Yugoslav Journal of Operations Research
8 (1998), Number 2, 331-341

ECONOMIC MODELLING AND THEORY OF FUZZY SETS APPLICCATION IN MACROECONOMIC PLANNING WITHIN THE PROCESS OF TRANSITION

Sofija ADŽIĆ, Otilija SEDLAK
Faculty of Economic, Subotica
Put M. Pijade 9-11, 24000 Subotica
Yugoslavia

Abstract: The transition process from administrative to (mainly) market mechanisms of managing and regulating the economy is taking place under the conditions of intensive changes within internal and external surroundings. The structure of aims and actions, as well as the theoretical and data basis to describe this process is an extraordinarily complex system, having numerous feedbacks with different regulative mechanisms regarding their costs and effects. Within the process of formulating long- term economic policies, as the basic subset of the elements of macroeconomic planning, there is a certain arbitrariness in the selection of regulative mechanisms and in the estimation of their costs and effects. To a great extent, it is a consequence of the difficulties in defining appropriate economic models. Obviously, there is the need for formalized and systematic planning.

The large of number of inputs, followed by their mutual interactions producing outputs, cannot be quantified and presented in a classical way, but in a purely linguistic way, which is very suitable for improving conventional methods and models for the description of actual phenomena.

The application of fuzzy sets has been advanced to treat imprecise and uncertain information. Fuzzy instruments can overcome the restrictions of classical quantitative methods when describing and defining problems of economic development, thus enabling a more exact approach to qualitative modeling.

Keywords: Economy in transition, intensive changes in internal and external circumstances, microeconomic planning, economic modeling, fuzzy sets.

1. INTRODUCTION

A contemporary economy is an extraordinarily complex system, inside of which individual economic units and variants are linked by numerous feedbacks consisting of a variety of regulation mechanisms. Under such circumstances, regardless of mechanisms of mutual relations, the economy is not capable of determining its future development without alternatives. Inside each initial point there are numerous alternatives consisting of different possibilities for creating development strategies. The absence of an institutionalized system's coordinating functions and macroeconomic regulation, accompanied by the completely autonomous decision making of economic subjects, may cause structural disturbances, monopolies, unemployment, etc. On the other hand, conscious social intervention inside autonomous economic mechanisms can often cause similar negative consequences, such as: resource waste, technological drawbacks, malfunctioning of administration, etc. The problem of the proper selection of relations between autonomous economic mechanisms and macroeconomic mechanisms must be conceived within the broad context of dichotomy. It is the relation between a self-regulating economy or one that is not self-regulating and the state, i.e. its institutions dealing with macroeconomic regulation, which can or cannot be competent for formulating the aims of economic mechanisms. [2]

ECONOMY	GOVERNMENT
self-regulating	not competent
not self-regulating	competent
self-regulating	competent
not self-regulating	not competent

Theoretically, within the first two cases, the solution is simple: (1) if the economy is self-regulating with the government being incompetent, the economic development should be governed by autonomous economic mechanisms, and (2) if the economy is not self-regulating but the government is competent, macroeconomic mechanisms should be taken into account. The real problem can be found in transitional cases (3) in which the economy is self-regulating and the state is competent, thus providing a proper choice between two good mechanisms. A similar case (4) appears when the economy is not self-regulating and the state is not competent, thus providing a choice between two bad economic mechanisms.

The choice between automatic economic mechanisms or macroeconomic mechanisms depends on general confidence in the inherent stability or instability of an economy. It is the question of using macroeconomic regulating mechanisms as a rule or as an exception, i.e. should the intensive and broad use of macroeconomic

mechanisms be treated as a regular or an exceptional situation. The historic experience of conscious social regulation imposes the need for the following rules: 1) the existing economic resources and restrictions should be monitored by consistent social regulation, 2) in order to achieve generally accepted social aims, it is necessary to develop a network of institutions within an economic system through which the major economic subjects will be enabled to follow their own interests, as well as to act as an integral part of a larger harmonious, market based economic system, 3) restrictions resulting from a lack of knowledge about the economy must also be taken into account.

