

INDUSTRIAL PERFORMANCE AND A MARKET STRUCTURE
(A REVIEW OF A GAMING EXPERIMENT)

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ABSTRACT

This paper demonstrates patterns of industrial performance and factors of competitiveness in a representative gaming experiment carried out with a help of a simulation model of universal commodity production at Novosibirsk University. The paper inquires about disequilibrium dynamics of the modeling economy and concentrates on repeated decisions of players emphasizing the role of experience and learning in their behaviour. It analyses the intra- and inter-sectoral competition and path-dependent structures of production. The interpretation of experimental results is evoked by Marxian economic theory. The study shows that the applied theoretical framework can lead to propositions deduced or derived empirically in industrial economics.

INTRODUCTION

The model developed by K.K. Valtukh in collaboration with F.E. Pusep (Вальтукх and Пусеп 1988) basing on the formalised exposition of Marx's theory of commodity and surplus value (Valtukh 1987) reflects interconnections between technological and socio-economic sides of capitalist reproduction. This model was used as a teaching tool and as an instrument of investigation in the classroom (Ryzhenkov 1990, Ryzhenkov 1991). The present paper reports some new findings skipping a few details of the experiment .

I recall that there are three sectors specializing in manufacturing only one kind of commodity on strictly monoprodukt firms. Each kind of commodity can be produced by three or less technological modes. Every elementary technique can belong to different capitalists, but initially there are nine capitalists possessing nine firms with respective elementary techniques. Technological modes diffuse here endogenously mainly through imitations by new entrants. Inventions and innovations occurred in the past not considered explicitly.

A capitalist is allowed to construct a "new" firm with any given technique. There is no problem for him if he has only one "old" firm. But if the capitalist has two "old" firms, a creation of a "new" firm requires to give up at least one "old" firm. Stocks of raw materials from closed firms may be

productively consumed, yet their fixed assets are lost. These conditions imply the "administrative" market-entry and market-exit restrictions.

The structure of output in the basal year was such that commodities were sold at prices of production providing equal (positive) profit rates in all (three) sectors, the reproducible resources were fully utilized, workers bought necessary consumer goods to satisfy their normal needs.

At the same time in that idealized situation there were disequilibrium elements too: it is, perhaps, sufficient to mention here different magnitudes and composition of individual advanced capital, unequal profitability of firms and of techniques. Due to these (and to some other) elements the economy develops giving rise to new combinations of opposite tendencies.

Possible paths of evolution are not absolutely predetermined by the initial conditions and by the rules of the game in spite of purely deterministic form of all equations of the model. The point is that personal selective decision-making introduces stochastic elements in reproduction of capital. A bifurcation can occur at each situation depending on concrete decisions of the economic agents.

THE NON-LINEAR DISEQUILIBRIUM DYNAMICS

The dynamics of the main structural parameters, such as output, production capacity, prices, individual and social labour values (approximated by corresponding total labour input coefficients), profitability and others are displayed in Figures 1-20. The discrete points are connected by linear pieces for greater visuality.

The deep source of non-linearity is the endogenous technological progress. Although all techniques are characterised by fixed input coefficients and constant returns to scale at optimal combinations of inputs, a production possibility set is not a cone since the constraint of labour supply excludes a limitless expansion of existing plants (cf. Вальтух 1974). The division of investment into intensive and extensive, opening and closing of firms, disproportions of reproduction are immediate factors of non-linearity.

Disequilibrium *lato sensu* which was present already at the initial situation reproduces itself. Let us look at Figures 2, 10. At the very beginning of the game players having been endowed with money capital awaiting its application. Demand for elements of fixed assets for investing in the existing and in new firms rocketed. Still, the productive capacities of the second sector producing elements of fixed assets and stocks of the respective goods were too limited to match the increased demand. This disparity motivated the expansion of this sector amplified by the self-ordering. The production capacity tended to expand until output caught up to demand (cf. Sterman 1985, 18-21).

