Fuzzy cognitive maps face the question of the Greek current account deficit sustainability

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FUZZY COGNITIVE MAPS FACE THE QUESTION OF THE GREEK CURRENT ACCOUNT DEFICIT SUSTAINABILITY

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Abstract – *This paper offers an alternative approach to policy modeling aiming at considering the question of the Greek current account deficit sustainability using Fuzzy Cognitive Maps (FCM). Given that the large Greek current account deficit figures reported during the past few years have become the source of increasing concern regarding its sustainability and bearing in mind the wide variety of views on this issue, we have chosen to resort to an entirely different technique compared to traditional policy modeling. The paper concludes that despite its size, the current account deficit of Greece can be considered sustainable. This conclusion, however, must not be taken as neglecting the structural weaknesses that lead to such a deficit. In fact, even in the absence of any financing requirements these high deficit figures point to serious competitiveness losses with everything that these may entail for the future performance of the Greek economy.*

Keywords*: Tem Soft Computing, Fuzzy Cognitive Maps, Current Account Deficit Sustainability*

I. Introduction

The question of the Greek current account deficit sustainability has trigged considerable debate during the past few years while revealing a number of serious weaknesses of the Greek economy. We have thought, therefore, that the reader may find it useful to devote some time to sharing and considering the points raised in this paper concerning this controversial issue.

Let us start, therefore, by reminding that the Eurozone membership of Greece may have sacrificed a major policy tool, namely the exchange rate, it has however, relieved the economy of any deficit - financing requirements concerning its external accounts. The fact remains, however, that the substantial increase of the current account and the budget deficits of Greece during the past few years has become a source of major concern at both national and international levels as it rings a warning bell regarding the deteriorating competitiveness of the Greek economy which, in its turn, points to the need for serious structural reforms.

The extent to which the government has already embarked in such reform – making procedures and the effectiveness of the measures taken is an open issue outside the scope of the present paper, the purpose of which is to focus on a question concerning the specific period, until these measures may have become successful, namely the extent to which the sizable current account deficits of the past few years can be considered sustainable.

Given this wide variety of opinions concerning the extent to which this deficit can indeed be considered sustainable and the large selection of methods employed, we have decided to resort to using data - driven reasoning instead of model – based analysis. As explained later on in this paper, what we have done is base our analysis on Fuzzy Cognitive Maps and Genetic Algorithms aiming at relieving our analysis from the constraints imposed by the philosophy and the structure of the econometric model selected.

The paper starts with an outline of the FCM methodology as part of the technical background, followed by a description of the problem and a brief literature review. The final section of the paper will cover the empirical results followed by the conclusions derived.

II. FCMs: A Brief Review

Fuzzy Cognitive Maps introduced by Kosko as an extension to Cognitive Maps in 1986 [1] offer a technique that adapts human knowledge by combining fuzzy logic and neural networks. There has been a large and active improvement in research efforts during the past twenty years, aiming at linking together fuzzy logic and neural networks to lead to FCM models [2]. This combination has been considered essential because the two approaches view the design of “intelligent’’ systems each from a different angle, one supplementing the other [3]. In this sense, the advantages of neural networks in providing algorithms for learning, classification, and optimization are combined with fuzzy logic which deals with high level reasoning issues and uncertainty in a linguistic form thus creating an entirely new type of system [4].

The basic principle and elements of a CM are simple: The concepts used by an individual decision-maker are represented as nodes, and the causal relationships between these concepts are represented as directed arrows [5]. Each arrow is characterized by a weight, a real value that indicates the effect of the causal relationship between nodes. This representation makes up a figure of nodes and arrows called “Cognitive Map” in which the various concepts are considered as variables of the system. The advantage of this scheme is that it offers a global view of the different links between causal relationships and concepts in the model. The map offers three different types of causal relationships between two nodes p and q (p→q) indicating all possible causality directions as follows:

Positive (+) causality, in cases in which p promotes q meaning that an increase in the cause variable will bring about an increase in the effect variable, while a decrease in the cause concept will result to a decrease in the effect concept.

Negative (-) causality, in cases in which p prevents, or is harmful to q, in which case an increase in the cause variable will result to a decrease of the effect variable and vice-versa.

No effect (0), when p has no effect on, or does not matter for q.

Kosko proposed the Fuzzy Cognitive Map model as a technique to overcome the problems faced when representing knowledge as a search tree [6]. Thus, a FCM can be viewed as a dynamic system represented by an acyclic graph while its equilibrium behaviour can be used as an inference mechanism [7]. The advantage of this qualitative dynamic model when compared with other quantitative models is its simplicity in both model representation and execution [8]. It is interesting to point out, that the main advantage of a FCM model compared to the traditional econometric (quantitative models) is that they are not as demanding as the latter in their form of construction and development. The most significant contribution of FCM models concerns the representation of the relationships involved in a fuzzified form. This means that their description includes numerical values instead of just signs, permitting the application of varying degrees of causal inferences. In addition, when compared with cognitive maps, each directed edge of FCMs is associated with a number that expresses relationship. As a result, the FCM theory has been improved to such a degree, so that it can allow the structure of an Intelligent Decision Support System [9] using FCM as an inference machine.

II.1. Basic Principles of FCMs

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. This value is usually normalized to the interval [–1, 1]. The value of -1 represents a full negative causality and creates inhibiting effects, while +1 represents full positive causality creating a promoting effect. Zero value denotes a neutral causal effect. Other values correspond to different intermediate levels of causal effect. 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, indicated 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 principle of how simple FCMs works is explained via an example, consisting of two connected concepts as depicted in Figure 1.

