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 (Вальтух 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 monoproduct 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

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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 rares in all (three) sectors, the reprodu-
cible 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 tech-
niques. Due to these (and to some other) elements the economy
develops giving rise to new combinations of opposite   tenden-
cies.

Possible paths of evolution are not absolutely predeter-
mined 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 Fi-
gures 1-20. The descrete points are connected by linear pi-
eces for greater visuality.

The deep source of non-linearity is the endogenous techno-
logical progress. Although all tecnniques are characterised by
fixed input coefficients and constant returns to scale at opti-
mal combinations of inputs, a production possibility set is not
a cone since the constraint of labour supply excludes a limit-
less expansion of existing plants (cf. Вальтух 1974). The divi-
sion 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 en-
dowed 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 catched up to demand (cf. Sterman 1985,
18-21).

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

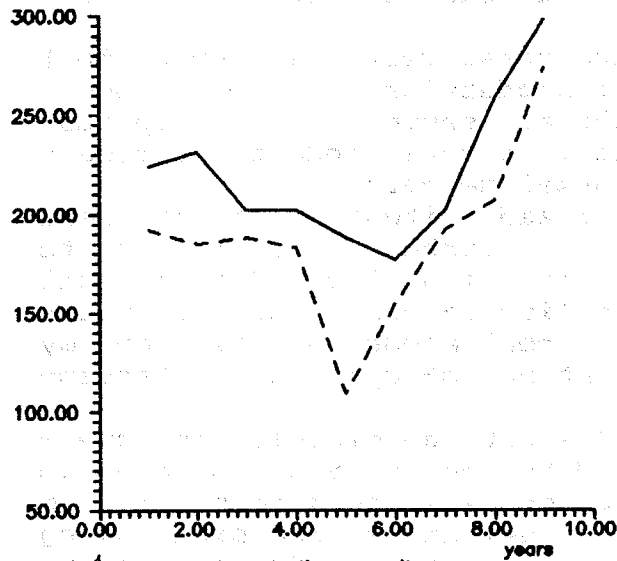Fig.1. Output and production capacity
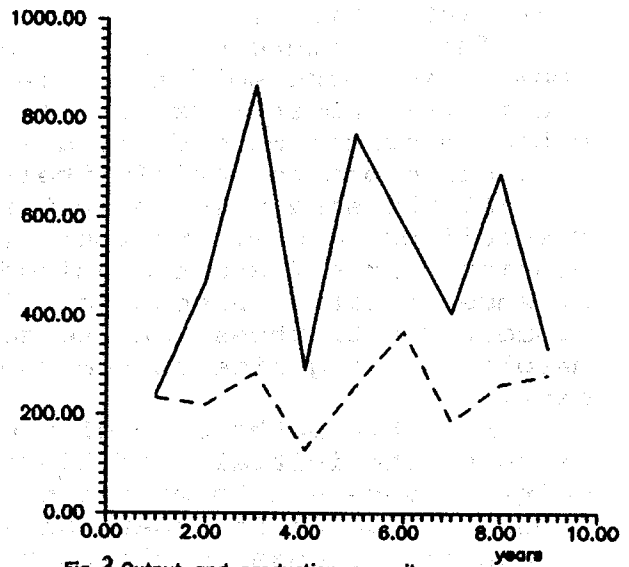   of the first sector (in physical terms)

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

Note. Output   _ _ _ _ _ _
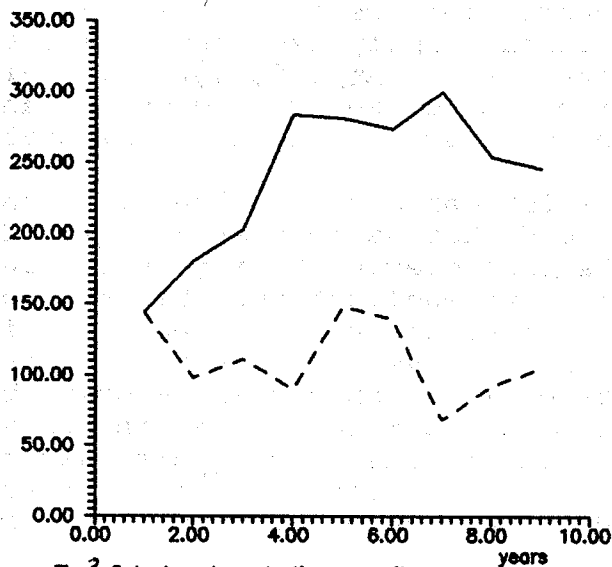   Production capacity _____