In each succeeding time interval the capacity (the "hun-

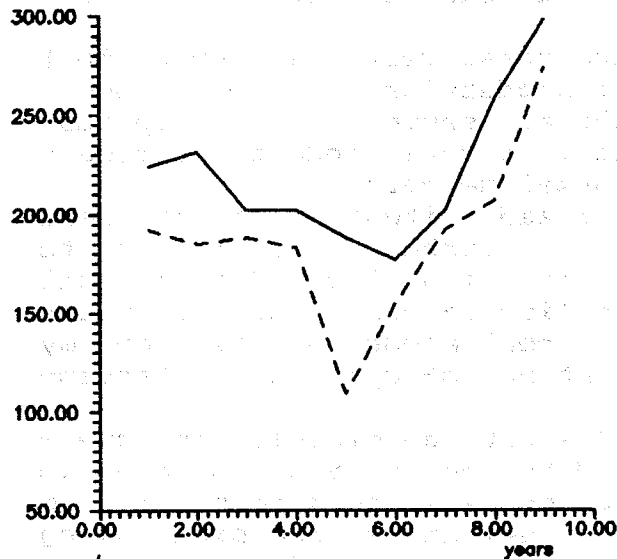


Fig. 1. Output and production capacity of the first sector (in physical terms)

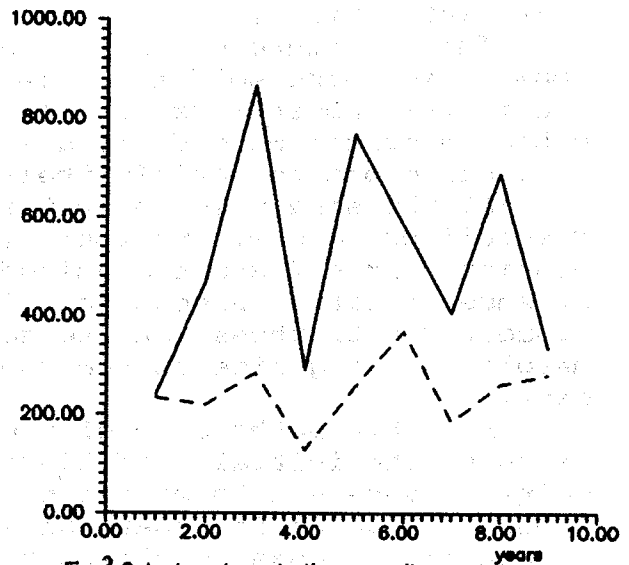


Fig. 2. Output and production capacity of the second sector (in physical terms)

Note. Output -----
 Production capacity _____

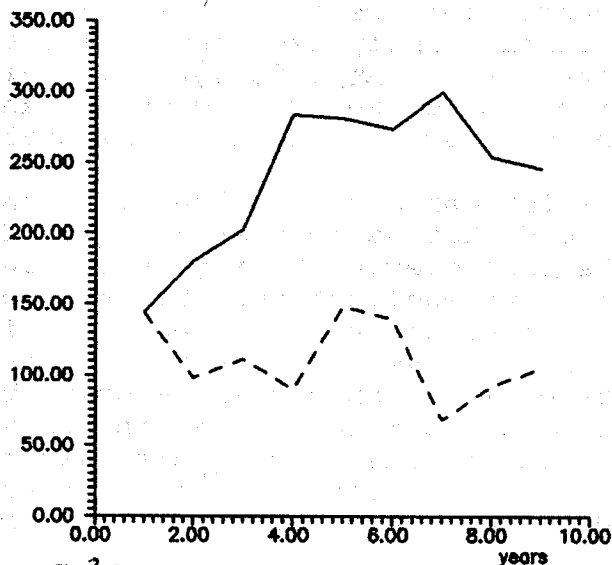


Fig. 3. Output and production capacity of the third sector (in physical terms)