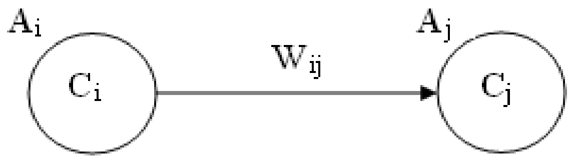

Fig. 1. Connection between nodes

The directed edge Wij from concept Ci to concept Cj indicates how much Ci causes Cj. The edges Wij take va1ues in the fuzzy causa1 interva1 [-1, 1]. Wij=0 shows no causa1ity Wij > 0 indicates causal increase: Cj increases as Ci increases, and Cj decreases as Ci decreases. Wij < 0 indicates causa1 decrease or negative causa1ity: Cj decreases as Ci increases, and Cj increases as Ci decreases.

The calculation of AL of each node indicates the degree to which the concept is active in a model. This value is a floating-point number from -1 to +1, explicitly defined by equation 1.

$$A_i^{(t)} = f\left[\sum_{\substack{j=1 \\ j\neq i}}^{n} A_j^t W_{ij}\right] \qquad (1)$$

where: $A^{(t)}_i$ the activation level of concept Ci at iteration t, Wij the strength of relation from concept Ci to concept Cj and f the transformation function.

The main purpose of the transformation function f is to reduce the weighted sum to a certain value range i.e. from -1 (negatively inactive) to +1 (Positive active).

An FCM works in discrete steps and the activation level of each of the system nodes as well as the weighted arrows are set to specific values based on expert assessment.

Thereafter, the system is free to interact and this interaction continues until the model:

Reaches equilibrium at a fixed point, with the activation levels, being decimals in the interval [-1, 1], stabilizing at fixed numerical values.

Exhibits a limit - cycle behaviour, with the activation levels falling in a loop of numerical values under a specific time-period.

Exhibits a chaotic behaviour, with the activation level reaching a variety of numerical values in a non-deterministic, random way.

Since the system follows an iteration process, the calculation of the new activation level takes into consideration the previous value of the AL. For a given concept, the AL can be calculated taking into account the activation levels of all the concepts that have exerted influence on it at the previous iteration and Equation 1.is transformed as follows:

$$A_i^{new} = f\left[\sum_{\substack{j=1 \\ j\neq i}}^{n} A_j^{new} W_{ij}\right] + A_i^{old} \qquad (2)$$

A^{new} is the ew activation level of concept Ci at time t+1, A^{old} is the activation level of concept Cj at time t.

The graph representation of a FCM can be described also by a square matrix. This matrix contains the weight values of connections between corresponding concepts. Thus we can write the FCM function of equation 3.5 in an even simpler way by writing the status of all concepts as a row-vector S, with notation $\{C_1, C_2, \ldots, Cn\}$ for n concepts, and the weights of the edges in a n × n matrix W, where each element Aij gives the weight of the edge from concept Ci to Cj . If there is no causal link between two concepts, the value of that link Aij is zero. The general form of a weight matrix is the following:

$$W = \begin{pmatrix} W_{11} & W_{12} \\ W_{21} & W_{22} \end{pmatrix} \qquad (3)$$

where, W_{12} is the weight of the causal relationship between C_1 and C_2.

II.2. Intelligent Decision Support Systems (CI-DSS) using Genetic Algorithms.

Decision-makers and policy proponents face serious difficulties when they have to design dynamic systems because such a task requires special knowledge outside their domain of interest. In addition, formulating an econometric (mathematical model) may be difficult, costly and even impossible for some of them, while numerical data may be hard to transform in a linguistic form which could facilitate the understanding of a system [10]. The present paper moves along this direction aiming at building such a system that will both be easier to use and modify in the framework of a changing environment [11]. A final advantage to point out concerns the interpretation of the results which are thus self explanatory without the need to transform mathematical values into natural language.

II.3. Hybrid model - Introduction to evolutionary strategy

The objective of the Genetically Evolved Fuzzy Cognitive Map (GE-FCM), is to overcome the main weakness of FCMs, which involves the recalculation of the weights corresponding to each concept every time a new strategy is adopted [12]. This approach solves the problem by combining FCMs with Genetic Algorithms (GAs) thus creating a much more suitable hybrid model, bearing in mind the complication of real world environment In this context, the FCM part of the algorithm computes the final activation levels given the weights and relationships between concepts, 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. The GA concepts are very appealing since they offer the optimal solution without a problem-solving strategy, once the requirements are defined [13]. It is interesting to point out that the hybrid approach is reflected in both the implementation of the GA and in the methodology applied for solving the problem. In fact, the reasoning behind this hybrid methodology is to use it for obtaining the optimal values of the weights corresponding to the variables of the model rather than the optimal values of the variables themselves.

