Microstructure and Macrobehavior of Centralized and Decentralized Systems

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A b s t r a c t

The paper presents some results of research regarding the relationship between the centralization degree and the efficiency of economic systems. A simple system dynamics model has been used in these studies. The model has applied certain J.Kornai's ideas concerning economic systems. Simulation experiments have confirmed the viewpoint that overall economic behavior arises from within feedback loops creating microstructure of each system. Two basic kinds of microstructure have been distinguished: centralized and decentralized. Macrobehavior generated by them is close to these observed in planned and market economies. The paper is divided into four parts. In the first one, basic Kornai's ideas are outlined. In the second part, model is presented, whereas in the third one, some results of simulation are analyzed. Conclusions drawn from the experiments are presented in the fourth part.

INTRODUCTION

According to experience, changes in the centralization degree influence the functioning of economic system. Centralization degree means here the scope of independence of firms in decision making and at the same time the scope of concentration of economic power in a central government. Usually, the centralization degree is higher in the planned (socialist) economies than in the unplanned (market, capitalist) economies. In our studies we have followed J.Tinbergen's guideline (1964, p.50):

> *The influence exerted by planning must be estimated with the aid of a comparative analysis: we must compare a situation in which planning has been applied with one in which it has not been applied, leaving all other data unchanged.*

The paper is intended for two major objectives - to help reach a better understanding of how the centralization degree influences the functioning of economic system, and to show how local policies governing microeconomic decisions create observed overall macroeconomic behavior. At the same time presented studies closely correspond to system dynamics philosophy: macroeconomic behavior arises from interactions among many local decision points (Forrester, 1989). Our purpose was to construct system dynamics model in order to search for relationship between centralization and the mode of functioning of economic systems. Presented model takes into consideration J.Kornai's conceptions of economic systems (Kornai, 1971; Kornai and Martos, 1981) which are very consistent with system dynamics principles (Forrester, 1968; Wolstenholme, 1982; Wolstenholme and Coyle, 1983).

1. J.KORNAI'S THEORY OF ECONOMIC SYSTEMS

There are two main streams in Kornai's works. The first is of methodological character (Kornai 1971; 1981). Kornai strives for a formulation of theory of economic systems which can be more useful than the general equilibrium theory. The second is connected with the shortage phenomenon inherent in the socialist economy which he wants to recognize and describe (Kornai 1980; 1986).

J.Kornai presented his basic conception of economic systems in the book "Anti-Equilibrium". It is basically a critical essay as indicated by its title, i.e. a criticism of equilibrium theory (1971, p.5):

> *Up to the present, economics has produced only a single complete theory describing the operation of the economy from a systems-theoretical point of view. This conceptual framework, typically expounded in formal mathematical models, is called general equilibrium theory and derives from the teachings of Walras.*

Kornai has opposed to the viewpoint that equilibrium is desirable state of an economy. An intensive clash between opposed forces is more preferable to a halfhearted "state of equilibrium" in the economy. He does not assume that the economy is always in equilibrium, or that it moves smoothly from one equilibrium to another. Individuals may be striving for equilibrium but disequilibrium is the rule rather than the exception (1971, p.309-312).

Kornai has described macroeconomic processes on the basis of microeconomic, so-called "standard" decisions of firms and individuals (1971, p.117-121). Standard decisions are repeated periodically, employ algorithms composed of a few simple steps and require little information. The everyday activities of offices, enterprises and households are typically of this nature. The algorithm of the standard decision process merely involves the application of a few rules of thumb, and for this reason the decision is made quickly. The standard decision processes enable the economic system to economize on the intellectual and material inputs of the control processes. It is impossible to devote great energy to each and every problem of economic life, to explore all feasible choices, to predict all consequences of their acceptance, and so on. Kornai's conceptions agree with the theory of bounded rationality (Simon, 1982).

Kornai's theory of economic systems has opposed to the classical rationality of traditional economics. He does not presume that individuals and firms have perfect information or the ability to optimize their performance. A good model of economic system must be descriptive and simulate the system performance accurately. Decision making must be portrayed as it is and not as it might be if people were omniscient optimizers. The general model described by Kornai does not assume optimization, strictly rational and consistent behavior. It is based only on the assumption that in the economic system casual relationships prevail (Kornai 1971, p.57).

Kornai has divided the economic system into the real sphere and the control sphere. The variables of the real sphere can represent stocks of material goods and resources, production, consumption, turnover, etc. The regulation of the real sphere takes place in the control sphere. There are definite operators, called response functions which describe regularities in the behavior of decision makers within the system. In Kornai's concept there are two kinds of control processes: higher and autonomous (vegetative) ones. Higher processes depend on institutional conditions and they are different in capitalist and socialist economies. On the other hand autonomous processes are common in these two types of economies. The autonomous functions are usually sufficient to secure the system's existence, its survival, and its preservation. The higher functions are always necessary to achieve more than only survival.

The autonomous control mechanisms consist of standard decisions and rely mainly on non-price signals. One can meet the simple theoretical formulation that in a capitalist economy control takes place in a decentralized manner on the basis of price signals. On the contrary, in a socialist economy it takes place by means of non-price, "quantitative" signals, in a centralized manner. Kornai has emphasized that more detailed analysis proved that this simple assumption is inaccurate. Apart from the extreme importance of price signals in capitalist economies, non-price signals have also a major part to play. The capitalist enterprise directly reacts to non-price signals: accumulation or decrease of stocks, increasing or decreasing utilization of capacities, changes in employment and unemployment, increasing or decreasing backlog of orders - and to deviations of the actual values of all these variables from their normal values.

As regards the socialist economy, there are no doubt that non-price signals have very important role. They take the form of central plan instructions: the mandatory prescription of output targets and input quotas for the organizations of the lower level and, in the final analysis, for the enterprises. Elaboration of the plan instructions was based on information concerning productive resources and input requirements.

In autonomous processes control by norms plays a very important role (e.g. inventory norms, the norms of backlog of unfilled orders, etc.). The decision maker observes whether the actual functioning of the system deviates from the norm. If it does, he interferes. He modifies the values of the control variables in a manner whereby the functioning of the system tends to the path prescribed by the norm. Control by norms is based on custom, routine and on very simple rules.