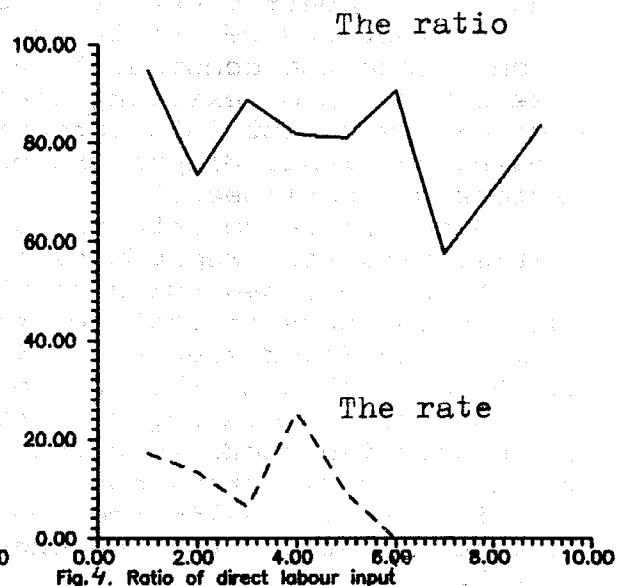


Fig. 4. Ratio of direct labour input to employment in the economy and rate of unemployment (%)

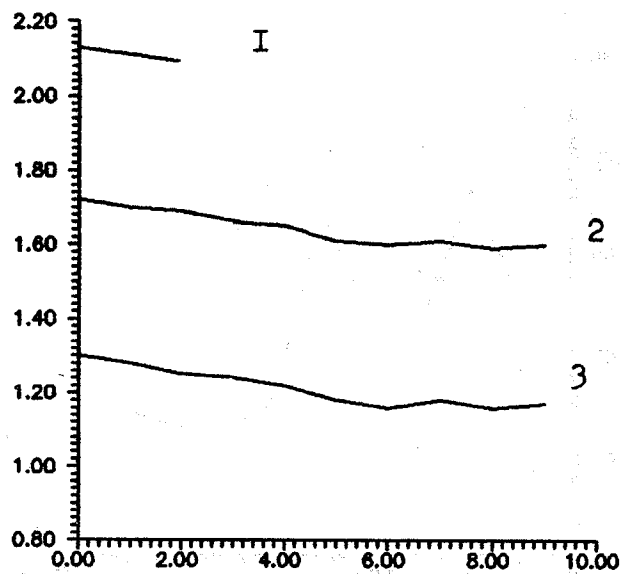


Fig.5. Individual values of the first commodity by technology (man-years/cost units)

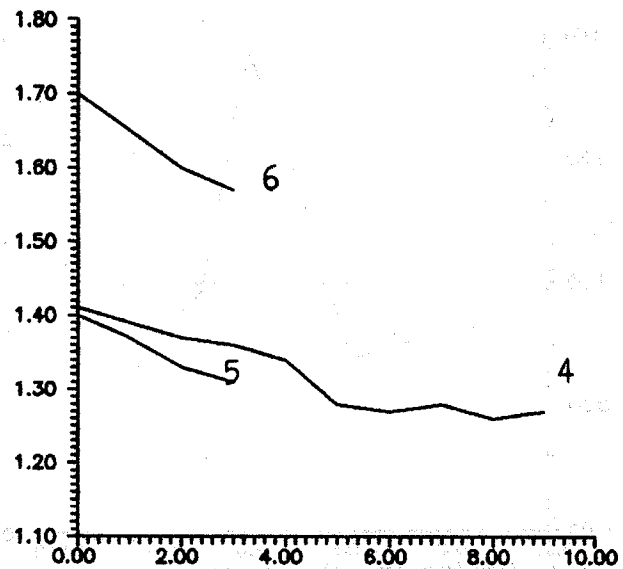


Fig.6. Individual values of the second commodity by technology (man-years/cost units)

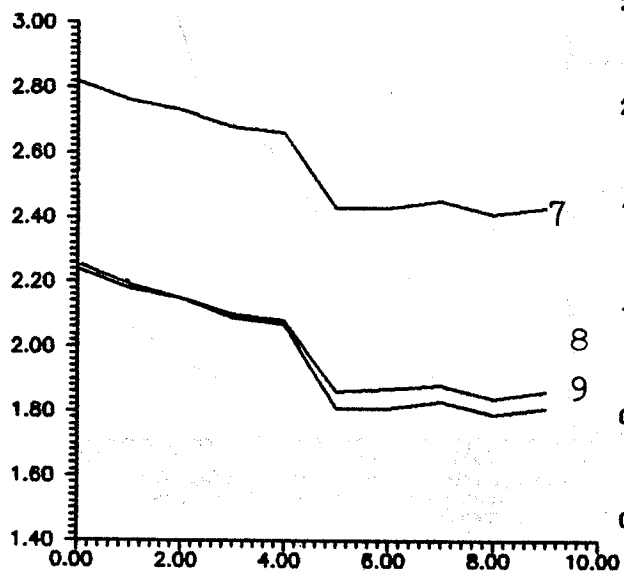


Fig.7. Individual values of the third commodity by technology (man-years/cost units)