More specifically, the GA evolves a population of individuals each of which is encoded as a weight matrix structure describing the degree of causal relationships between the participating concepts [14]. The initial generation contains weight matrices with random values. The evolution of the individuals is performed with the help of the FCM model, which computes the final activation levels of the concepts. The activation level of a certain concept in focus denoted by ALd,i is used to calculate the fitness of each individual-weight matrix Wi according to the following equation:

$$Fitness(W_i) = 1 / (1 - abs(AL_{di} - mean_{50}(AL_{ai}))) \qquad (4)$$

where AL_{di} is the target (desired) value of the activation level for the concept in focus Ci and $mean50(AL_{ai})$ is the mean value of the last fifty actual activation levels of concept Ci as these are computed by the FCM. It is clear from equation 4 that the closer to the target value this mean is, the more appropriate the weight matrix is. In fact, the fitness function uses the average values of the last fifty activation levels to account for limit-cycles, that is, a state in which the ALd,i exhibit periodic fluctuations and do not stabilize at equilibrium values as previously described. Thus, if the activation level of the concept in focus reaches equilibrium then the corresponding weight matrix in this case can be considered to be more appropriate compared to another individual-matrix that has resulted to limit cycle [15].

II.4. Fuzzy Knowledge Base - Linguistic Fuzzy Sets Encoding

Given that fuzzy knowledge-based systems [16], simulate human thinking we have found it useful to integrate a fuzzy knowledge base to GE-FCMs, aiming at capturing the aspects of human intelligence that are associated with the complexity of a real-world problem. The main focus in this case is to deal with this complexity by providing a simple methodology for constructing a GE-FCM hybrid system that bases its processing on a Fuzzy Knowledge Base, especially constructed for this particular case. This approach enables the incorporation of both symbolic and connectionist knowledge in one system and provides the means by which linguistic variables are encoded in numerical values for carrying out mathematical computations with the result transformed back to descriptive values for inference purposes.

The number of linguistic variables depends both on the complexity of the real-world problem described by the model as well as the accuracy required. Thus, the general structure of the fuzzification of a typical crisp variable describing the activation levels of a FCM is depicted in Figure 2.

The first interval begins at -1 and the last ends at +1. Each of the intervals is given a name, corresponding to a certain linguistic variable, and is subsequently stored in a fuzzy knowledge base in order to be used during the defuzzification process. The fuzzy set encoding is a key step in our methodology because it is used to build up the most important element of the GE-FCM based Decision Support System, namely the Fuzzy Knowledge Base (FKB).

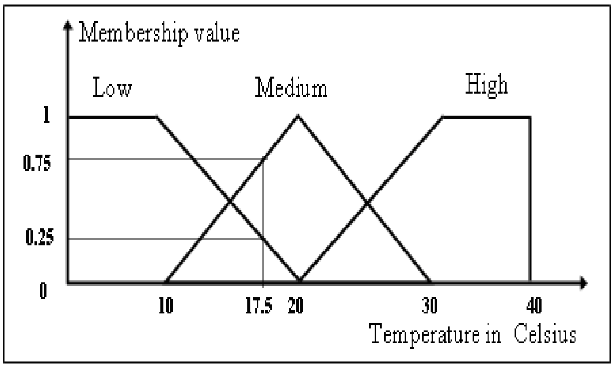

Fig. 2. Membership Function of Linguistic Variable Temperature

The integration of a Fuzzy Knowledge Base (FKB) to GE-FCMs as described in this section encodes the policy-makers's assessment concerning a given real-world problem and records it in a graphical representation language [18]. More specifically, the linguistic sample is encoded directly in a numerical matrix using an uncertainty fuzzy distribution and is subsequently reduced to a scalar form [12]. This linguistic matrix reflects the quantization levels of the input and output spaces, and the number of fuzzy set values assumed by the fuzzy variables [19].

In Fuzzy Cognitive Maps the term set consists of specific linguistic variables describing the activation level of the concepts participating in the model. These variables are associated with values within the range [–1, +1]. The number of linguistic variables depends on the complexity of the real-world problem described by the model and the desired model accuracy.

The process of designing a GE-FCM model and integrating a FKB system is the following:

Stage 1. Identification
Verbal identification and description of the problem. Definition and determination of the problem parameters that determine its target. These parameters will be treated in the next stage as the concepts participating in the model under construction.

Stage 2. Conceptualization
Selection of the parameters identified above as the candidate concepts of a FCM. For each concept the following must be defined:

- A descriptive name
- The causal relationships between this concept (source) and the rest of the concepts (destinations)
- The sign and weight value of each relationship

Stage 3. Formalization
Graphical representation of the FCM containing the concepts identified and their causal relationships. Implementation of the updating mechanism that calculates the new activation levels of the concepts for every iteration of the model.

Stage 4. Integration
Implementation of each concept as a linguistic variable.
For each linguistic variable the analyst needs to define the following:

- The term set of the activation levels of the concept
- The range of numerical values for each member of the term set of the concept
- The membership function of each member of the term set. This will normally orient the overlapping areas.

Stage 5. Experimentation
Determination of the initial levels of activation for each concept on the FCM. Calculation of the final activation levels (baseline) by running the model for a certain number of iterations and evaluation of the results. In case of a stable equilibrium then execution of next stage.

Stage 6. Realization-Inference
Baseline activation levels analysis and interpretation of the results according to the Fuzzy Knowledge Base and the membership functions (i.e. the overlapping areas).

Once the system has been tested for reliability by evaluating the baseline results, the policy maker can try a number of scenaria with target values set for each activation level and use the GE-FCM to drive the activation of the concept in focus to the desired level.

If the target is attained then the analyst uses the Fuzzy Knowledge Base to determine the context in which the target activation level is realized (i.e. the activation of the remaining concepts evolved by the GA that contribute to attaining the target).