System dynamics models are very expedient for presenting Kornai's conception of economic systems. Level equations mostly describe the real sphere whereas rate equations describe the control sphere (decision making). System dynamics models do not require linear functions and make possible the presentation of Kornai's idea of non-continuity involving thresholds of sensation. They can be presented with the aid of table functions. The basic idea of system dynamics is feedback. A negative (or goal seeking) feedback tends to counteract any disturbances caused by a positive feedback, and to move the system toward an equilibrium or goal. Thanks to a negative feedback we can present control by norms.

Kornai's studies are rather qualitative in nature. He deals with the problem of dynamic tendencies of complex systems, that is, the behavioral patterns they generate over time. Kornai is unconcerned with precise numerical values of system variables in a specific period of time. He is much more interested in general dynamic tendencies of systems: whether the system as a whole is stable or unstable, oscillating, growing, declining or in equilibrium. He strives to describe the properties of different control mechanisms (Kornai and Martos 1981).

2. DESCRIPTION OF THE MODEL

System dynamics model applying Kornai's ideas concerning non-price signals and norms in autonomous processes has been constructed. The model is based on stock or order signals, in which price does not play any role. We have not strived for reproducing the operation of a concrete economic system and we have investigated an abstract system consisting of two or three co-operating firms. The aim of our studies was to construct models as simple as possible which could be useful in demonstration of how functioning of economic system depends on its centralization. J.Tinbergen emphasized (1964, p.51):

> *Precise theoretical analyses can be made more easily for simple, well-defined cases than for complicated situations.*

It is assumed that such a simple model could be a basic element of more complex models.

Each enterprise in our model produces one kind of products and consumes products manufactured in the second firm. A total output of each enterprise is divided into two parts: one used in the production of the second firm (raw material) and one used for consumption, capital expenditure, etc. (final output). The production capacity of each firm is determined only by its material stock. There are nor capital stock neither labor in this extremely simple model.

Activity of each firm is described by means of the following variables: stock of raw materials (SM), stock of products (SP), production (PRO), total shipment (SHI), shipment for final purposes (FIN), shipment for the production purposes (RAW), backlog of orders for products (BO), orders for raw material (ORD), plans from the superior unit: production plan (PLAN) and distribution plan (DIST).

2.1. Causal structure

Let us consider two causal-effect diagrams of two co-operating firms in the case of centralized (Fig.1) and decentralized system (Fig.2). In the centralized economy, activity of each firm is strictly regulated by a superior unit (e.g. the central planning bureau or a ministry) which determines the production plan (PLAN) and the distribution plan (DIST). The latter one describes how the total shipment of each firm is divided between the second firm (RAW) and final purposes (FIN). Orders, as a form of direct contacts among firms, do not exist. Delivery of materials depends only on the shipment from the second firm. The basic goal of each firm is to fulfill the targets of an annual plan. Only in such a case the director and his staff can be rewarded by the superior unit.

Fundamental to the practice of system dynamics is the identification of feedbacks. There are two kinds of single negative feedbacks in each firm:

$$SM \rightarrow PRO \rightarrow SM,$$
$$SP \rightarrow SHI \rightarrow SP.$$

The two firms are linked by means of a positive feedback loop which does not contain any negative relationship:

$$SM1 \rightarrow PRO1 \rightarrow SP1 \rightarrow SHI1 \rightarrow RAW1 \rightarrow SM2 \rightarrow$$
$$\rightarrow PRO2 \rightarrow SP2 \rightarrow SHI2 \rightarrow RAW2 \rightarrow SM1.$$

It is the predominant feedback on the first diagram. Therefore we can deduce that the strictly centralized system produces selfreinforcing or compounding changes and it is exposed to