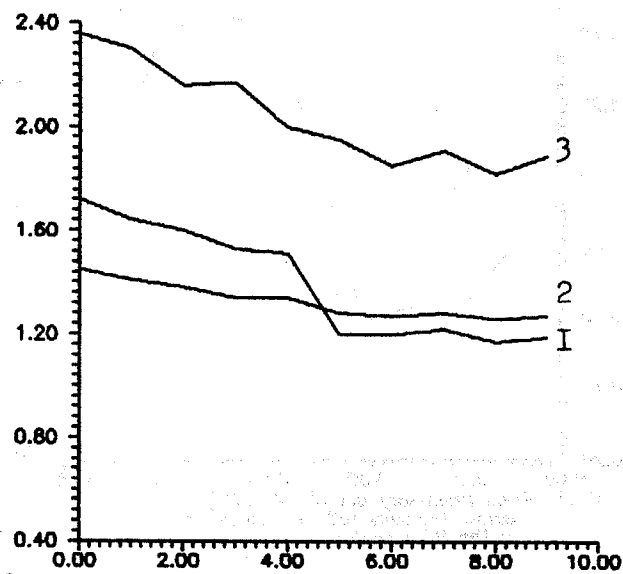


Fig.8. Total labour input coefficients by sector (man-years/cost units)