Stages 1, 2 and 4 described above must be carried out with the aid of a group of experts who can determine the variables affecting the policy – makers' target and describe the magnitude of each concept in the FCM using a linguistic fuzzy classification. Every expert proposes a fuzzy interval for each concept together with its related linguistic explanation, thus identifying the important concepts or variables influencing the strategic target, as well as the various causal links between them.

III. A Glance at the Greek Current Account Deficit Issue

There are sources in the literature [20] which suggest that a generally accepted figure determining the current account deficit sustainability threshold is about 5% of GDP. To the extent that this figure can be considered as applicable to the Greek case, the year 1999 must be taken to be a benchmark with the deficit exceeding 6% of the GDP. Since then this figure followed a sustained upward trend climbing to a worrying 14.5% for the year 2008. A brief look at the recent developments concerning the various current account items point, at least to a large extent, to structural weaknesses given that the bulk of the deficit is caused by the trade balance items. The position of the Bank of Greece on the issue suggests that, to their largest extent, the sustained increases of the current account deficit underline the competitiveness weaknesses of the economy, with the rising Euro only adding to the problem [21,22]. In fact, the high current account deficits of the recent past reflect the excess of investment demand over national savings, with the gap between savings and investment showing a spectacular rise. More specifically, total investment spending has risen from an average of 21.5% of the GDP during the period 1995-2001 to 24.0% of the GDP during the period 2002-2008 while total savings has declined from an average of 17.2% of the GDP between 1995 and 2001to 10.8% of the GDP during the period 2002-2008[1] [23]. 1. The decline of savings, in its turn, reflects a corresponding rise of the private consumption pattern which has developed to include a large number of importables due to its mismatch compared with domestic production and which has been fostered by the high rates of credit expansion[2].

Reports of the Central Bank of Greece 2008 I [24], in addition, point to a second source of excessive deficit, namely a variety of exogenous disturbances. Such influences are payments for vessel construction abroad to face the increased transportation requirements of markets like China and India, as well as the dramatic increases of the international crude oil prices during the recent past, given the low price elasticity of demand and the heavy energy dependence of the country's economy in an environment of high growth rates.

Such an environment, therefore, can do very little to ease the chronic problems of the country's trade balance, with the situation being aggravated by the ever-increasing interest payments that reflect the country's external borrowing requirements due to these specific weaknesses. The services surplus which is sensitive to exogenous disturbances and the EU transfers for the period 2007 – 2013 can not be regarded as reliable long run solutions to such a vicious cycle which comes as a result of high deficits followed by external borrowing and leading to high interest payments and subsequently even higher deficits. This is why the policy makers have no alternative but focus on a number of important structural weaknesses among which several forms of labour- as well as product-market imperfection and bureaucratic malfunctions occupy leading positions. In fact, with FDI inflows discouraged by such weaknesses the authorities need to finance the deficit by attracting portfolio investment which increases interest payments and thus contributes to a further widening of the current account deficit.

It is only natural, therefore, that this pessimistic framework raises serious concerns regarding the sustainability of the current account deficit of Greece, which will be the issue of the analysis that follows.

IV. Literature Background

The bulk of the literature on the topic has been written prior to the current international crisis and the majority of the sources refer to the issue with regard to the question of financing the US current account deficit, a procedure that had recently come to rely, almost exclusively, on sovereign funds, among which the Chinese ones occupied a leading position. Such sources

[1] The disequilibrium brought about as a result of the excess of investment demand over national savings is reflected in the increase of private consumption expenditure following a considerable consumer credit expansion. The substantial rates of growth during the past few years have added to the difficulty of the problem causing a sustained rise of a trade deficit in which the import bill is a multiple of the export receipts. The high income - and the low price - elasticity of imports according to estimates made by the Research Department of the Bank of Greece, together with the lack of import substitution in the Greek economy are only making matters worse.

[2] Bank of Greece [23].

include Mann [25] pointing to the fact that the United States spend more than it earns only to support global growth thus creating a huge trade and current account deficit the sources of which are to be traced in the early nineties [26]. In a number of rather rare cases, such alarming bells came to be confronted with reassuring voices like, e. g. [27] who feel that the dollar depreciation used as a short sighted deficit – restricting device will be of more concern to foreign authorities who will be compelled to support the U.S. currency by buying dollars in order to prevent further depreciation of the US currency. It is interesting to note, however, that in this case the author fails to take into account the adverse repercussions of the dollar depreciation on international crude oil prices. More recent contributions involve Bergsten and Williamson [28] Obstfeld and Rogoff [29], Edwards [30] and CRS [31], with the first one dealing with topics like the determination of the sustainability level of the US current account deficit. The extent to which such a "sustainability threshold" can be determined presupposes defining a sustainable current account deficit as one that "changes in an orderly fashion through market forces without causing jarring movements in other economic variables, such as the exchange rate" [26]. This means that such a deficit level is not expected to disturb capital flows and the net international investment position of the economy in a way that will result to substantial adverse repercussions on macroeconomic magnitudes like the domestic currency exchange rate, the interest rates, consumption or investment.

It is interesting to point out, however, that articles referring to the sustainability problem in general appear even during the decade of the eighties for a number of country cases [32], most of them underlining the role of the gap between savings and investment opportunities, while others Milesi and Razin, [33] or Roubini and Wachtel [34], focus on a number of country studies or on the case of transition economies respectively. Baharumshah et al. [35] consider the current account sustainability question and the constraint which it imposes to a number of East Asia countries while the case of the UK economy and its Eurozone membership prospects are treated by Church [36] who seems to be concerned by the unavoidable neutralisation of the exchange-rate policy instrument and the extent to which external balance problems may be treated in such a case. Finally, the contribution of Bussière et al. [37] is very interesting as they focus on deriving structural current account positions, i.e. position which can be considered as "normal" from a long run perspective when cyclical effects have died out.

