspace but nevertheless only one), gradient descent on the error surface is guaranteed to find it. If the output units have a non-linear but monotonic transfer function, the bowl is deformed but still has only one minimum, so gradient descent still works. However, with hidden units, the error surface may contain many local minima, so it is possible that steepest descent in weight space will be trapped in poor local minima. The learning rate can be thought of as a user controlled step-size during the gradient descent. It is common to use an additional term in the gradient descent procedure (the momentum term) which conceptually adjusts the learning rate dynamically so such oscillations between the walls of the bowl are avoided and the learning process may be sped up. There many ways to interpret neural "learning". The above formulation gives a *geometric* interpretation. From the statistician's point of view neural networks are analogous to nonlinear, nonparametric regression. The task of the training procedure is to estimate a function between input (say A, B,..., E) and output variables (y). The function is parameterised by the network weights and the nonlinear transform and takes the form:

$$y = g(A, B, .., E; w_{ij}) \tag{6}$$

Thus learning is analogous to estimating the regression parameters (w_{ij}) using gradient descent rather than, say maximum likelihood. The estimated function, g(), is constructed by composition and nesting of simpler exponential functions (as determined by the asymmetric sigmoid). This represents a major difficulty in explaining the plausibility of the estimated relationship. In Refenes et al. (1994) a formulation of neural networks as nonparametric regression systems is given, which provides simplified and explicit representation of the estimated function.

3.2. Training and Test Sets

The training and test sets consist of data provided in a pre-processed form and presented as factor A and factor B. These factors are the inputs to the network with Y being the target output. The postulated model used here is based on that of Deger and Sen (1990) whereby it is assumed that investment (expressed as a share of GDP) is affected by military expenditure also expressed as a share of GDP. Furthermore, as Deger and Sen (1990) note due to life cycle effects as well as the assumptions of the Metzelerian target saving hypothesis we assume that savings and therefore investment is a function of growth. Thus the hypothesised relationship for investment takes the form I/GDP = *f*(Milex/GDP, GDPgr) and therefore factor A is the share of defence spending in GDP (Milex/GDP) while factor B is the GDP growth rate (GDPgr). Data on the defence burden is derived from SIPRI Yearbooks while the growth rates of GDP are taken from Greek National Accounts (constant prices) and from the forecasts of the Centre of Planning and Economic Research (Balfoussias, 1995). The training set covers the period 1954-1994 while the forecasts of the defence spending reductions on investment shares in GDP cover the years 1995-2000 for each of the three scenarios i.e. Scenario A a 1% yearly reduction in the defence burden, Scenario B a 5% yearly reduction and finally Scenario C where the defence burden remains unchanged at its mean value of the last five years.

The network performance in respect to convergence and generslisation ability can vary dramatically with the network and data related parameters such as network topology, training time, gradient descent terms, initial conditions etc. A series of simulations were performed in order to identify a region of statistical stability of the network performance. All three scenarios were estimated with a neural network containing two layers of hidden units and training time of 5,000 iterations. The standard back propagation algorithm was used.

4. NEURAL NETWORK RESULTS

The forecasted effects of defence spending reductions on investment shares in GDP for each of the three scenarios for the years 1995-2000 are shown in Table 4.1 and in Figures 4 and 5 below. Overall, one may tentatively suggest that the results appear to be fairly consistent and indicate that a reduction in the Greek defence burden will have a positive impact on investment and by extension on growth rates. However, the size of the beneficial effects depends, as one would expect, on the size of the defence cuts.

TABLE 4.1

Forecasted shares of investment in GDP, 1995-2000

	1995	1996	1997	1998	1999	2000
Scenario A	20.51	20.54	20.65	20.75	20.85	20.96
Scenario B	19.85	20.32	21.15	22.35	23.73	24.93
Scenario C	20.43	20.44	20.45	20.47	20.47	20.47

Starting with Scenario C, whereby military expenditure is kept constant at its mean value of the past five years (5.58% of GDP), investment (I/GDP) is forecasted to stay almost unchanged throughout the period of the forecasts (1995-2000). The results suggest that in the context of this scenario only a 0.2% change would be achieved i.e. investment as a share of GDP rises from 20.43% to 20.47% of GDP. In the case of Scenario A with a hypothesised 1% yearly reduction in the defence burden the forecasted effect is a 2.19% increase in I/GDP from 20.51% to 20.96% of GDP. Finally in Scenario B, with a hypothesised 5% yearly reduction in the military burden a total 25.6% increase in investment shares is forecasted i.e. investment would rise from 19.85% to 24.93% of GDP. This result suggests that the total hypothesised reduction in the defence burden would bring about an almost equivalent increase in the shares of investment in GDP with the concomitant beneficial effects on growth rates.