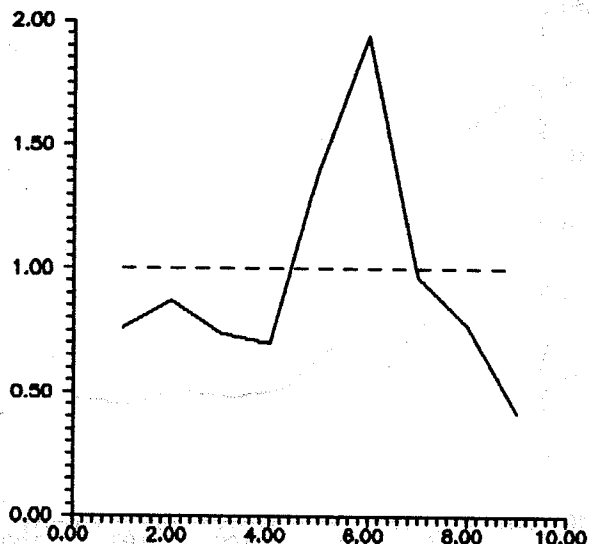


Fig. 9. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the first sector

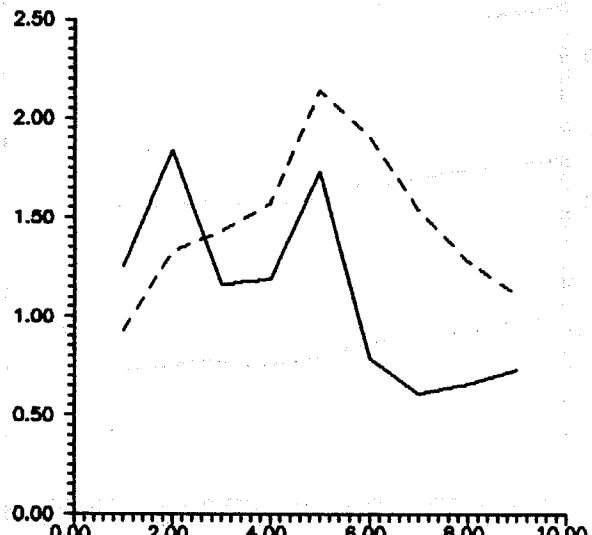


Fig. 10. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the second sector

Note. Demand-supply ratio ———
 Price (wage rate) - - - - -

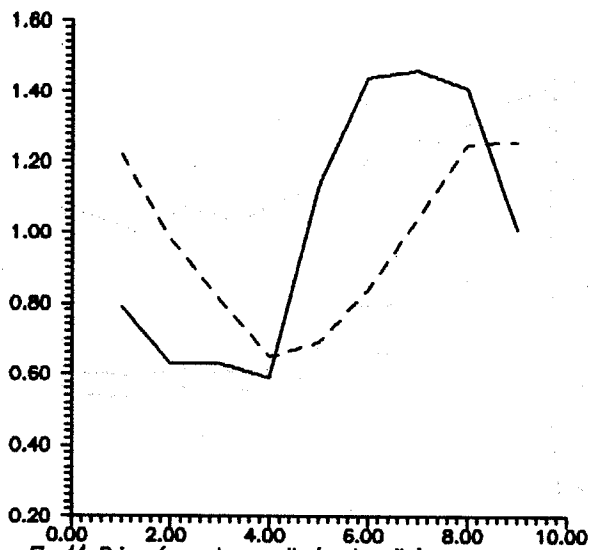


Fig. 11. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the third sector

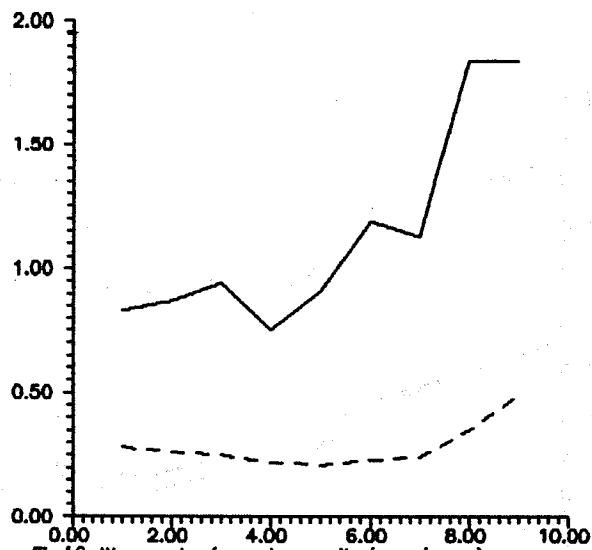


Fig. 12. Wage rate (monetary units/man/years) vs demand-supply ratio for labour power (dimensionless)

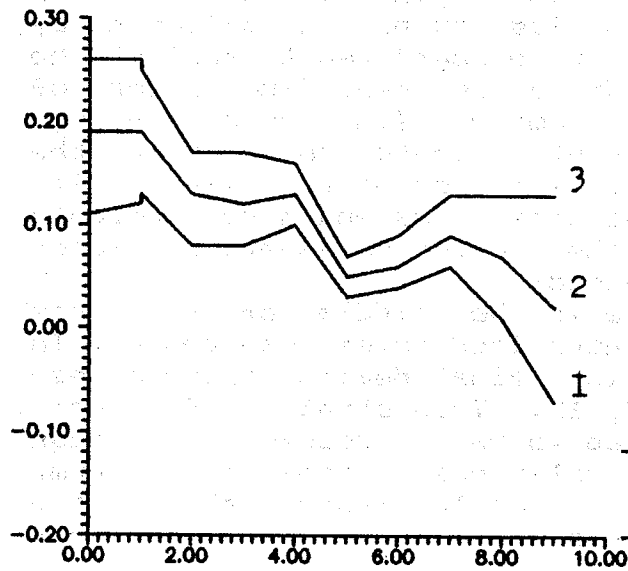


Fig.13. Profitability of the technological modes in the first sector (dimensionless)