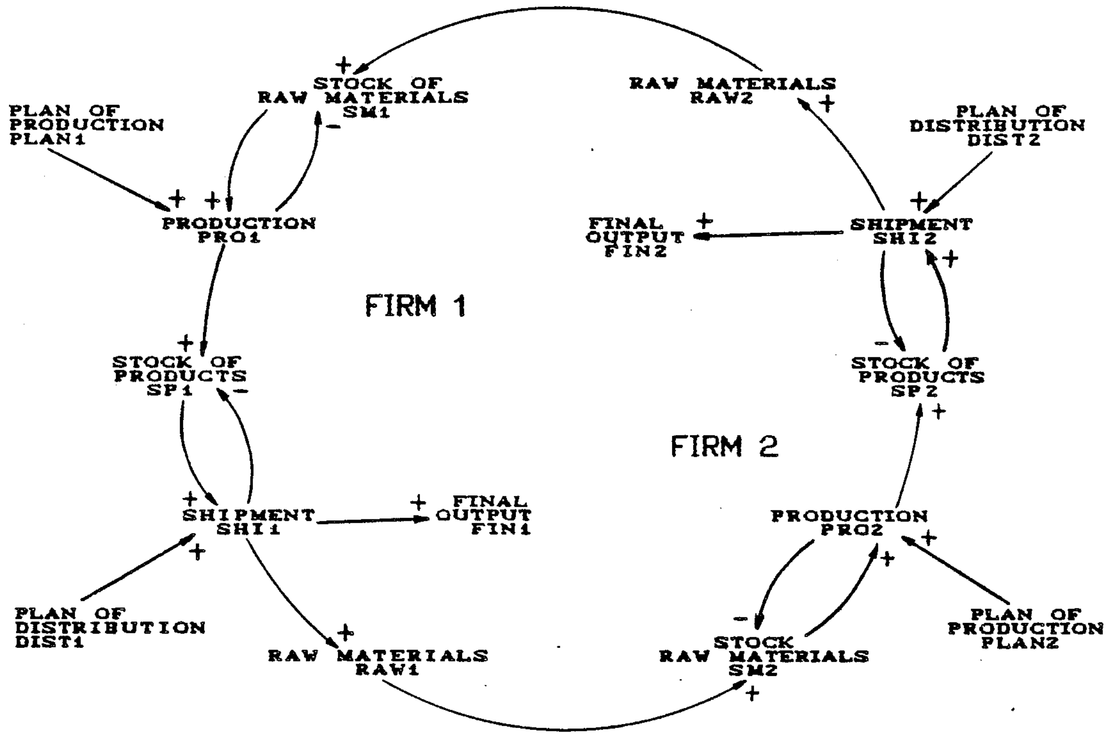

Fig.1 Causal structure of a centralized system

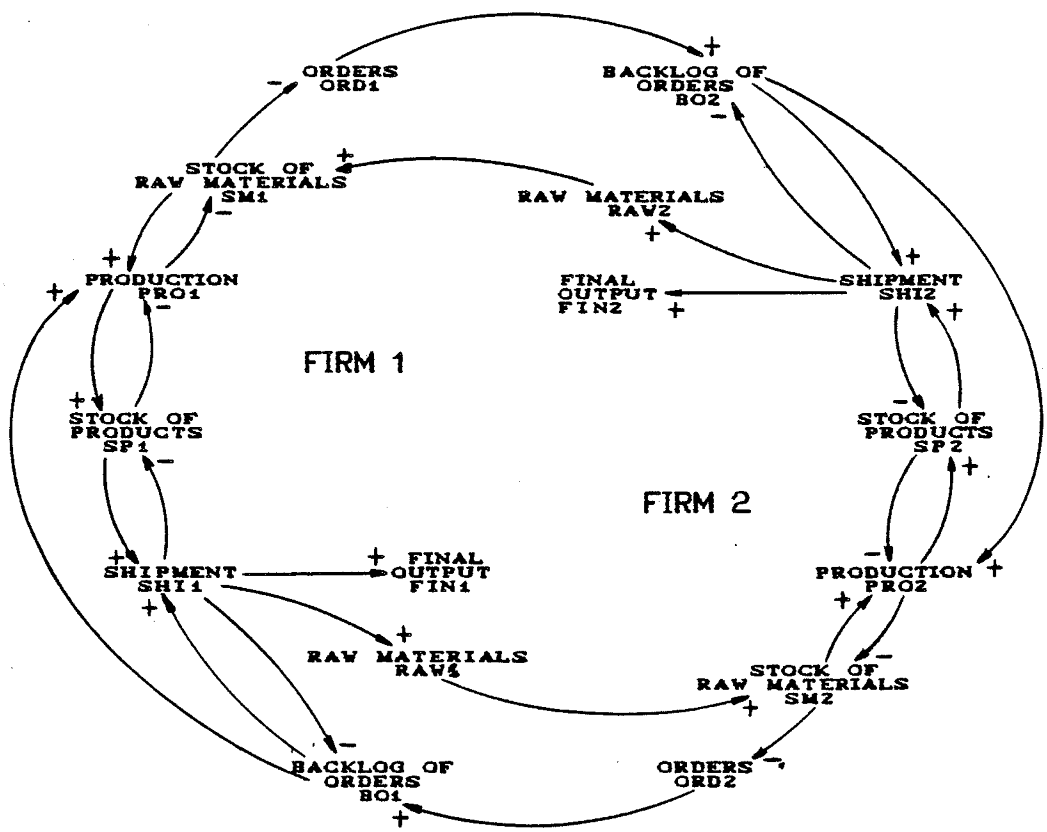

Fig.2 Causal structure of a decentralized system

instability particularly in the case of disturbances.

In the decentralized economy strictly control carried on by a superior unit does not exist. The basic form of contacts among firms are orders. Orders (ORD) for products of a firm are accumulated in the backlog of orders for products (BO) which is depleted by shipment. The basic goal of each firm is to sell maximum of its products. Only in such a case the profit of the firm might be high. Thanks to orders, two negative feedback loops linking the both firms appear on the second diagram:

$$SM1 \rightarrow ORD1 \rightarrow BO2 \rightarrow SHI2 \rightarrow RAW2 \rightarrow SM1,$$
$$SM2 \rightarrow ORD2 \rightarrow BO1 \rightarrow SHI1 \rightarrow RAW1 \rightarrow SM2.$$

Production (PRO) depends on the stock of product (SP) and (or) on the backlog of orders for products (BO). There are three additional kinds of negative feedback loops in each individual firm:

$$BO \rightarrow PRO \rightarrow SP \rightarrow SHI \rightarrow BO,$$
$$SP \rightarrow PRO \rightarrow SP,$$
$$BO \rightarrow SHI \rightarrow BO.$$

On the base of properties of negative feedback we can suppose that these eight additional loops (especially the two first linking both firms) make the decentralized system more stable in comparison with the centralized one. This is the main conclusion of the above qualitative analysis.

2.2. The mathematical model

We must take assumptions regarding the "central" plan in the centralized system. Let us first assume that the central planning bureau has a perfect information on the manufacture within firms described by means of input coefficients. Next let us assume that the annual final demand is known and we can determine shipment of each firm for final purposes. Thank to this information the central planning bureau can elaborate the "central" plan by means of well-known Leontief formula:

(1) $$\overline{PLAN} = (\bar{E} - \bar{A})^{-1} * \overline{FIN},$$

where $\bar{E}$ is a unit matrix and $\bar{A}$ is a matrix of input coefficients. $\overline{PLAN}$ and $\overline{FIN}$ are vectors of an annual production of firms and of an annual final output. Of course, it is not the unique procedure of working out the "central" plan. According to principle of optimization prevailing in socialist economy, we can maximize the final output of the system on the base of (perfect) information of capacities of each firm (Johanson, 1978, p.21-37; Polowczyk, 1986).

We have investigated functioning of the system during a year divided into 52 weeks. Each level and each rate has its own weekly norm. Norms are denoted by "N" added to the original name of a variable. A name of a variable contains the number of a firm only in that case when such discrimination is necessary. If the name does not contain the number of a firm, it means that the equation is true for the both firms. The weekly production norm of a firm is equal to:

(2) $$PRON = PLAN / 52.$$

Next we have assumed that

(3) $$SHIN = PRON,$$

(4) $$FINN = FIN / 52,$$

(5) $$DIST = FINN / SHIN,$$

(6) $RAWN = SHIN - FINN,$

(7) $ORDN = A * PRON.$

Level equations take the following form:

1. equation of orders backlog for products:

(8) $BO1 = BO1 + ORD2 + FINN1 - SHI1$
or $BO2 = BO2 + ORD1 + FINN2 - SHI2$

2. equation of stock of raw materials:

(9) $SM1 = SM1 + RAW2 - PRO1 * A1$
or $SM2 = SM2 + RAW1 - PRO2 * A2$

3. equation of stock of products:

(10) $SP = SP + PRO - SHI.$

Equations (8) describe changes in the control sphere and equations (9) and (10) - changes in the real sphere. All equations register states of levels at the beginning of a week. In equations (8) we assume that the final demand decomposes proportionately during a year and its weekly norm is equal the norm FINN.