Despite the chronic balance of payments problems facing the Greek economy, the issue of its current account deficit sustainability has been brought forward only during the past several years with a rather small number of papers. Those by Pantazides [38] and Apergis et al. [39] agree that the pressure exercised on the various macroeconomic variables by the current account deficit on a continuous basis is not enough to cause serious disturbances on the basic macroeconomic variables of the country's economy and that the deficit is therefore sustainable. Since then, however, a number of important developments have taken place affecting the structure and statistics of the external transactions of Greece: To begin with, Greece has become a member of the Eurozone since 2001, something which has deprived the authorities from the exchange rate policy instrument while relieving them from answering the question on how to finance external imbalances. In addition, during the last few years, the current account deficit has increased dramatically, both in absolute terms as well as a GDP fraction, something which makes the question of its sustainability even more difficult to answer. Finally, there have been radical changes concerning the external sector data compilation, like the exclusion of the capital EU transfers from the current account while interest payments are now recorded on an accrual rather than on a cash basis. All these developments have taken place after 2001 and have contributed to raising further doubts on this issue. Thus it is no wonder why in the light of these developments Anastasatos [40] does not seem to share the optimism of the two sources mentioned above, pointing to the fact that the current account deficit reflects a competitiveness problem which erodes economic growth and increases foreign debt in a rather lackadaisical political and social environment that relies heavily on the country's Eurozone membership[2].

The disagreement as to the extent to which the current account deficit of Greece can be regarded as sustainable, as well as the determination of a widely acceptable sustainability level are due to a large extent to the variety of techniques used to approach the issue. Pantazides and Apergis et al. [38] use the reasoning suggested by Husted [41] who focuses on the international debt stock, hence the accumulation of the annual external transactions deficits, "to decide whether the budget constraint is expected to be intertemporally balanced". Anastasatos [40], on the other hand points to the inadequacy of the Balassa – Samuelson hypothesis to explain the Greek case to a large extent, suggesting the use of dynamic general equilibrium models in the context of Blanchard and Giavazzi [17].

[2] The IMF [42] tends to agree more or less with Anastasatos [40], using, however, a variety of methodologies on the subject.

Finally, the IMF (2007) paper [42] quantifies the competitiveness deficit by using no less than three methodologies, namely the Macroeconomic Balance, the Equilibrium Real Exchange Rate and the External Sustainability Approach. Additional room for disagreement is offered by the extent to which competitiveness is defined as just price and cost one, or, instead as including non – price components like technology, quality, brand name and market knowledge.

Given this wide variety of opinions and methods we have decided to resort to using data - driven reasoning instead of model – based analysis What we have done, in fact, is base our analysis on Fuzzy Cognitive Maps and Genetic Algorithms aiming at relieving our analysis from the constraints imposed by the philosophy and the structure of the model select

V. The Model

The model used consists of ten concepts with the central one representing the current account deficit. The leading endogenous variables are exports and imports of goods and services, the algebraic sum of which equals the main concept. The basic determinants of export receipts are foreign demand and competitiveness indices, which, in their turn are affected by the euro dollar exchange rate. Concerning import payments national income is the main determinant while crude oil prices and freight rates seem to play a vital role as well, the latter by affecting the demand for ships imports. Finally, the external debt is taken to act as a constraint to the import bill. Figure 3 shows the interaction of these variables between one another with Table I indicating the variable – concept names and initial activation levels.

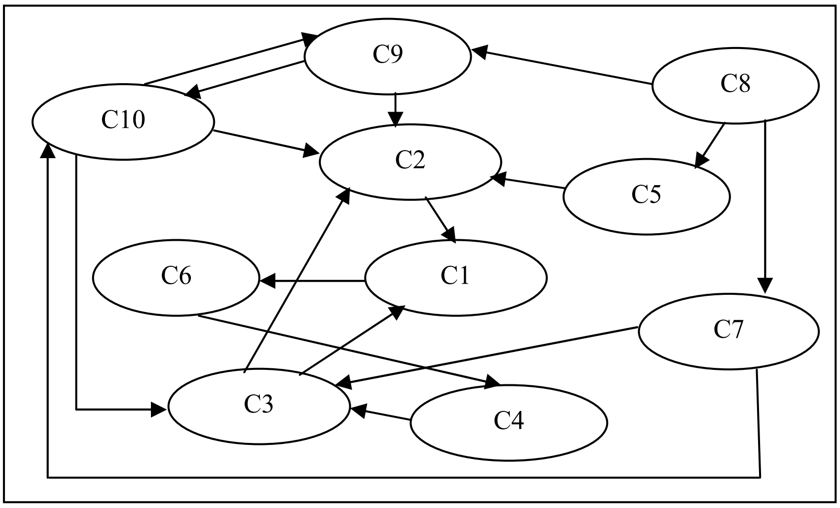

FIG. 3. The Model Structure

TABLE I
CONCEPT DESCRIPTION – INITIAL ACTIVATION LEVELS

CONCEPT	DESCRIPTION	INITIAL A / L
C1	CURRENT ACCOUNT DEFICIT	-0.8
C2	EXPORTS GOODS & SERVICES	+0.6
C3	IMPORTS GOODS & SERVICES	-0.7
C4	GROSS DOMESTIC PRODUCT	-0.2
C5	COMPETITIVENESS – RELATIVE PRICES	-0.2
C6	EXTERNAL DEBT	-0.4
C7	INTERNATIONAL CRUDE OIL PRICES	+0.8
C8	DOLLAR EURO EXCHANGE RATE	-0.4
C9	FOREIGN DEMAND	-0.3
C10	FREIGHT RATES	-0.3