FIGURE 4

Actual (1954-1994) and forecasted (1995-2000)
shares of investment in GDP

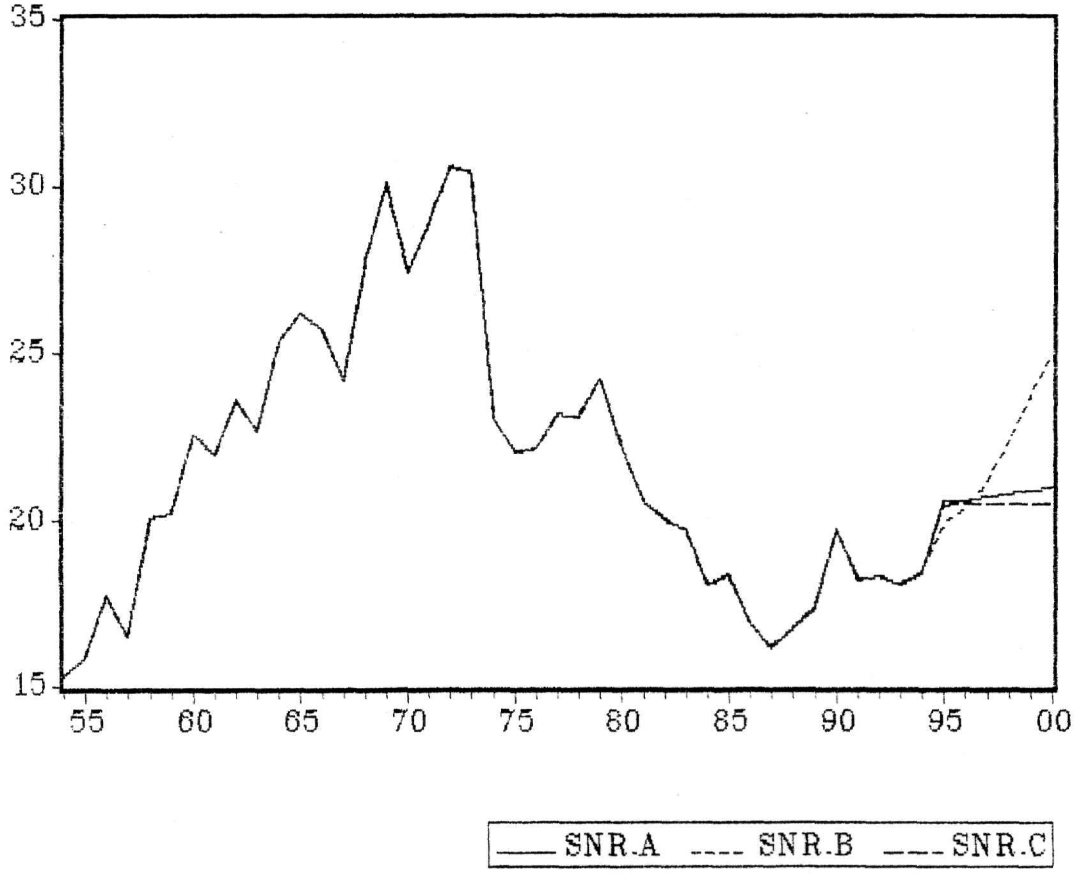
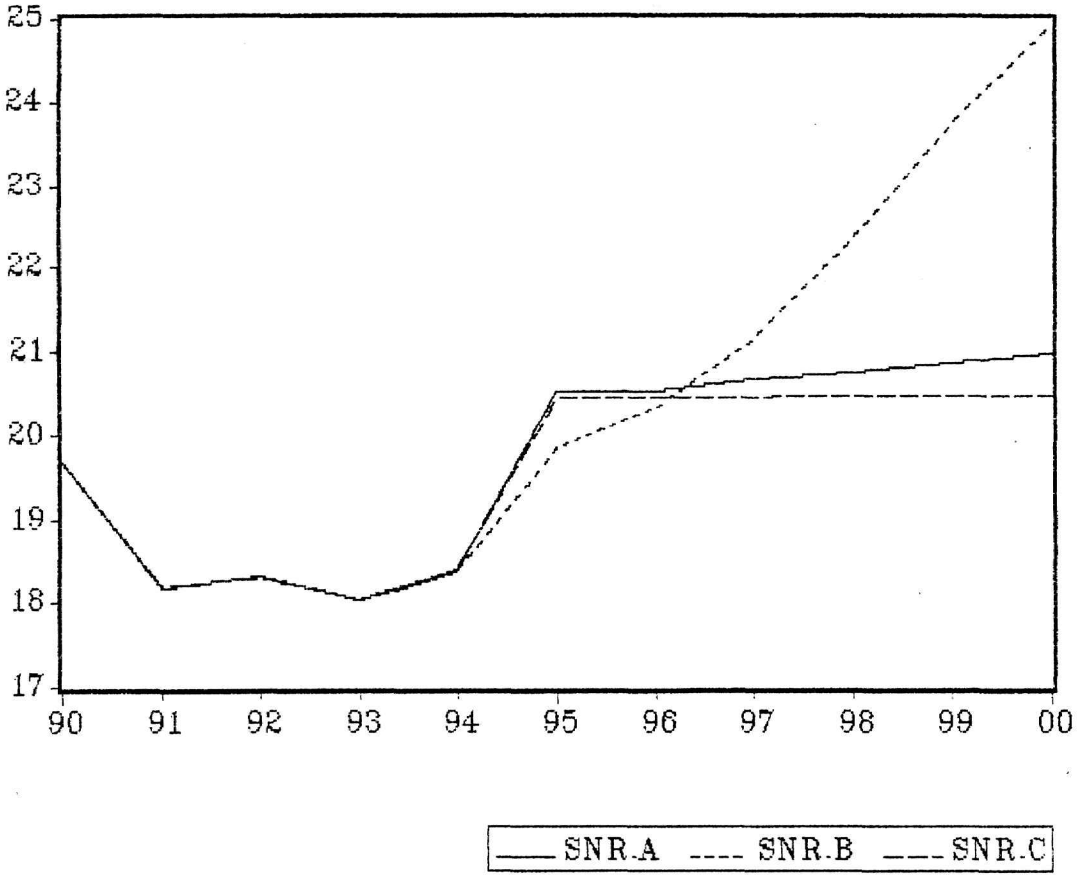


FIGURE 5

Actual (1990-1994) and forecasted (1995-2000) shares of investment in GDP



5. CONCLUSIONS

This study investigated the potential effects of reductions in the Greek defence burden i.e. the share of military expenditure in GDP. Using neural networks it examined the effects of three alternative scenarios on investment shares in GDP. Scenario A hypothesised a 1% yearly reduction in the defence burden, scenario B a 5% yearly reduction in the defence burden and scenario C assumed that the defence burden remains unchanged at its mean value of the last five years. The obtained forecasts for the period 1995-2000 suggest that small yearly reductions in defence allocations would bring about appreciable changes in investment expenditure as a share of GDP with the concomitant beneficial effects on output. However, Greek military expenditure appears to be almost exclusively determined by external security considerations and in particular by the strategic entropy of the Balkan region and principally by the tense relations with its neighbour Turkey (Larrabee, 1992; Kollias, 1995a, 1995b, 1996; Kapopoulos and Lazaretou, 1993). Given therefore, the strategic instability of the area and the dim prospects of a substantial breakthrough in Greek-Turkish bilateral relations, Greece will probably continue to allocate valuable human and material resources to defence despite the high opportunity costs involved. This reduces the possibility of appreciable beneficial effects from defence spending reductions.

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