We have distinguished four kinds of possible standard decisions in each firm: raw material ordering, production planning, shipment of products and distribution of products among customers. These decisions are made every week.

1. The provision decision is described with the aid of the following formula:

(11) $ORD = ORDN + (1/AT) * (SMN - SM).$

The smaller raw material stock, the larger is order, and inversely.

2. The production decisions use two auxiliary variables:

(12) $AX1 = PRON + (1/AT) * (SPN - SP),$
(13) $AX2 = PRON + (1/AT) * (BO - BON),$

Everyweek production decision can be described by means of the two alternative table functions:

$$(14a) \qquad PRO = \begin{cases} AX1, & \text{if} \quad AX1 \le SM/A \\ SM/A, & \text{if} \quad AX1 > SM/A \\ 0, & \text{if} \quad AX1 < 0, \end{cases}$$

$$(14b) \qquad PRO = \begin{cases} AX2, & \text{if} \quad AX2 \le SM/A \\ SM/A, & \text{if} \quad AX2 > SM/A \\ 0, & \text{if} \quad AX2 < 0. \end{cases}$$

Thus, the production is equal to its norm corrected by deviation of products stock from its norm or deviation of product orders backlog from its norm. The smaller products stock or the more outstanding orders, the greater production. Simultaneously production cannot grow beyond raw material stock limits and cannot be negative. We can say approximately, that the first formula is close to situation when the firm manufactures "for the warehouse", and the second - when firm manufactures "for orders".

3. The third kind of decisions concerns everyweek shipment. We have introduced two other auxiliary variables AX3 and AX4:

(15) $AX3 = SHIN + (1/AT) * (SP - SPN),$

(16) $$AX4 = SHIN + (1/AT) * (BO - BON),$$

which are applied in the following two table functions:

(17a) $$SHI = \begin{cases} AX3, & \text{if} \quad AX3 \le SP \\ SP, & \text{if} \quad AX3 > SP \\ 0, & \text{if} \quad AX3 < 0. \end{cases}$$

(17b) $$SHI = \begin{cases} AX4, & \text{if} \quad AX4 \le SP \\ SP, & \text{if} \quad AX4 > SP \\ 0, & \text{if} \quad AX4 < 0. \end{cases}$$

The weekly shipment is equal to its norm corrected by deviation of products stock from its norm or deviation of product orders backlog from its norm. The greater products stock or the greater backlog of orders, the greater the shipment. Moreover the weekly shipment cannot be greater than products stock SP and can not be negative.

4. The shipment is divided into two parts (final output and raw material). We have introduced an auxiliary variable AX5:

(18) $$AX5 = AX5 + (FINN - FIN),$$

which accumulates unfulfilled final demand. Distribution is implemented by means of the two following rules:

(19a) $$\begin{cases} FIN = SHI * DIST \\ RAW = SHI - FIN \end{cases}$$

(19b) $$\begin{cases} FIN = SHI * (AX5/BO) \\ RAW = SHI - FIN \end{cases}$$

The first rule states that products distribution goes on according to the proportion established on the base of norms at the beginning of the year. The second rule states that distribution of products among customers is proportional to declared orders.

We have supplemented the above model with two auxiliary equations which sum up production and shipment for final purposes:

(20) $$SPRO = SPRO + PRO,$$

(21) $$SFIN = SFIN + FIN.$$

3. SIMULATION

We have carried out a series of simulation experiments applying the model presented above. The most important results are presented below. There are eight possible combinations of decision-making patterns described above (1*2*2*2). We have chosen from them five combinations for further investigations. They are presented in table 1.

We have excluded from our considerations three combinations (14a -17b - 19a, 14b - 17a - 19a, 14b - 17b - 19a), in which orders backlog is not taken into account in the decision concerning distribution, although it is taken into consideration in other decisions. These combinations have seemed to be non-probable to appear in the real systems.

Table 1

Denotation of control mechanisms	Formulae of decision-making rules concerning		
	production	shipment	distribution
I c.m.	14a	17a	19a
II c.m.	14a	17a	19b
III c.m.	14b	17a	19b
IV c.m.	14a	17b	19b
V c.m.	14b	17b	19b

Taking into account the role of orders in decision-making processes we have assumed that the I and the II c.m. correspond to centralized economy. In the case of the I c.m. orders do not play any role in standard decisions. Every decision takes into account norms established by the central planning bureau at the beginning of a year . Thus, we can say that it is the case of a highly centralized system. In the II c.m. orders are taken into consideration only in the phase of distribution. It is the case of a quasi centralized system, very common in the countries of real socialism. Production plans are established by the superior unit but distribution goes on under the pressure of customer's informal orders. The III, the IV and the V c.m. correspond to decentralized systems, because of importance of order signals in decision making.

We have assumed that in the I and the II c.m. production plans and proportions of products distribution among customers are worked out by the central planning bureau. In the other three cases production plans and proportions of distributions are designed by independent firms. For the sake of comparability we have assumed that production plans are the same in all cases and they comply with formula (1). The purpose of carried out experiments was to examine how this plan would be executed under conditions of various control mechanisms.

Several series of experiments were carried out. Each series consisted of five experiments corresponding to individual control mechanisms. Different assumptions regarding initial values of raw material stocks, norms of raw material stocks, norms of product stocks and norms of product orders backlogs were taken into account in each series[1].

Production results of enterprises are closely connected with the control mechanisms. In case of the I c.m. (high centralization) the reduction of initial raw material stocks has caused a decrease of total production and a decrease of shipment for final purposes. Similar phenomenon has been caused by increase of product stocks norm. In case of the II c.m. (quasi centralization) total production plans have always been fulfilled but plans of final output have never been achieved. The smaller the initial raw material stocks, the bigger norms of raw material stocks and product stocks - the smaller is the part of products for final purposes. In these situations firms must devote a bigger part of their production to complete stocks to norm levels.