Economies in transition from administrative to mainly market-oriented management mechanisms are characterized by the following phenomena: 1) the problem of a proper choice between the conscious and automatic regulation of the economy, and 2) inadequate application of contemporary economic theory in the process of modeling, testing and verifying solutions carried out by the economic system's institutions. To a great extent, this particular problem is the consequence of difficulties characteristic of economies being a state of entropy, lacking self-regulating mechanisms and governed by an incompetent state.

The role of conscious management over economic development is based upon: 1) analysis of the need for macroeconomic planning inside systems undergoing great changes, 2) estimation of the particular model's structure leading to its real values when there is a lack of organized research of the problems of economic modeling, 3) in circumstances characterized by numerous inputs and their complex interactions, when they can only be explained through linguistic forms, the power of fuzzy sets will be included as an instrument to overcome the restrictions of conventional, quantitative methods in the modeling process.

2. THE PROBLEMS OF MACROECONOMIC PLANNING IN SYSTEMS UNDERGOING LARGE CHANGES

The role of macroeconomic planning in the transition process must be observed as a function of the state in transition. The results of research [1] are shown in the following table:

Table 1: The basic functions of the government in the process of transition:

1. The creation and development of a decentralized market structure
• Macroeconomic stabilization
• Liberalization of prices and foreign trade
• Restructuring
• Privatization
• Providing foreign financial support

Table 1: Continued

2. Traditional functions
• Establishing global relations in distribution
• Activities oriented to savings increase
• Directing the global course of capital
• Controlling the foreign trade balance
• Managing the process of social reproduction in the public sector and in monopoly enterprises
• Controlling the utilization of natural resources
• Neutralization of negative ecological effects
3. The maintenance of stability
• Control over the inflation
• Strengthening market competition
• Stimulating balanced regional development and the disposition of the population, economy and infrastructure
• Stimulating the process of new employment
• Measures for overcoming economic and social problems caused by the high rate of unemployment
4. Reducing risk and uncertainty in business planning
• Direct development planning and programming
• Long-term industrial policy
• Long-term agricultural policy
• Foreign trade development strategy
• Technological development strategy
• Development of the infrastructure to collect, process and distribute economic information data.

The set of these complex functions upon which the whole project is based requires macroeconomic planning. Inside the institutional vacuum originating from dismantlement of the bartering system, there is a growing need for new regulating economic mechanisms. Moreover, in spite of all deficiencies, the market has had to take over even regulative mechanisms which in developed economies belong to administrative institutions.

The need for macroeconomic planning in a system undergoing large changes can be presented in three fundamental forms of planning (Table 2). The first form of planning, i.e. the direct allocation of resources and investment activities carried out by the state, has been abandoned, thus endangering the fundamental principals of transition and diminishing the desirable effects of the mobilization

Table 2.

MACROECONOMIC PLANNING

Direct allocation planning	Economic policies planning	Institutional planning
• Economic sectors • Regional planning	• Fiscal policy • Monetary policy • Foreign currency • Technological development strategy (education, ecology) • Industrial policy • Agricultural policy • Big systems development strategy (energy, transport, waterworks, telecommunications, civil engineering..)	Properties: • privatization • contract protection Markets • goods and services • money and capital • foreign currency • labour force Market infrastructures • banks • stock market • institutional funds

typical of large infrastructural projects. It has also diminished the effects of the corrective function of these investments which could eliminate market deficiencies, especially the consequences of monopolies. The second form of planning is related to defining new fundamental aims and economic and political courses for the macroeconomic policy. The creation of a new concept of indirect management by means of the economic policy has faced enormous difficulties and uncertainties in the course of the current phase of transition. The basic precondition for efficient management by means of economic policies is the realization of appropriate microeconomic conditions, above all the proper motivation of economic factors to utilize available resources in the best possible way, and their ability to select and formulate the best possible business policies. In this way, it is possible to establish a direct link between the market and planning. The existence of an efficient market with clearly defined ownership is a precondition for successful planning by means of macroeconomic policies. The third form of planning in the process of transition is establishing the mechanisms of automatic regulation. It includes institutions, long-term rules of decision making, as well as the proper patterns of behavior ensuring efficiency at the microeconomic level, followed by the spontaneous coordination of economic decisions. The process of transition is based upon a twofold arrangement, i.e. developing market mechanisms and creating an efficient government [5].