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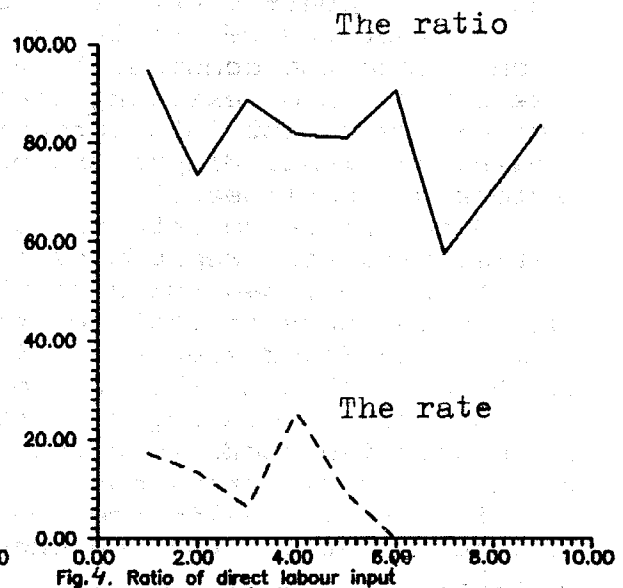   of the third sector (in physical terms)

The ratio

The rate

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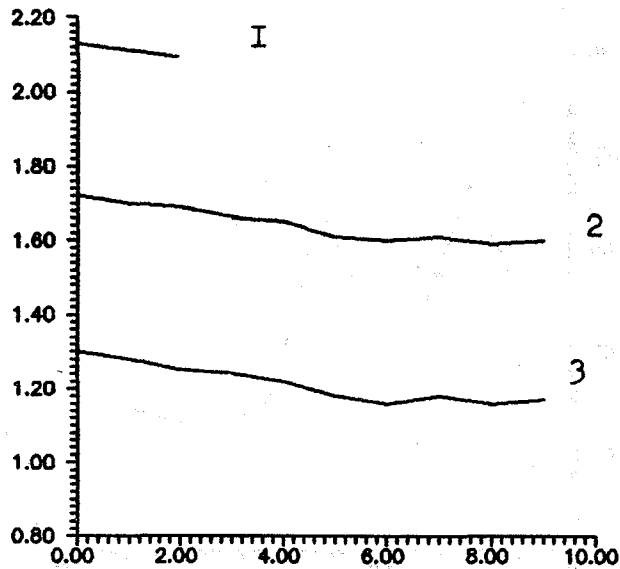   to employment in the economy and
      rate of unemployment (%)

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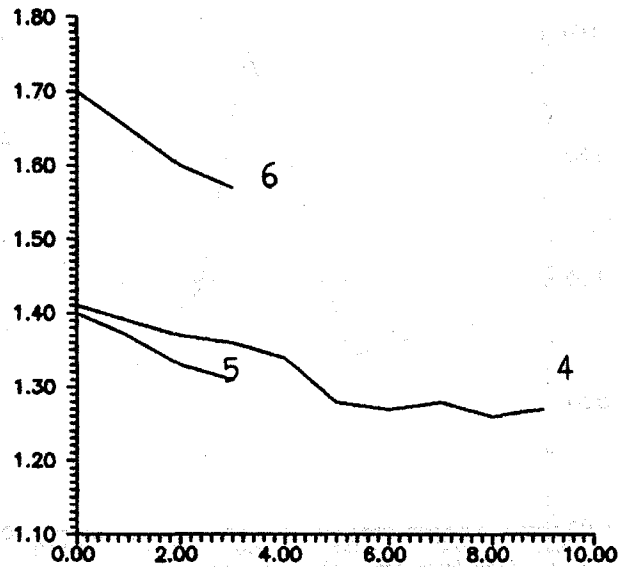by technology (man–years/cost units)