In case of the III, the IV and the V c.m. plans of production for final purposes are always fulfilled except the series in which norms of product orders backlogs have been increased. On the contrary, total production has always been higher than that from the plan. The higher are norms of raw materials and products stocks, the higher is also production. It is caused by a rising number of orders.

Norms of raw materials stocks have been always reached except the I c.m. In this case raw material stocks have been reduced in comparison with initial values.

Norms of product stocks have been always reached except the V c.m., when no single decision takes into consideration the gap between the actual stock and the norm of the stock. For the III c.m. product stocks are always higher than norms.

In addition, stabilization of production was examined in each experiment. The period of production stabilization has been the shortest for the I and the II c.m. but in experiments, when initial raw material stocks were low or product stocks norm were high, production was stabilized below norms PRON.

In the next group of experiments enterprises have implemented "non-balanced" plans. We have assumed that as a result of imperfect information, plans of final output were increased by 5% in comparison with the "well-balanced" plan[2]. In the case of the I c.m. it caused a notable decreasing of global production and of shipment for final purposes. Stocks of raw materials and stocks of products have been reduced. Production has not stabilized but has constantly decreased during the year. Acute shortages have appeared because of the positive feedback: shortage causes shortage. In the case of the II c.m. a new plan has caused no changes in functioning of enterprises in comparison with the previous group of experiments. In remaining experiments (for the III, IV and V c.m.) the higher plan of final output has been achieved thanks to higher production of each enterprise.

All the experiments discussed above concerned the system consisting of enterprises with the same control mechanisms. The other series of experiments has been carried out with the aid of the model consisting of enterprises with different control mechanisms. In addition we have assumed that enterprises are realizing the "non-balanced" plan. On the ground of these experiments we have observed three essential regularities:

1. The enterprises with the I c.m. have always fulfilled plans of total production and plans of increased final production if they have not co-operated with other enterprises controlled by means of the I c.m. Enterprises with the II, the III, the IV and the V c.m. co-operating with such a firm have not fulfilled their plans and their production has always stabilized below norms PRON.
2. The worst results have been achieved in the enterprises with the II c.m. Although these firms have achieved the global production plan, they have never fulfilled the plan of final output.
3. Each of the firms has achieved the increased plan of final output if the system consisted of enterprises only with the III, the IV or the V c.m.

All these experiments were repeated by means of model with stochastic disturbances. These disturbances have concerned only transport of products. Randomness has been included in the distribution decisions:

(22) $$FIN = FIN * \alpha,$$

(23) $$RAW = RAW * \beta,$$

where α and β are two normal random variables. Random events excite modes of behavior to which the system is internally inclined. These kind of experiments have confirmed the above conclusions. Moreover. we have observed a notable increase of product stocks in enterprises with the V c.m., but only in cases when the co-operating enterprises have not had the I c.m. or the II c.m. It has been possible thanks to suitable increase of global production above norms PRON. Thus, we can say, that phenomenon of overproduction has been observed in cases of firms which production and distribution decisions depend on orders.

Next, all above experiments were repeated with the model consisting of three firms. Their results have confirmed the above presented ones. Moreover, in the case of centralized mechanisms the bigger number of co-operation links caused that the system is more inclined to disturbances.

Figures 3-11 show patterns of behavior for selected experiments. The key describing each figure is in the table 2.

Table 2

Figures	Control mechanisms		Description of experiments
	Firm 1	Firm 2	
Fig.3	I c.m.	I c.m.	Basic case
Fig.4	I c.m.	I c.m.	"Non-balanced" plans
Fig.5	I c.m.	I c.m.	"Non-balanced" plans with randomness
Fig.6	III c.m.	III c.m.	Basic case
Fig.7	III c.m.	III c.m.	"Non-balanced" plans
Fig.8	III c.m.	III c.m.	"Non-balanced" plans with randomness
Fig.9	I c.m.	V c.m.	"Non-balanced" plans
Fig.10	I c.m.	V c.m.	"Non-balanced" plans with randomness
Fig.11	III c.m.	V c.m.	"Non-balanced" plans with randomness

4. CONCLUSIONS

Our experiments have confirmed that by modeling decision making and the physical structure of the system at the microlevel, the macroperformance of the system emerges naturally out of the interactions of the system components (Sterman, 1984).

The outcomes of presented experiments are quite consistent with the J.Kornai's theory of shortage concerning a socialist economy, i.e. a highly centralized economy. There are various concrete manifestations of the same general phenomenon of shortage. One kind of shortage results from the planner's fault, another one from the negligence of the factory supplying the product or the trading company that sells them, and a third one may be the consequence of the price having been fixed too law, etc. According to Kornai, institutional conditions and rules of behavior to which these conditions lead are the main reason of permanent shortage. It will be reproduced as long as the institutional conditions for its chronic reproduction exist[3]. Phenomenon of shortage observed in our experiments has been caused by a predominance of the positive feedback.

On the other hand, the behavior exhibited by the model in the case of a decentralized system, resembles the pattern of performance experienced in market economies. They are characterized by a high elasticity of behavior and a small sensibility to random disturbances, what has been caused by a predominance of negative feedbacks. However, they are internally inclined to phenomenon of overproduction.

Analysis of this paper is a preliminary attempt to deal more seriously with the role played by the centralization degree in the functioning of economic systems. Additional work is needed to enrich the presented considerations.

NOTES

1. The detailed results of experiments have been presented by J.Polowczyk (1987). The computer program has been written in FORTRAN.

2. It is the implementation of Tinbergen's idea (1964, p.53) concerning the introduction of

> *...the possibility of wrong forecasts, which would reduce the effect of a planned policy, and the possibility of wrong assumptions about some coefficients, having the same consequences.*

3. K.Saeed (1986; 1989) presented very interesting experimentation which is an attempt to identify the institutional factors that limit economic growth of a developing country.