3. THE FUNDAMENTAL PROBLEMS OF MACROECONOMIC MODELING IN THE SYSTEMS UNDERGOING LARGE CHANGES

An economic model represents a simplified system of relations connecting the selected economic parameters which are used for: 1) controlling the results of economic development, 2) foreseeing the development of some economic phenomena, and 3) evaluating the costs and the effects of particular institutional solutions and macroeconomic policies. Even though economic models cannot fully reflect the actual state within a system, there have been a lot of approximations in describing its structural and functional characteristics [4]. Thus, in traditional models to control economic growth, the following parameters are used: index of national income increase, level of employment, consumption and capital investment. The inputs and outputs are normally presented separately, and only rarely can they show the integral development of the system as a whole. This is often the case in systems undergoing large changes. The problems of the operational application of economic models in the process of transition [1] can be reduced to the following aspects: 1) neglecting the effects of subjective and institutional factors, 2) inadequate application of already applied models. 3) insufficient evaluation of factors influencing the process of modeling, 4) insufficient evaluation of the relations between particular parameters is regard to control and the goals of the system. In fact, the essential problem of the models used for evaluating and foreseeing phenomena within the process of transition is the fact that major economic phenomena do not occur at the level of the macroeconomic system, but inside numerous micro and mezzo level factors, i.e. enterprises and their formal and informal associations. Therefore, in order to get better results at the macroeconomic level, it is more efficient to put efforts into the research of mezzo sectors of economic systems being more specialized production sectors. After getting precise results, it is possible to make further generalizations. Regarding specific features of the economy in transition, we propose to divide the economic and social sector into eleven sets: 1) industrial state sector, 2) industrial privatized sector, 3) private sector of industry and handicrafts, 4) public and pseudo public agricultural sector, 5) private agricultural sector, 6) privatized civil engineering sector, 7) private civil engineering sector, 8) public sector of remaining industry, 9) privatized sector of remaining industry, 10) private sector of the remaining industry and 11) social sector.

Another problem is the selection of a proper theoretical basis. There are numerous contradictory requiremenents within the process of transition, such as: the simultaneous establishment of a balance between the market of commodities and production factors, renewal of economic development, establishment of new institutions, etc. Therefore it is not possible to formulate homogenous theoretical foundations for establishing the model. The models of general balance based on Valras' works are mostly preferred by the World Bank, and are advantageous for their effects on resource allocation, the influence of some fiscal instruments on economic sectors, as well as for the analysis of the effects of market mechanisms. However, this

particular theoretical approach cannot provide satisfactory results in cases of unbalanced markets. Therefore, more convenient models are used, such as "pst" ones, belonging to Keynesian and monetary theory. They provide more real interpretations of phenomena, such as: inflation, balance of payment deficit, budgetary deficit and unemployment, as well as their repercussions on economic sectors. Proper timing is also a very important factor for selecting the model. It is well known that stabilization and balance should be established within a short time, the renewal of development should be accomplished over the medium term, while establishing market institutions and infrastructures requires a longer period of time. Thus, three models within this unique process can be defined: 1) models for testing privatization policies and market infrastructure development, 2) models for analyzing the current economic course and for testing the effects of monetary and fiscal policies within the above mentioned eleven economic sectors, 3) models for analyzing the means of economic development renewal and for testing the long-term macroeconomic policies supporting the whole process.

In order to formulate appropriate models, it is necessary to resolve the problem of a supporting information base. Previously, the information retrieval system was burdened with a broad network of institutions, expensive data collecting and processing and was thus unable to provide an adequate information base necessary for economic policy factors. Disintegration of the country resulted in dismantling of the institutions of the previous economic system. The "black market" was flourishing blooming and led to a large information gap, causing the need for empirical analyses to be based upon a descriptive and linguistic approach to economic parameters and phenomena.