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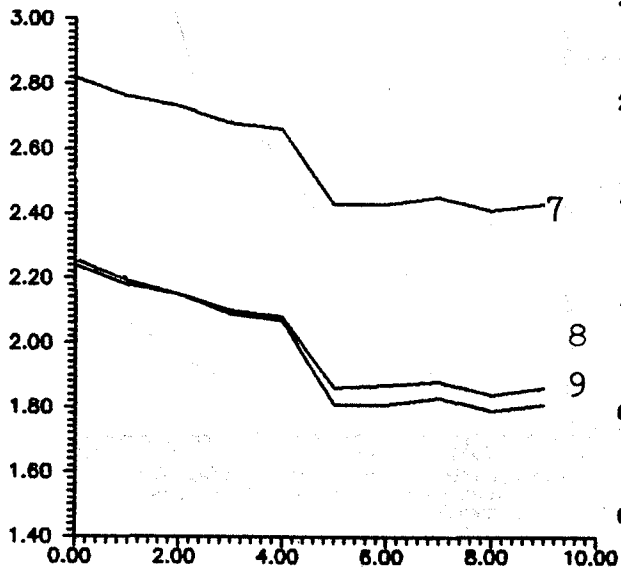technology (man–years/cost units)

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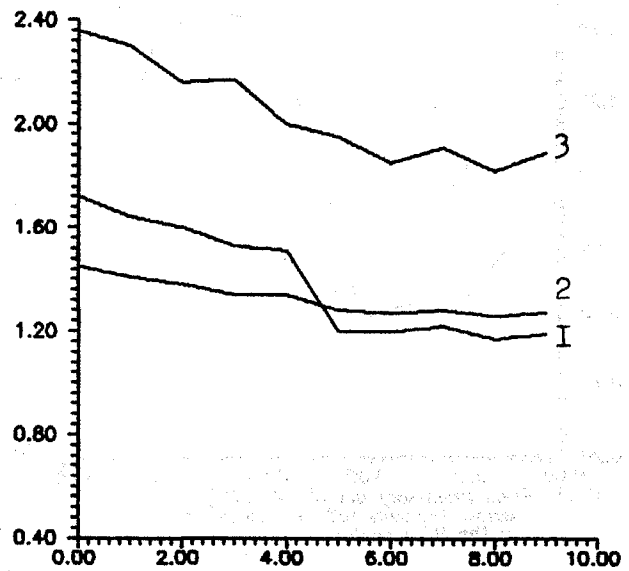technology (man–years/cost units)

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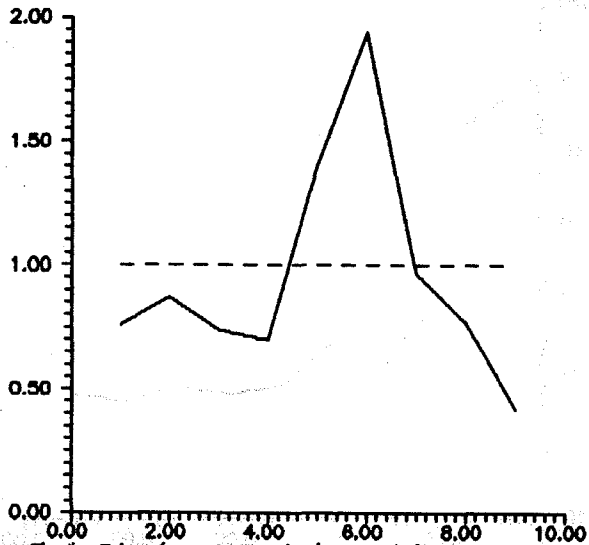sector (man–years/cost units)

Fig. 9. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the first sector
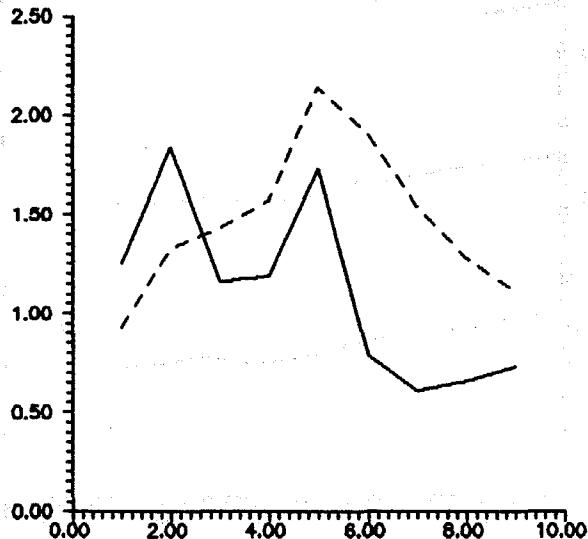
Fig. 10. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the second sector