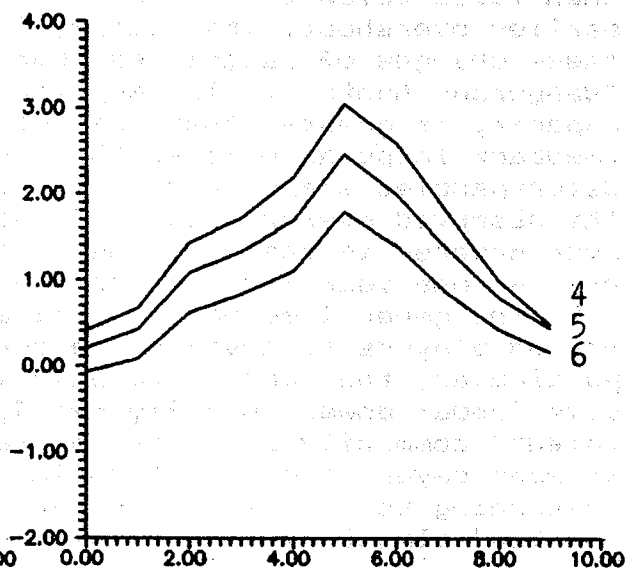


Fig.14. Profitability of the technological modes in the second sector (dimensionless)

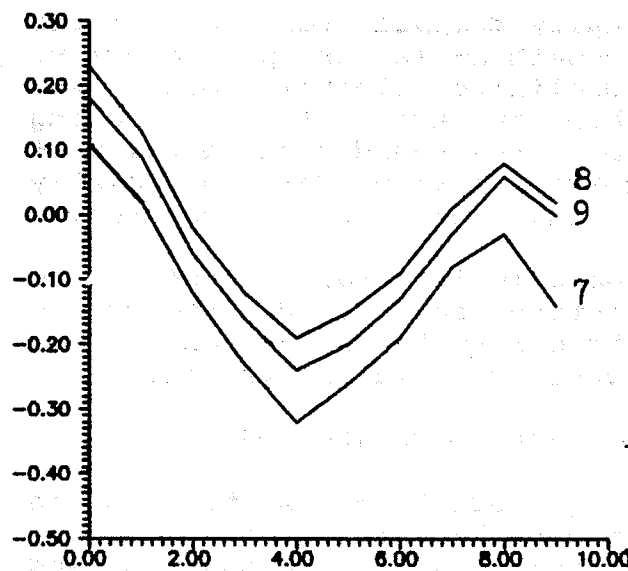


Fig.15. Profitability of the technological modes in the third sector (dimensionless)

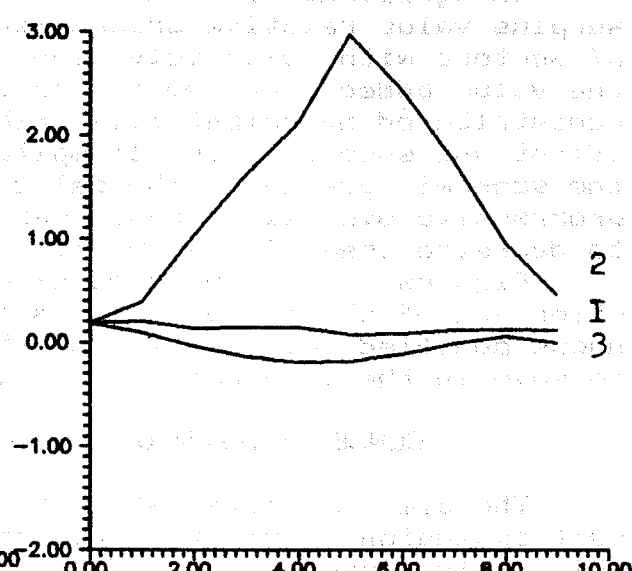


Fig.16. Rates of profit in the sectors of the economy (dimensionless)

er") overshoots the previous demand (the "running wild boar") then falls below in the next year in trying to correct the earlier overshoot. The demand, in its turn, is affected by these changes of capacities (our "wild boar" reacts against the "dangerous hunter"). The amplitude of recurrent fluctuations of capacity is greater than that of demand. Time delay in the feedback loops as well as the abrupt attempts to correct the discrepancies shape such behaviour (cf. Forrester 1976, 2-2). The observed overexpansion of the capacities would be probably even greater if the lifetime of the productive assets was longer than one year fixed in this sector.

The general economic decline in the middle of the game forced players to develop the centralized crisis management. In particular, they agreed to stimulate final demand hiring excessive labour power (see Figures 4, 12). This strategy of "benevolent" commodity producers proved to be successful, although it went beyond capitalist social relations in their pure form. (Returning to the risky metaphor, I could imagine that the "hunter" almost tamed the "wild boar".)