VI. EMPIRICAL INVESTIGATIONS AND RESULTS

VI.1. The Baseline Scenario

This baseline scenario aims at investigating the extent to which the structure of the model reflects the actual domestic and international economic environment as it stood immediately before the crisis. This requires feeding the initial activation levels and weights as shown in Tables I and II to derive the final activation levels as follows:

A comparison between initial and terminal activation levels as these are shown in Tables I and II shows that the model simulates both the Greek and the global before – crisis economic environment rather successfully. Indeed, it is shown that the current account deficit, despite an initial declining tendency, can not be lower than 11% of the GDP, with exports and imports amounting to about 25% and 35% of GDP respectively, figures that comprise both goods and services. The economy is growing at rather substantial annual rates, while the external debt is close to 130% of the GDP. Finally, the international environment dictates continuing competitiveness deterioration, oil prices about 50$ per barrel, a low dollar with respect to the euro and a slowing down of foreign demand and freight rates for both BDI and BDIY indices. The dynamic simulation performed rather well with the exception of the foreign demand and freight rates which yield slightly higher terminal activation levels compared to the corresponding initial ones. This, however, is to be expected, given that these two variables are exogenously determined in the model and consequently their interaction with the rest of the concepts during simulations is expected to be rather limited.

TABLE II
WEIGHTS INTERACTION – INITIAL WEIGHTS AND FINAL A/L

CONCEPT INTERACTION	WEIGHTS	FINAL A / L
C1 → C6	0.9	- 0.9
C2 → C1	- 0.5	+ 0.8
C3 → C1	0.5	- 0.7
C3 → C2	- 0.3	- 0.7
C4 → C3	- 0.7	-0.1
C5 → C2	- 0.5	- 0.6
C6 → C4	- 0.5	- 0.7
C7 → C3	0.5	+ 0.7
C7 → C10	- 0.3	+ 0.7
C8 → C5	0.5	- 0.4
C8 → C7	- 0.7	- 0.4
C8 → C9	- 0.2	- 0.4
C9 → C2	0.5	-0.1
C9 → C10	0.9	-0.1
C10 → C2	0.7	+ 0.1
C10 → C3	- 0.5	+ 0.1
C10 → C9	- 0.7	+ 0.1

VI.2. Policy Simulations

The policy simulations are performed using hybrid model based genetic optimization algorithms as described in section II.2. A hybrid model of this type is able to trace the degree of the causal relationships between the various concepts so that it can “force” them to be activated to a certain level. Such hybrid models are expected to contribute to the effectiveness of decision-making by defining, for each possible concept selected, the activation level achieved with a certain set of weights evolved by the GA. The resulting simulations 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 able to proceed to tactical movements in his decision-making exercise by varying the degree of such relationships in line with the final activation levels the model has suggested.

VI.3. Scenario 1 : Recovering from the Crisis

TABLE III
WEIGHTS INTERACTION – SCENARIO 1: RECOVERING FROM THE CRISIS

CONCEPT INTERACTION	WEIGHTS	FINAL A / L
C1 → C6	0.05	+0.7
C2 → C1	0.96	+0.7
C3 → C1	0.64	+0.6
C3 → C2	- 0.73	+0.6
C4 → C3	- 0.51	+0.2
C5 → C2	0.02	+0.5
C6 → C4	0.19	+0.2
C7 → C3	0.42	- 0.6
C7 → C10	- 0.75	- 0.6
C8 → C5	- 0.34	- 0.4
C8 → C7	0.50	- 0.4
C8 → C9	- 0.46	- 0.4
C9 → C2	0.92	+0.1
C9 → C10	0.71	+0.1
C10 → C2	- 0.25	+0.8
C10 → C3	0.07	+0.8
C10 → C9	- 0.21	+0.8

The recovery of the international environment from the effects of the global crisis is introduced in the model by setting a number of exogenous variables to activation level values that reflect a revival of international economic activity. More specifically, we assume that such an environment would dictate oil prices to reach about 80$ per barrel, the increase of the foreign demand for Greek exports of goods and services to range between 5% and 6% and the combined Clarkson's index of the international freight rates to exceed 20,000 dollars per day. What we seek to find in this particular case is the extent to which a revival of the international economic activity will contribute to boosting up domestic activity as well. The simulation results as these are depicted in the values assumed by the various concepts indicate that recovering from the crisis can contribute to a considerable reduction of the Greek current account to figures that can be easily considered as representing a sustainable deficit. More specifically, the current account deficit in GDP terms is calculated to be reduced to figures as low as 4%, with the GDP assuming its before - crisis substantial rates of growth. The reduction of the deficit will come about as a result of the competitiveness improvement and will lead, in its turn, to a reduction of the external debt.