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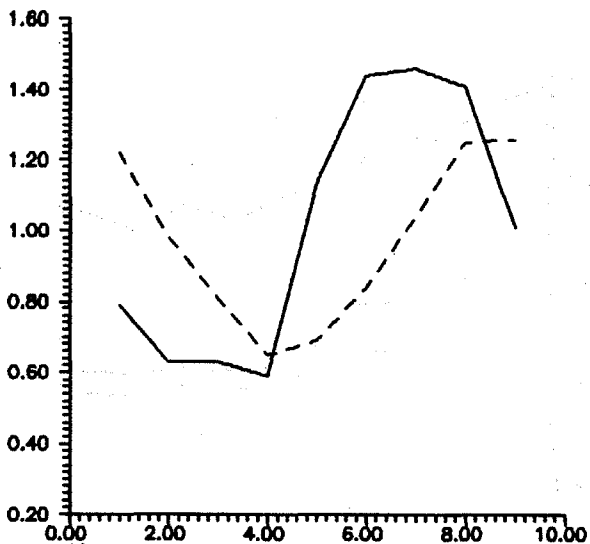   Price (wage rate)   ----------

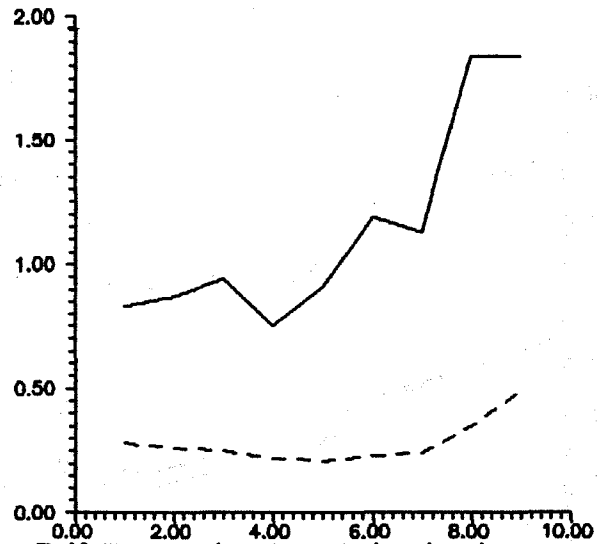Fig. 11. Price (monetary units/cost units) vs demand-supply ratio (dimensionless) in the third sector

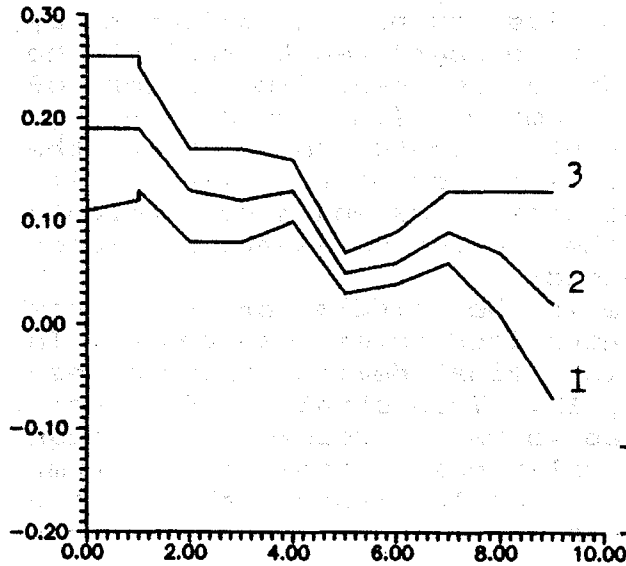Fig. 12. Wage rate (monetary units/man/years) vs demand-supply ratio for labour power (dimensionless)