4. POSSIBILITIES FOR THE APPLICATION OF FUZZY SETS IN THE PROCESS OF DECISION MAKING WITHIN MACROECONOMIC PLANNING IN SYSTEMS UNDERGOING LARGE CHANGES

Decision making is a human activity intended to set goal and tasks, and determine the course and the order of activities needed to achieve specific aims. Within macroeconomic planning, the process of decision making is of essential importance for the following functions: selecting the right policy, strategy and aims of development, inventing new products, and the proper distribution of resources. Dynamic changes and the need for more efficient measures in adapting a system in a turbulent environment require radical improvements in the decision making process. Normally, decision making relies on the results of particular evaluations. But, evaluations in an economy are extraordinarily complex because of economic phenomena being conditioned by numerous factors which may be caused either by interior or exterior factors, either by subjective or objective factors. Moreover, an economy doesn't necessarily have a satisfactory amount of precise data for reliable decision making. A great deal of information is provided in descriptive or linguistic

forms. For example, "unemployment" can be described as "low", "moderate" or "high", while the results of an investment can be described as "close", "far" or "very far" from the expected increase in production or structural changes. Therefore, some decisions are made either on the basis of experience and intuition, or on the basis of the decision maker's subjective judgement and estimation. There have been strongly expressed requests to initiate radical improvements not only in the managing process, but in the decision making process as well. In order to obtain a formalized and systematic decision making process, it is necessary to develop proper instruments for more exact modeling. In this sense, the fuzzy sets theory seems to represent an appropriate mathematical apparatus for dealing with uncertainties, subjectivity and vagueness. Figure 1 presents a decision making process using fuzzy regulators.

Fuzzy logic and the respective theory of fuzzy sets used in the process of decision making inside macroeconomic planning can be applied for:

- structuring the problem in order to get its precise and clear description
- supporting possible solutions
- efficient and precise searching for possible and acceptable ways to carry out decisions
- a flexible approach in unexpected situations
- decreasing the possibility of making a mistake

Information processing and decision making using fuzzy regulators can be realized in three stages:

- fuzzification
- interference
- defuzzification

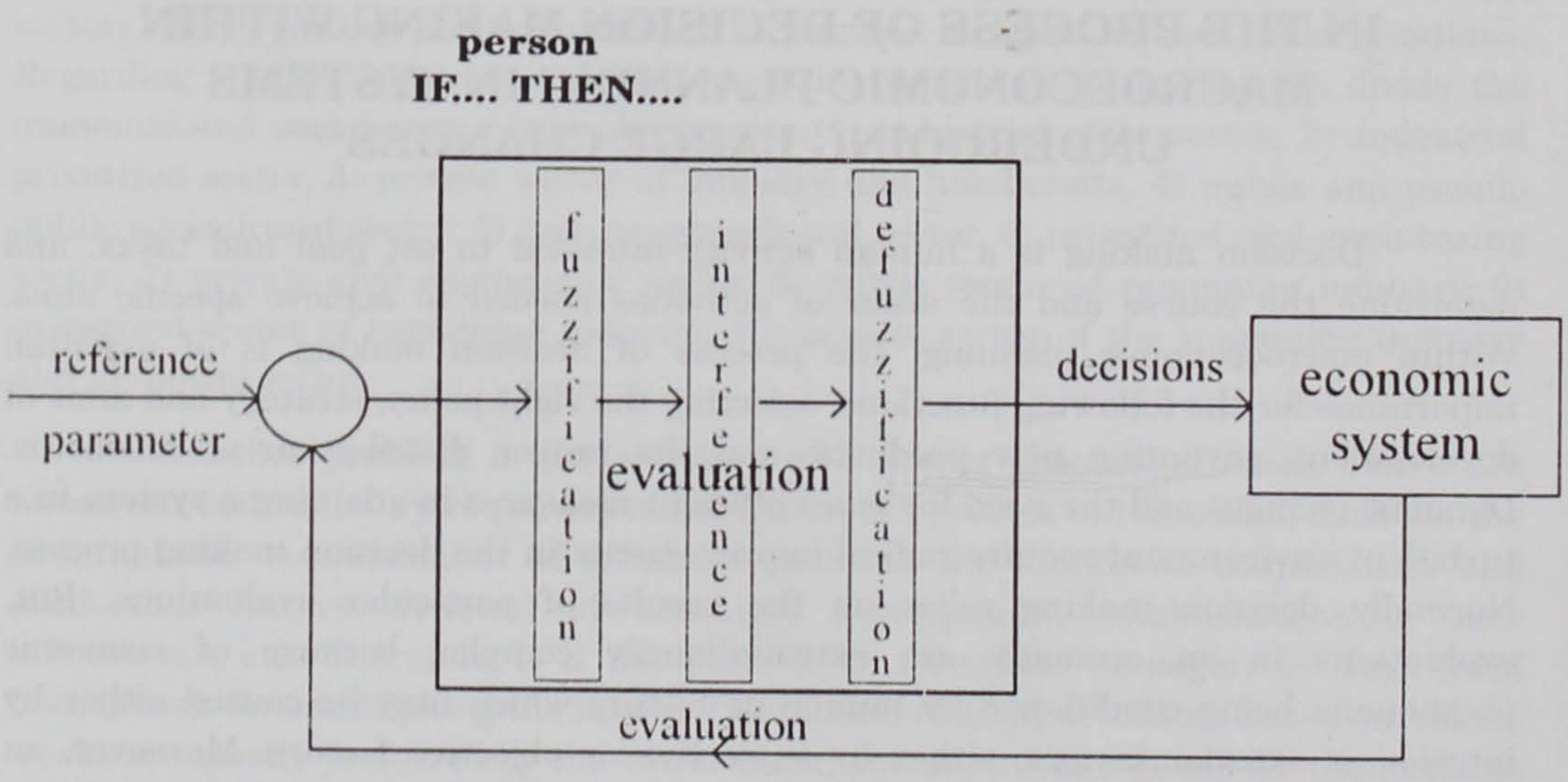

Figure 1: The structure of fuzzy regulators

Uncertainty and approximate reasoning, used by the mathematical theory of fuzzy sets, simulate the process of normal human reasoning. Decision making inside macroeconomic planning is not always a matter of something being true or false; it often involves the term "maybe". In fact, creative decision making processes are unstructured, playful, contentious, and rambling.

We shall demonstrate the application of fuzzy sets in basic decisions over time between consumption and capital accumulation. In linguistic terms more consumption means less capital accumulation and the smaller the capital accumulation the smaller the future output, and hence the smaller the future potential consumption. In this phase a decision must be made between alternative consumption, policies. We must judge the value of present versus future consumption.

The fuzzy approach in describing the relationship between inherently imprecise quantities such as capital per worker, consumption per worker, investment per worker seems quite natural. The first thing to do is to develop the set of descriptors or qualifers used to describe the above quantities. As a first attempt, perhaps the list

- "very small capital per worker" (consumption per worker, investment per worker)
- "small capital per worker" (consumption per worker, investment per worker)
- "medium capital per worker" (consumption per worker, investment per worker)
- "large capital per worker" (consumption per worker, investment per worker)
- "very large capital per worker" (consumption per worker, investment per worker)

represents the discrimination one has on capital per worker, consumption per worker and investment per worker.

Next, we define the fuzzy sets to represent each of these qualifers. The scale and extent of the domain must be selected. We can create an arbitrary, subjective scale, ranging for convenience from 0 to 100 along some natural continuum.