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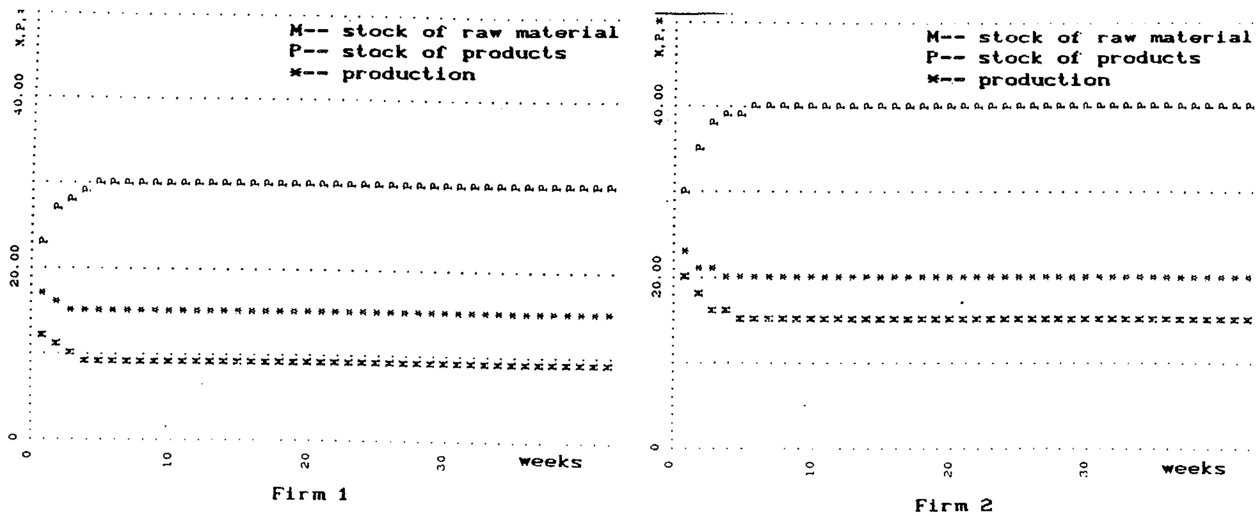