VI.4. Scenario 2: Competitiveness Improvement

The issue of the reduced competitiveness is the main problem facing the Greek economy and, primarily, the export performance of its goods and services in the international markets. The scenario of competitiveness improvement is introduced in the model by setting the activation level of concept number 5 to a range of values that indicates substantial competitiveness improvement via the real effective exchange rate. The desired improvement in this case can be brought about via either an improvement of the relative cost or price ratio to the benefit of the Greek side, or by devaluing the domestic currency against those of the partner countries. The results derived in terms of terminal activation level values indicate that such a possibility will definitely contribute to reducing the current account deficit to a one - digit figure in terms of GDP share. It is encouraging to see, however, that competitiveness improvement is not as effective as it is believed to be in reducing the deficit, something which agrees with the Bank of Greece recommendations that point to non – price competitiveness recipes for supplementing the real effective exchange rate adjustment [24]. It goes without saying, however, that competitiveness improvement and the consequent reduction of the deficit will be followed by a reduction of the external debt, something which is also a must for a Eurozone membership.

TABLE IV
WEIGHTS INTERACTION – SCENARIO 2: COMPETITIVENESS IMPROVEMENT

CONCEPT INTERACTION	WEIGHTS	FINAL A / L
C1 → C6	- 0.01	- 0.7
C2 → C1	0.23	- 0.8
C3 → C1	-0.49	+0.7
C3 → C2	- 0.76	+0.7
C4 → C3	- 0.94	- 0.1
C5 → C2	- 0.12	+0.4
C6 → C4	- 0.89	+0.03
C7 → C3	0.31	- 0.3
C7 → C10	- 0.75	- 0.3
C8 → C5	- 0.35	- 0.4
C8 → C7	0.20	- 0.4
C8 → C9	0.70	- 0.4
C9 → C2	- 0.44	- 0.6
C9 → C10	0.93	- 0.6
C10 → C2	- 0.79	+0.8
C10 → C3	1.00	+0.8
C10 → C9	- 0.10	+0.8

VI.5. Scenario 3: Oil Price Increases

TABLE V
WEIGHTS INTERACTION – SCENARIO 3: OIL INCREASES

CONCEPT INTERACTION	WEIGHTS	FINAL A / L
C1 → C6	- 0.01	- 0.7
C2 → C1	0.23	- 0.8
C3 → C1	-0.49	+0.7
C3 → C2	- 0.76	+0.7
C4 → C3	0.94	- 0.1
C5 → C2	- 0.12	+0.4
C6 → C4	- 0.89	+0.03
C7 → C3	0.31	- 0.3
C7 → C10	- 0.75	- 0.3
C8 → C5	- 0.35	- 0.4
C8 → C7	0.20	- 0.4
C8 → C9	0.70	- 0.4
C9 → C2	- 0.44	- 0.6
C9 → C10	- 0.93	- 0.6
C10 → C2	- 0.79	+0.8
C10 → C3	1.00	+0.8
C10 → C9	- 0.10	+0.8

This last simulation exercise aims at underlining the heavy dependence of the Greek external account on the oil price fluctuations. To this end we introduce considerably high international oil prices of the order of 100 to 120 dollars per barrel in order to investigate the extent to which the current account deficit, together with other concepts in the model is affected. The simulation results indicate that the current account deficit will inevitably remain to two digit figures in terms of GDP percent, with both imports and exports affected by the expensive oil. The high crude oil prices are shown to curb foreign demand to rather low rates of increase while the freight rates index will not be affected downwards probably due to the effect of the high energy prices on the BDIY rates.

VII. CONCLUSIONS

This exercise represents a rather original attempt to introduce the technique of Fuzzy Cognitive maps to facing problems related to economic policy. The issue tackled in this case is the extent to which the current account deficit of the Greek economy can be considered sustainable, a question which appears to be one of the leading economic policy issues both in the country and at an international level.

The algorithm employed seems to reflect the actual picture, given, of course, the aggregation level allowed by the model. The results obtained indicate the following:

1. The Greek current account is particularly sensitive to major exogenous disturbances like the recent considerable increase of crude oil prices. It is easy to see through such simulation exercises that the worries about the sustainability of the current account deficit can be eased once such external shocks are removed.

2. A reduction of the real effective exchange rate indices used by the Bank of Greece to measure cost and price competitiveness can be seen to contribute to a certain extent to reducing the current account deficit, either via a change in the nominal effective exchange rate or the relative prices. The effectiveness of such a policy measure, however, seems to be rather limited, not only because more than half of the Greek external trade takes place within the Eurozone area, but also because the non – price competitiveness weaknesses that are a menace for the Greek economy are not reflected in the changes of the real effective exchange rate [24].

3. It may be possible to reduce the excessive current account deficit as a result of the international crisis impact on the various current account items. However, this is expected to be more or less a temporary effect, given the structural weaknesses of the Greek economy and the rigidities that it suffers from concerning not only goods and services, but also labour markets. The Bank of Greece [22,23] has repeatedly expressed its worries on the issue of competitiveness erosion to which such rigidities contribute a great deal. In addition, certain restrictive fiscal policy measures announced by the government in its effort to reduce the fiscal deficit and comply with the demands of the Excessive Deficit Procedure are thought to add to the difficulties faced by the Greek economy in its effort to move towards recovery. Unfortunately, the high degree of aggregation regarding the structure of the FCM model used prevents the analyst from detecting the adverse repercussions of such market imperfections on the various concepts and incorporating their impact on the conclusions of the policy simulations. This weakness, needless to say, points the way for further research on the topic.