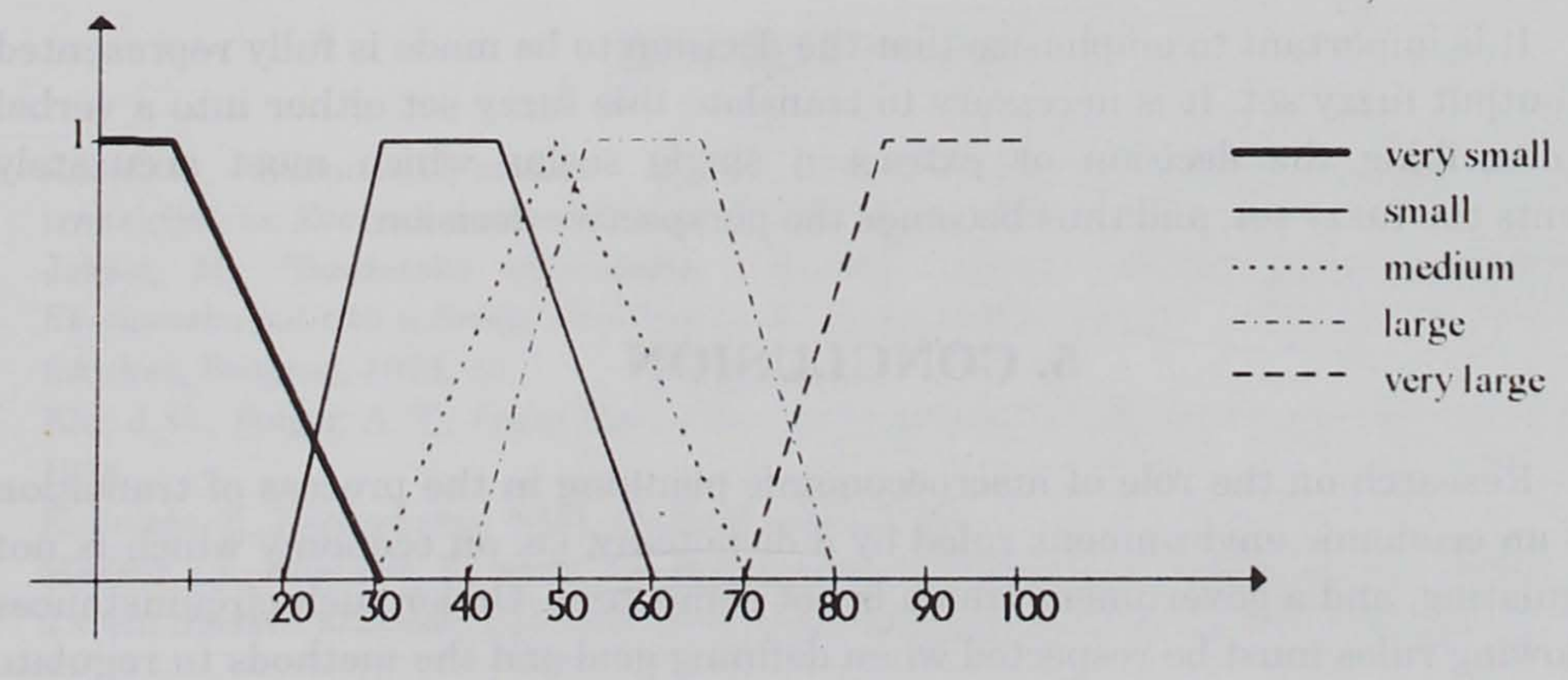

Figure 2: Fuzzy set for capital per worker

We are now ready to draw up the simple set of rules which will generate the decision. The algorithm of approximative reasoning for the decision making process consists of logical rules defined by experts.

The rules seem to be rather straightforward.

R1. IF "capital per worker" is "very small" THEN increase very much "investment per worker" and decrease very much "consumption per worker".

R2. IF "capital per worker" is "small" THEN increase "investment per worker" and decrease "consumption per worker".

R3. IF "capital per worker" is "medium" THEN leave unchanged "investment per worker" and "consumption per worker".

R4. IF "capital per worker" is "large" THEN decrease "investment per worker" and increase "consumption per worker".

R5. IF "capital per worker" is "very large" THEN decrease very much "investment per worker" and increase very much "consumption per worker".