FIG. 3

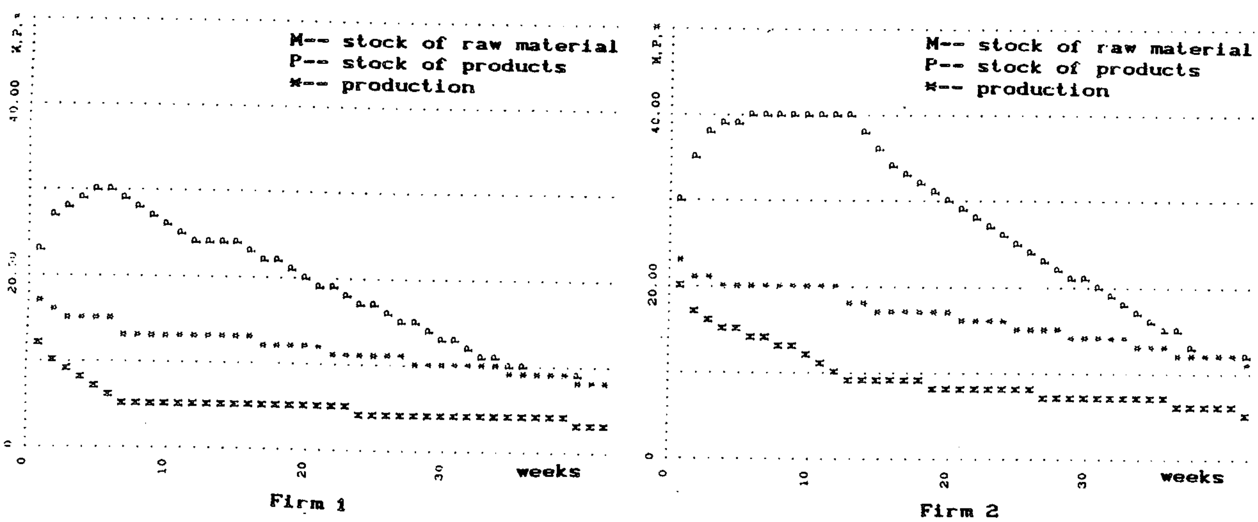


FIG. 4

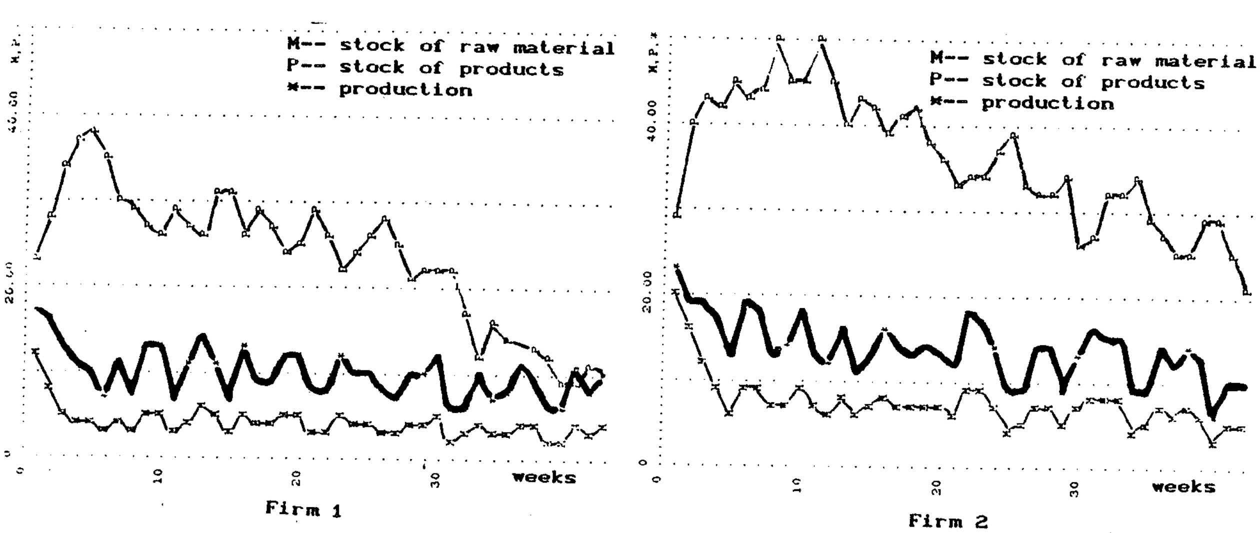
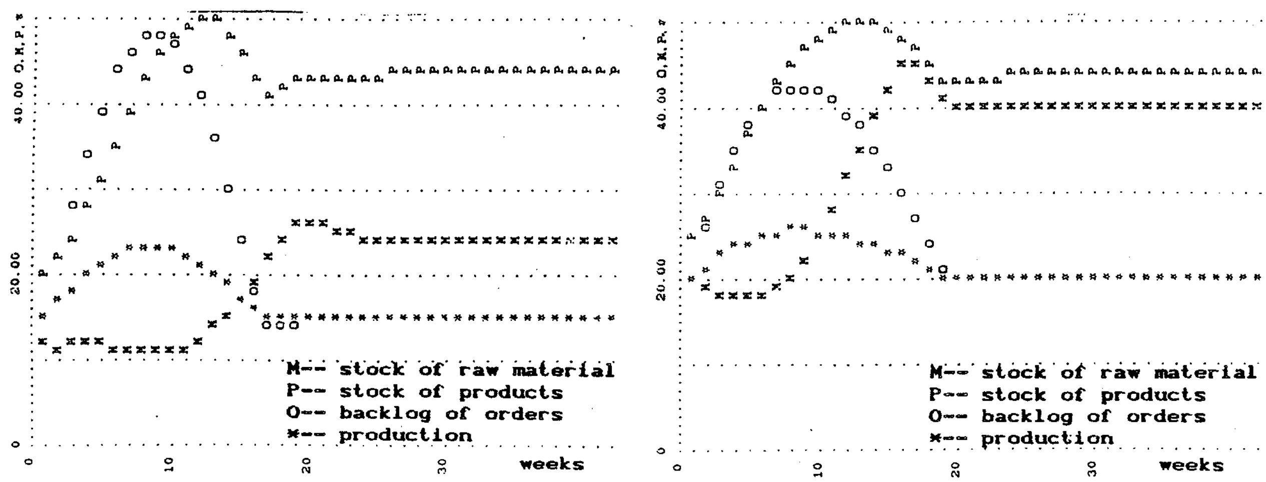
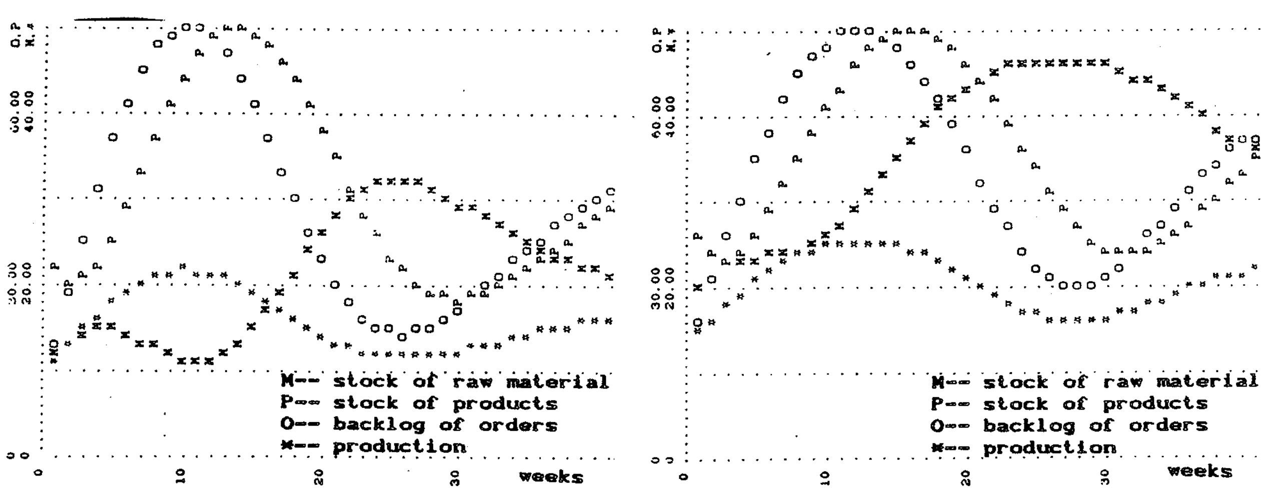