VALUES AND PRICES UNDER OLIGOPOLY

In each sector there is a dominant technique which is the most profitable. Dominated methods were either eliminated or suppressed while dominant ones diffused within the established sectors through new capital investments. Such choice of technique brings about some inefficiency from the social point of view since the most profitable methods are not necessarily the most labour-saving (cf. Figures 5-7, 13-15). A ranking of techniques according to profitability diverges from their ranking according to individual values. Due to disregarding innovations a tendency towards a technological uniformity and hence to eroding differences between firms' productivity levels was exaggerated.

In agreement with the classical theory of commodity and surplus value relative prices finally dropped for commodities of sectors with relatively high growth of labour productivity, the value added produced in the declining (third) sector was redistributed by competitive pricing in favour of the growing (first and second) ones. In spite of the bounded rationality of the economic agents technical change is to be defined socially progressive overall because magnitudes of social value tended to decrease (see Figures 5-8).

Figures 17-19 represent oligopolistic structures of production and of the markets. It is interesting that despite continuous modified reproduction of these structures prices tended to move in the long run in accordance with labour values.

CONCENTRATION OF CAPITAL AND FIRM TURNOVER

The aim of capitalist mode of production is to promote self-expansion of capital, but methods by which it accomplishes this imply depreciation of existing capital, stoppages and

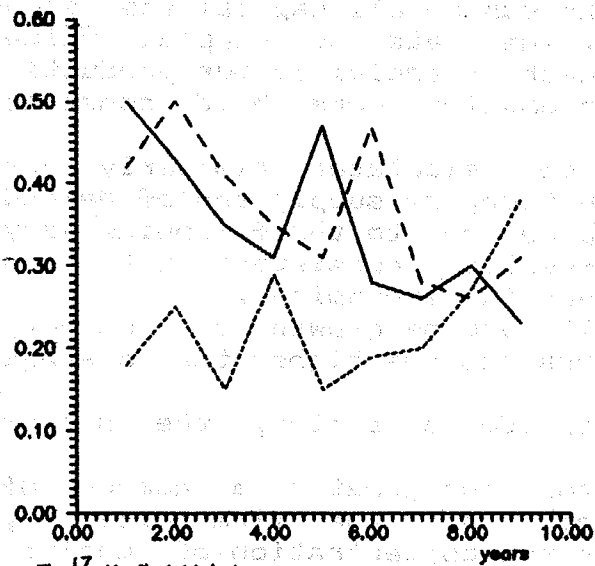


Fig.17. Herfindahl indexes for the first sector

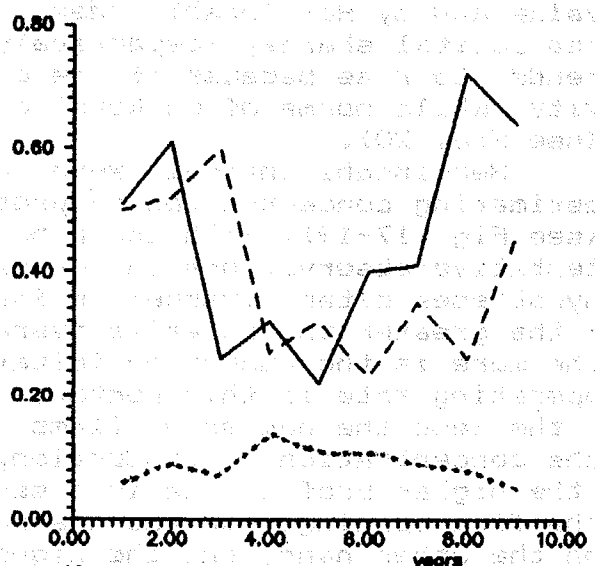


Fig.18. Herfindahl indexes for the second sector

Note. Producers' concentration _____
 Sellers' concentration - - - - -
 Buyers' concentration ·········