In general, we will expect to generate a fuzzy IF – THEN rule for every combination of terms in the sets of all states of economy.

The use of the rules: we sample the value "capital per worker" and look at each rule in term (and every rule exhaustivly) testing the truth of the antecedent proposition with respect to the state of the economy value. The consequent part of a fuzzy rule could be no more true than its antecedent component. So we truncate the fuzzy sets covering the domain of the corresponding antecedent in the rules in which they feature. In the fuzzy rule-based system of decision making, all rules are executed during each pass through the system, but with strengths ranging from "not at all" to "completely", depending on the relative degree to which their fuzzy antecedent propositions are satisfied by the data.

One of the essential advantages of the algorithm is impossibility for manipulations with creating inputs.

It is important to emphasize that the decision to be made is fully represented by the output fuzzy set. It is necessary to translate this fuzzy set either into a verbal phase describing the decision or extract a single scalar which most accurately represents the fuzzy set, and thus becomes the perspective decision.

5. CONCLUSION

Research on the role of macroeconomic planning in the process of transition implies an economic environment ruled by a dichotomy, i.e. an economy which is not self-regulating, and a government which is not competent. Under such circumstances the following rules must be respected when defining goal and the methods to regulate macroeconomic mechanisms: 1) only those economic variables which can be directly and precisely directed by the state and its institutions can be subjected to the process

of macroeconomic regulation, 2) applied regulative mechanisms should be subjected to the process of permanent technical improvement, 3) main fiscal and monetary instruments should be used exclusively for structural adapting of production and employment for new conditions of economy, 4) the restrictions imposed by available economic theories must be taken into account, which means that a large number of particular variables should be left to the market, although, by definition, it cannot always fulfill its role adequately.

A comprehensive economic model cannot be used to describe all relevant economic phenomena in a system and therefore it is necessary to develop a set of economic models on the basis of criteria and area of application: a) testing the policies of privatization and establishing the market infrastructure, b) testing the effects and expenses of short-term macroeconomic policies within the monetary and fiscal sphere, c) analyzing the models and ways to renew development regarding the eleven key economic sectors: state sector of industry, privatized industrial sector, private industrial sector and handicrafts, state and pseudostate sector of agriculture, private agricultural sector, privatized sector of civil engineering, private sector of civil engineering, public sector of the rest of economy, privatized sector of the rest of economy, private sector of economic and social activities. The theoretical foundations should be based on the achievements of the monetary and post-Keynesian school. In cases where it is not possible to define parameters and mutual relations between economic variables, we should rely on the method of the "invisible hand".

In order to overcome the consequences of uncertainty, subjectivity and vagueness, which are typical for large changes, beside modernization of the system for collecting, processing and distributing economic information, it is necessary to use more update technologies, for example the theory of fuzzy sets, as well as the achievements of the theory of expert systems for managing economic variables in which the input values and the output results can be presented in linguistic forms, thus contributing to a better estimation of the quality of economic development results.

REFERENCES

[1] Adžić, S., "Ekonomski modeli i njihova uloga u makroekonomskoj regulativi u procesu tranzicije", in: *Zbornik radova SYM-OP-IS '94*, Kotor, 1994, 40-42.

[2] Jakšić, M., "Budžetsko ograničenje i kvalitet valute - makroekonomski pristup", in: *Ekonomska politika u Srbiji: Problemi makroekonomske koordinacije, Ekonomika*, Ekonomski fakultet, Beograd, 1993, 13.

[3] Klir, J. G., Folger, A. T., *Fuzzy Sets, Uncertainty and Information*, Prentice Hall, New Jersey, 1988.

[4] Kukoleča, S., *Ekonometar*, SAM, Beograd, 1994, 21-22.

[5] Madžar, Lj., Knežević, V., Savin, D., Bošnjak, M., and Bujišić, B., *Makroekonomsko planiranje u svetu tržišnih privreda*, SZOP, Institut Drustvenih nauka, Beograd, 1992, 157-159.