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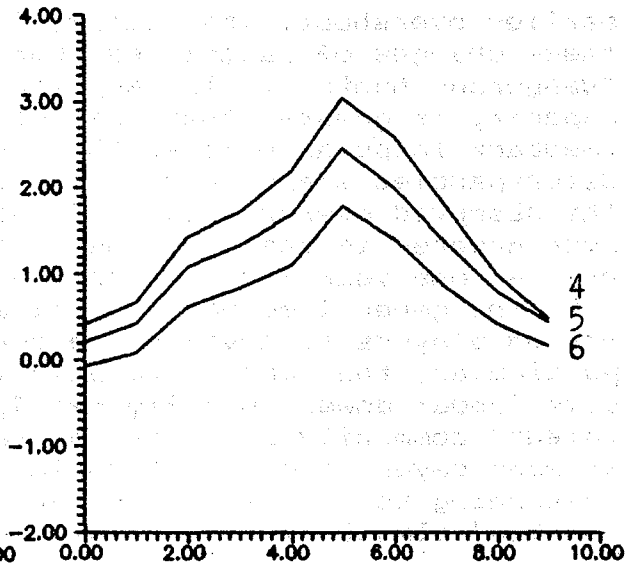

Fig.14.Profitability of the technological modes in the second sector (dimensionless)

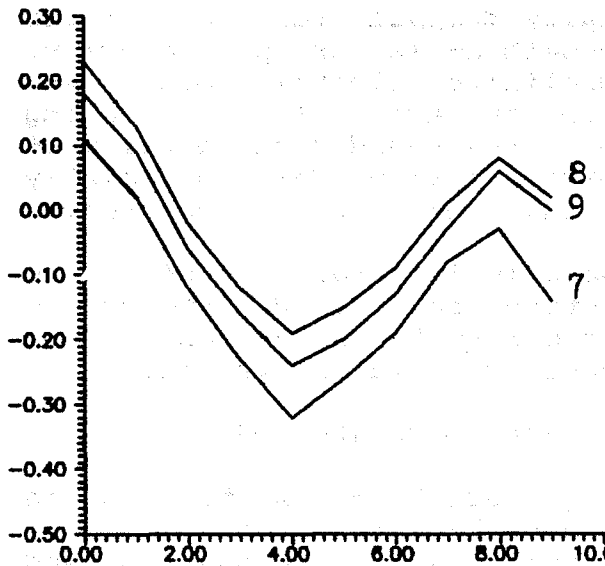
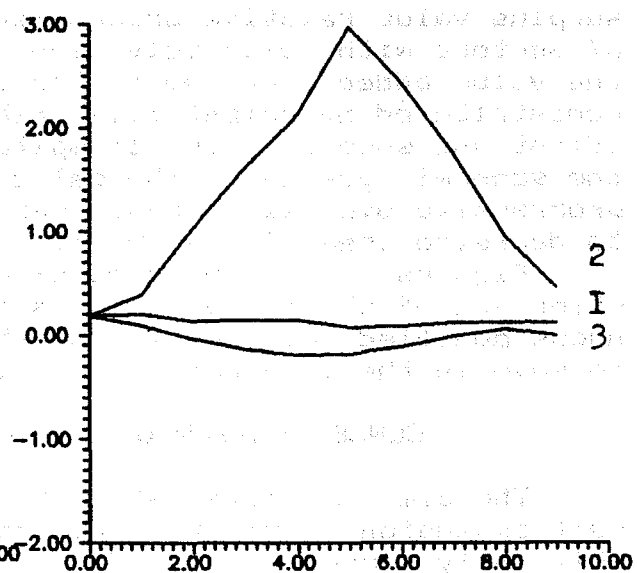Fig.15. Profitability of the technological modes in the third sector (dimensionless)