FIG. 5



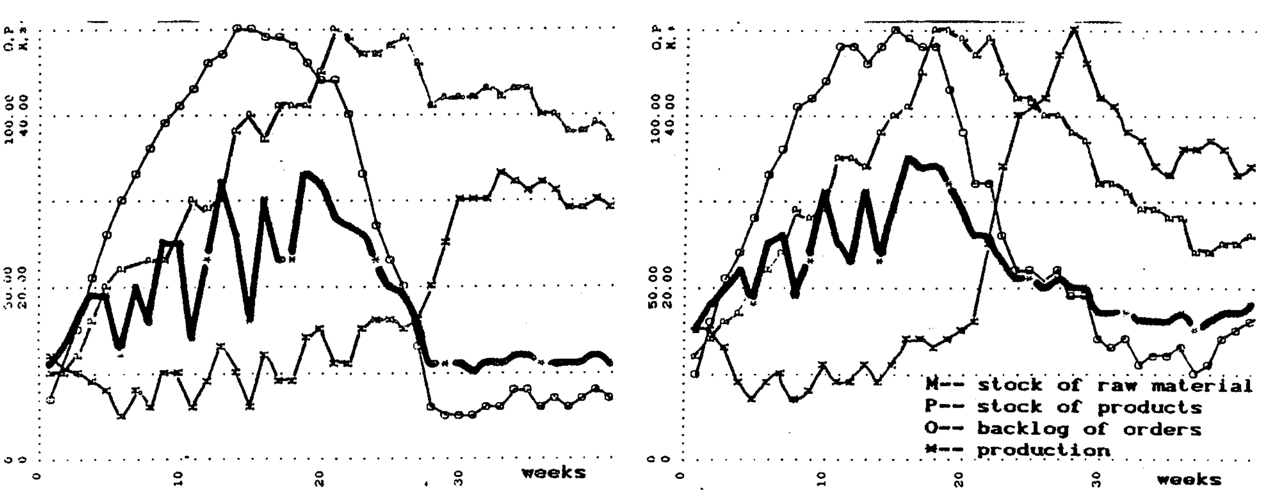
Firm 1 Firm 2

FIG. 6



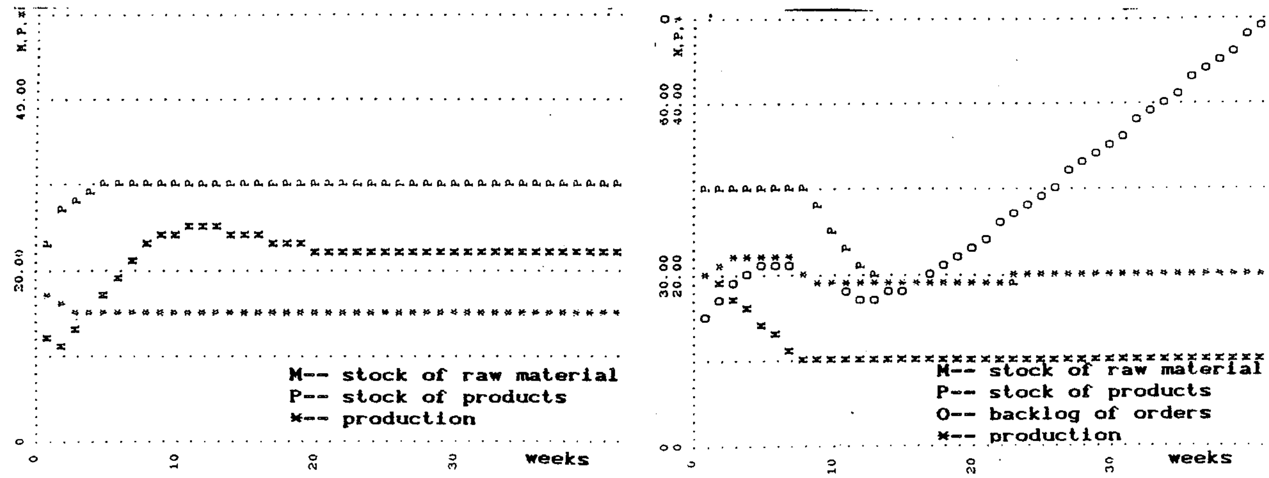
Firm 1 Firm 2

FIG. 7



Firm 1 Firm 2

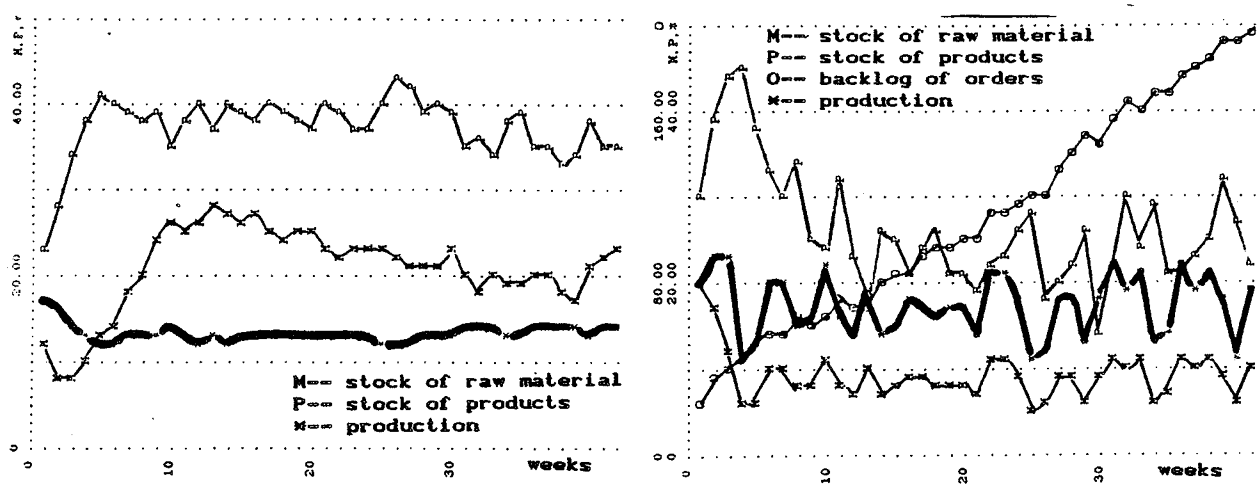
FIG. 8



Firm 1

Firm 2

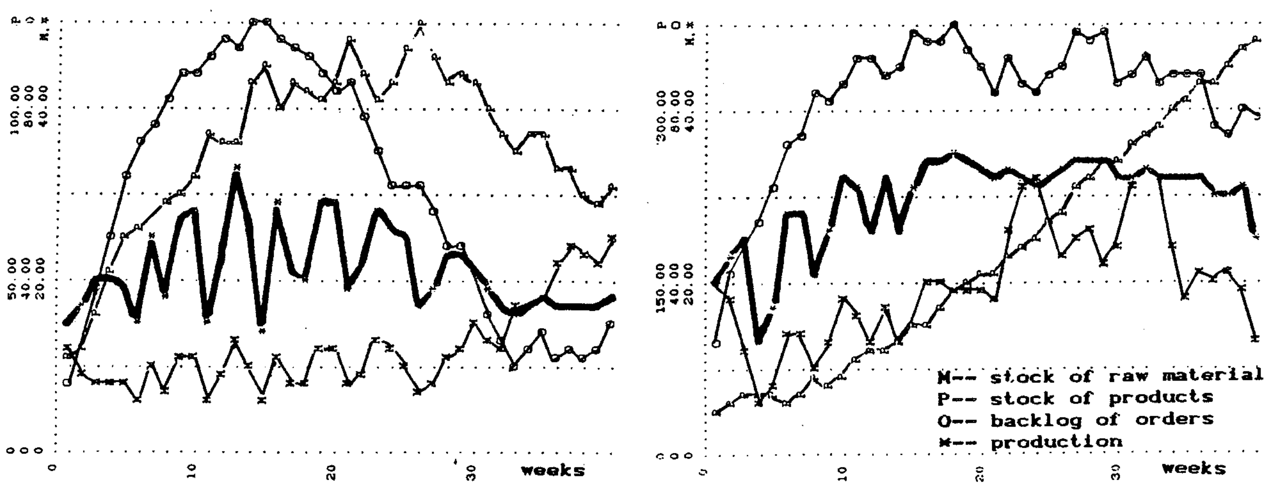
FIG. 9



Firm 1

Firm 2

FIG. 10



Firm 1

Firm 2

FIG. 11