The fact is that the persistence of high current account deficits may not raise any worries about its financing requirements, it indicates, however, the dominant role of the endogenous structural weaknesses mentioned earlier in preserving the tendency for such deficits. The symptoms of these structural weaknesses appear in the form of import price inelasticity and lack of import substitution, together with high income elasticity of imports on one hand and the well – known competitiveness problems on another, mentioned in Section III.

We need to emphasize once more that the conclusion of this paper arguing in favour of the Greek current account deficit sustainability, must not be considered as disregarding the need for serious structural reforms required to eliminate the fundamental problems pointed out by Anastasatos [40]. In fact we strongly agree on his recommendations requiring, among other measures, the elimination of the various market rigidities, the emphasis on high technology production, the attraction of export - oriented FDI and the reduction of the heavy energy dependence of the Greek economy. These recommendations have repeatedly been put forward in the past by the Bank of Greece (Bank of Greece, [23] and [24] with the policy makers hesitating to consider them in view of the high political cost involved.

APPENDIX

TABLE VI
FUZZY KNOWLEDGE BASE – FUZZIFICATION AND DEFUZZIFICATION

CONCEPT	FUZZIFICATION				INTERVAL
C1	-1,00	-1,00	-0,80	-0,70	>11%
C1	-0,80	-0,70	-0,40	-0,27	9-10%
C1	-0,40	-0,27	-0,07	0,07	7-8%
C1	-0,07	0,07	0,27	0,40	5-6%
C1	0,27	0,40	0,70	0,80	3-4%
C1	0,70	0,80	1,00	1,00	0-2%
C2	-1,00	-1,00	-0,80	-0,70	<11
C2	-0,80	-0,70	-0,40	-0,27	11 - 15 % GDP
C2	-0,40	-0,27	-0,07	0,07	16 - 18 % GDP
C2	-0,07	0,07	0,27	0,40	19 - 21% GDP
C2	0,27	0,40	0,70	0,80	22 - 24%GDP
C2	0,70	0,80	1,00	1,00	>25% GDP
C3	-1,00	-1,00	-0,80	-0,70	> 35 % GDP
C3	-0,80	-0,70	-0,40	-0,27	33-35 % GDP
C3	-0,40	-0,27	-0,07	0,07	30-32 % GDP
C3	-0,07	0,07	0,27	0,40	26-29 % GDP
C3	0,27	0,40	0,70	0,80	22-25 % GDP
C3	0,70	0,80	1,00	1,00	< 22 % GDP
C4	-1,00	-1,00	-0,80	-0,70	>8
C4	-0,80	-0,70	-0,40	-0,27	7-8 %
C4	-0,40	-0,27	-0,07	0,07	5-6 %
C4	-0,07	0,07	0,27	0,40	3-4 %
C4	0,27	0,40	0,70	0,80	1-2 %
C4	0,70	0,80	1,00	1,00	0-1 %
C5	-1,00	-1,00	-0,80	-0,70	> 111
C5	-0,80	-0,70	-0,40	-0,27	108-111
C5	-0,40	-0,27	-0,07	0,07	105-108
C5	-0,07	0,07	0,27	0,40	103-105
C5	0,27	0,40	0,70	0,80	100-103
C5	0,70	0,80	1,00	1,00	<100
C6	-1,00	-1,00	-0,80	-0,70	>131% GDP
C6	-0,80	-0,70	-0,40	-0,27	121 -130 % GDP
C6	-0,40	-0,27	-0,07	0,07	111-120 % GDP
C6	-0,07	0,07	0,27	0,40	101 -110 % GDP
C6	0,27	0,40	0,70	0,80	91 - 100% GDP
C6	0,70	0,80	1,00	1,00	UP TO 80% GDP
C7	-1,00	-1,00	-0,80	-0,70	>121 $
C7	-0,80	-0,70	-0,40	-0,27	101 - 120 $
C7	-0,40	-0,27	-0,07	0,07	81 - 100 $
C7	-0,07	0,07	0,27	0,40	61 - 80 $
C7	0,27	0,40	0,70	0,80	41 - 60$
C7	0,70	0,80	1,00	1,00	< 40 $
C8	-1,00	-1,00	-0,80	-0,70	>1.6
C8	-0,80	-0,70	-0,40	-0,27	1.4 - 1.6
C8	-0,40	-0,27	-0,07	0,07	1.2 - 1.4

C8	-0,07	0,07	0,27	0,40	1.0 - 1.2
C8	0,27	0,40	0,70	0,80	0.8 - 1.0
C8	0,70	0,80	1,00	1,00	<0.8
C9	-1,00	-1,00	-0,80	-0,70	< 1%
C9	-0,80	-0,70	-0,40	-0,27	1 - 2 %
C9	-0,40	-0,27	-0,07	0,07	3 - 4 %
C9	-0,07	0,07	0,27	0,40	5 - 6 %
C9	0,27	0,40	0,70	0,80	7 - 8 %
C9	0,70	0,80	1,00	1,00	>8%
C10	-1,00	-1,00	-0,80	-0,70	UP TO 5
C10	-0,80	-0,70	-0,40	-0,27	5-10.
C10	-0,40	-0,27	-0,07	0,07	10-15.
C10	-0,07	0,07	0,27	0,40	15-20
C10	0,27	0,40	0,70	0,80	20-25
C10	0,70	0,80	1,00	1,00	>25

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