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 long-
er 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 exses-
sive labour power (see Figures 4, 12). This strategy of "bene-
volent" 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 tech-
nique 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 tech-
niques 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 produ-
ction and of the markets. It is interesting that despite conti-
nuous 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
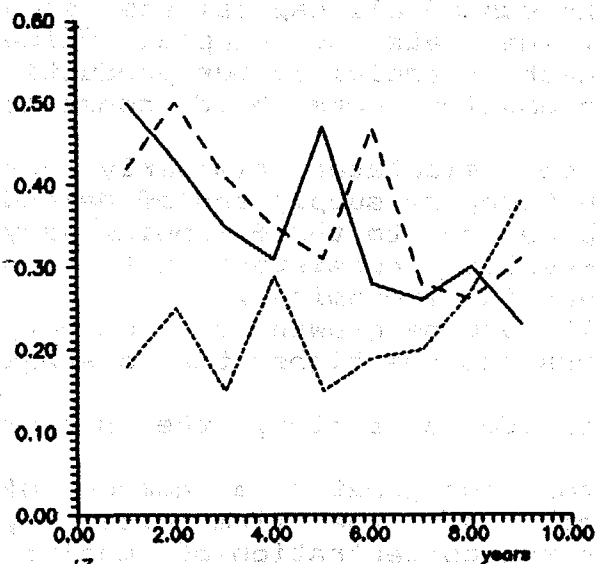this imply depreciation of existing capital, stoppages and
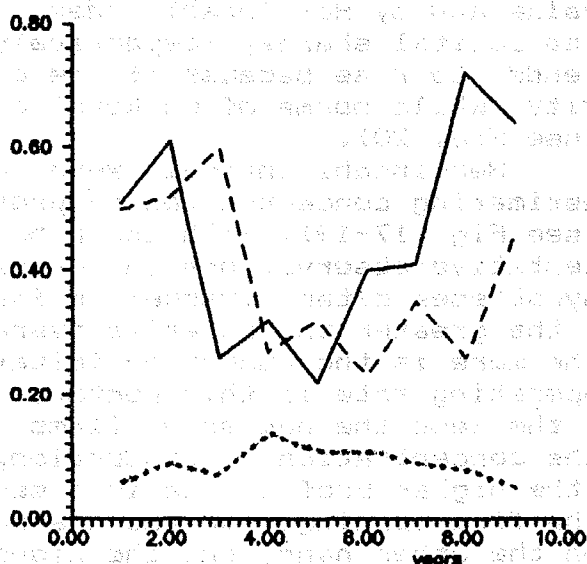
Fig. 17. Herfindahl indexes
for the first sector

Fig. 18 Herfindahl indexes
for the second sector

Note. Producers' concentration _____

Sellers' concentration   _ _ _ _ _ _ _ _ _
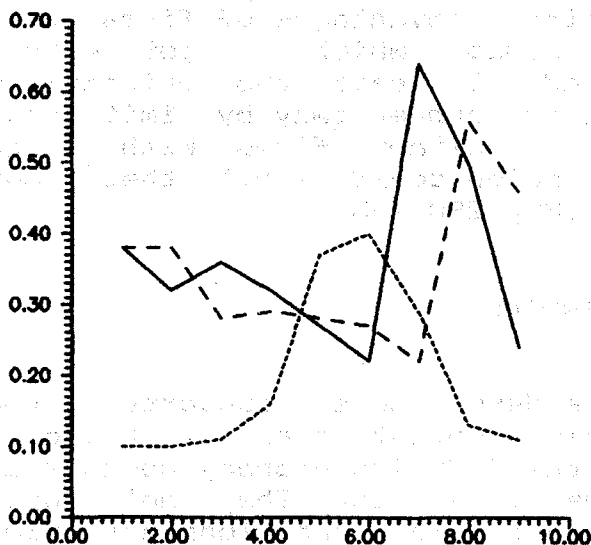
Buyers' concentration   •••••••••••••••••
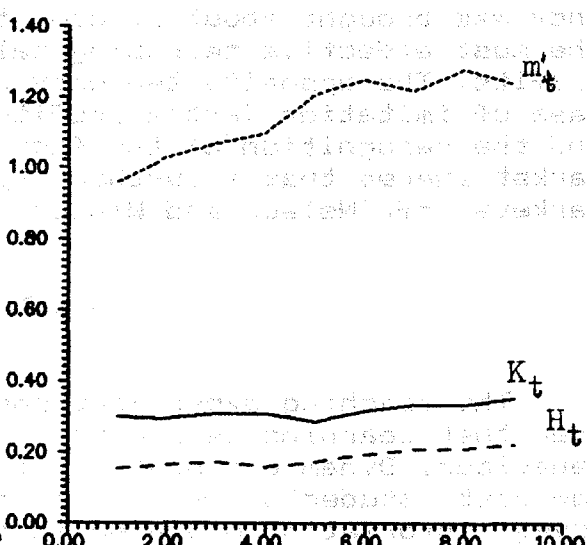

Fig. 19. Herfindahl indexes for
the third sector

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 commodites 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 hyposesis that the rate of imitation is higher in more competetive 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 controversal issues of eco-
nomic theory thus stimulating the interest in learning and
exploration.

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