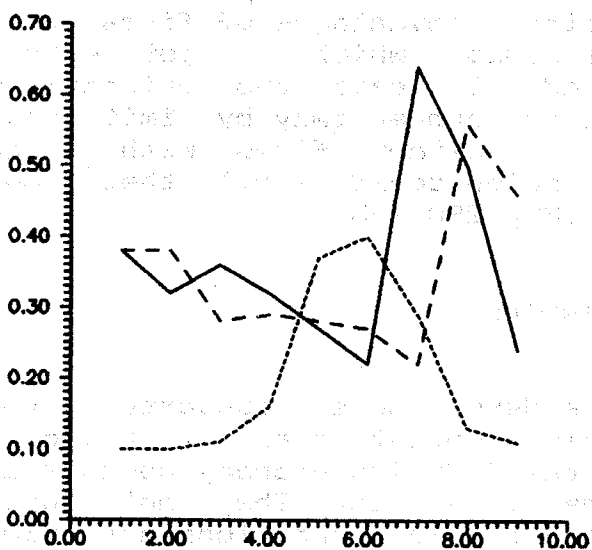


Fig.19. Herfindahl indexes for the third sector

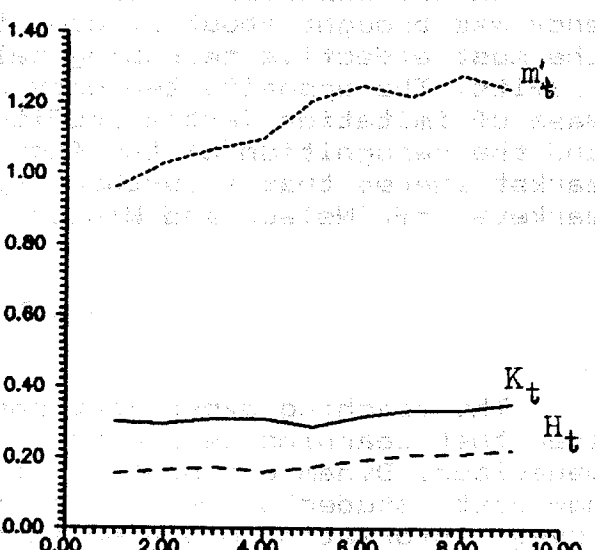


Fig.20. Accumulation of advanced capital K_t (ten thous. man-years), its concentration H_t (dimensionless) and rate of surplus value m'_t (dimensionless)

crises in the reproduction. This contradictory development was pronounced in our experiment too.

The processes of accumulation and of concentration of capital were rather monotonous judging by its total labour value and by Herfindahl index, the sum of all capitalists' squared capital shares, respectively. The rate of surplus value tended to rise because of the growth of social labour productivity while norms of workers' consumption were held constant (see Fig. 20).

Herfindahl indices were also calculated similarly for estimating concentration of production, of supply and of demand (see Fig. 17-19). With their help we come to the following very tentative observations in cross-section consistent with the hypotheses often advanced in industrial economics :

- the greater the relative overall rate of growth of output, the more is the number of imitators and the higher the average operating rate in this sector;
- the less the number of firms inside a sector, the higher the concentration of production;
- the higher profit rate in a sector, the greater a number of the firm openings, on the one hand, and of the firm closings, on the other hand, and the higher the concentration of supply;
- the lower the profitability of a sector, the more intensive the propensity to restrict production and supply of commodities among capitalists;
- the longer the lifetime of fixed assets in a particular sector, the higher the barrier to exit.

Our data do not warrant the hypothesis that the rate of imitation is higher in more competitive industries (cf. Mansfield 1961, 753). There was some apparent tendency for this rate to be lower in sectors with the longer lifetime of fixed assets, but it was difficult to isolate the influence of this factor from the influence of others.

In the experiment, *ceteris paribus*, the monopolistic tendency was brought about by competitive advantages of firms with the most effective technological modes, which got extra-profits. The opposite tendency had at least two origins: the ease of imitation (extra-profits are eroded away by imitators) and the recognition of the fact by extant firms with large market shares that a further expansion could spoil their own markets (cf. Nelson and Winter 1982, 280-295).

CONCLUSION

The teaching experiment considered above supports the idea that learning is a more basic concept than a rational behaviour. Dynamic evolution of the modeling economy depends on how fast students learn in the classroom. They not only reveal information embodied in the initial conditions and rules (like in the well-known game "Life") but create a new information as well via decision-making. The gaming experiment

helped to shed light on the controversial issues of economic theory thus stimulating the interest in learning and exploration.

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