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Teaching Experiments with a Simulation Model of Universal Commodity Production

Abstract

The paper considers how students learn commodity production and circulation via gaming experiments. We review two of them.

In the first, players run into reproduction on a decreasing scale aggravated if not caused by their non-cooperative behaviour. In this economy social and private benefits and costs diverge. Undertaking an investment a capitalist firm chooses typically that technique which maximises profitability, while the society is interested in that which requires the minimum input of labour.

In the second, players bring up extended reproduction resolving incompatible norms and setting new priorities with associated strategies of cooperative behaviour. Social and individual interests draw together consequently.

Introduction

There is a revival of belief in market economy all over the world. Still views on its nature are often superficial or even naive, for instance, among beginning students. They could be transformed into deeper understanding of the matter by means of simulation gaming.

Dramatic progress in the system dynamics methodology is apt to be linked with a formalised exposition of economic laws and non-observed factors.

Stochastic and dynamic phenomena (circulation of capital, fluctuations, etc.) are explicitly reflected in gaming experiments carried out at Novosibirsk University with a simulation model of universal commodity production.

This teaching tool describes interconnections between demand, investments, production capacities, output, supply and prices for three aggregated branches of a capitalist economy (Valtukh and Puseo 1988). An endogenous diffusion of innovations considered (still rather fragmentary) a separate component of the generation of new technology.

It turns out that players (owners of private firms) proceed in accordance with laws of capitalist reproduction. For example, a student can detect and investigate using self-acquired experimental data consequences of the law of value (unequal profitability of various technologies and firms, movements of relative prices, etc.).Students find out that greed for profit is a strong incentive to risk-taking, innovation and creativity. They pay attention to the seamy side of the

economy too (unemployment, aggressiveness of the firms and other).

The model woven through the educational process helps pupils to grasp a necessity of public control over reproduction according to uncovered economic tendencies, social priorities of efficiency and equity.

The paper is organized as follows. The next section presents the model sacrificing a mathematical description in the hope of achieving greater clarity of foundations under the space constraint. Later on two applications of this model are briefly examined. While students at the junior level did not accomplish effective economic growth, the elder fellowship modified successfully not only strategies and assumptions but the very norms of behaviour perhaps transiting from single-loop to double-loop learning (cf. Argyris and Schön 1978, 18-29).

The model and simplifications

A capitalist economy, or universal commodity production, is considered at a definite level of abstraction. All forms of economic activity extraneous or made outdated by capitalism are ignored. Moreover, some properties of capitalism are disregarded at this stage of the investigation.

It is supposed that workers are deprived of the means of production and sell their labour-power to capitalists. Natural resources are not scarce, all lands are nationalized and there is not a class of landlords.

There is a unified market for all commodities, including the labour power. The unity of the market manifests itself in depersonalizing of commodities of different owners. At any given data all commodities of a definite kind have the same unit price. There is no credit market in the economy, private consumption of capitalists is not taken into account. Supply of labour power is fixed as an exogenous magnitude.

Every sector consists of a number of single-plant firms. Each of them uses a unit technology and is a monoproduct one. Every sector specializes in manufacturing only one kind of commodity in such a way that inputs of all other products and of labour are indispensable. It is assumed that in all sectors but one producing elements of fixed assets a firm's output is intended exclusively for the market. Every capitalist owns a definite number of firms (one or two) which is less than a number of sectors (three). Thus the possibilities of natural economy and of autarchy are excluded. We abstract from international relations.

Both the period of production and the construction lag equal one year.

Functions of money, which can circulate or be hoarded, are attached to the first commodity. The commodity not saled is automatically transformed into money.

A total demand is compared annually with a total supply for each commodity. The minimum is traded at the price revised depending on the level of excess demand. The price of the first commodity is always identically one. Demanders or suppliers are proportionally rationed depending on the demand-supply ratio.

Products of the first sector are a raw material for the second and for the third sectors. Products of the second sector constitute elements of fixed assets in all sectors. Products of the third sector are used as a raw material in the first and in the second sectors. Finally, products of the second and of the third sectors are privately consumed by workers.

The reproduction is reflected with a help of a dynamic input-output model with technological methods of production. Each kind of commodities can be produced by three or less technological modes. Table 1 sets out direct input coefficients and coefficients characterising circulation of fixed capital in the economy. Every elementary technology can belong to different capitalists. But initially there are nine capitalists possessing nine firms with respective elementary technologies.

Social relations of the production system imply capital accumulation for profit. It is expected that technologies providing costs of production lower than social ones are, as a rule, getting a wide diffusion. They bring extra-profit to innovative firms. Every introduction of improved modes works on the new capital and on that already in action.

In our simulation model innovation activity is reduced to endogenous diffusion of technological modes mainly through imitations by new entrants. Inventions and product innovations are set aside.

A capitalist is allowed to construct a "new" firm with any given technology. 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, but their fixed assets are lost.

Firms cannot change the mix of products made in their existing plants or diversify production. A capitalists enter a sector only through construction of a new single-plant firm.

The capitalists were endowed by fixed assets and capital of circulation in the basal year. Yet they have not any materials inventory at the beginning of the first year (see Table 2).

Players (the capitalists) are informed about magnitudes of parameters in the basal (zero) year: prices of commodities, profitability of technological modes calculated at these prices (see Table 3). An organizer of the game can change exogenous parameters and coefficients if it is necessary.

Workers' decisions are reduced to determining a demand for consumer goods. This determination is carried out and processed automatically by a computer program.

Table 1. Input coefficients in physical terms and rates of renewal

RESOURCES	SECTORS								
	1			2			3		
	TECHNOLOGICAL MODES								
	1	2	3	4	5	6	7	8	9
Means of production									
product 1	0.	0.	0.	0.14	0.30	0.50	0.75	0.70	0.83
product 2 *	0.24	0.25	0.26	0.07	0.06	0.03	0.03	0.06	0.05
product 3	0.12	0.15	0.18	0.11	0.15	0.20	0.	0.	0.
Labour power	1.50	1.00	0.50	0.82	0.45	0.33	1.50	0.95	0.75
Rates of fixed assets renewal	0.20	0.20	0.20	1.00	1.00	1.00	0.10	0.10	0.10

*Product 2 constitutes elements of fixed assets. Its input coefficient represents the amount of fixed assets, in physical terms, which is wearing out in respect to the additional cost unit. The rate of renewal represents fixed assets wearing out during a year as a share of total fixed assets. This explanation is illustrated by the following example. Let a player wants to produce additionally 50 cost units of the first commodity using the third technique. It is necessary for him to buy and to install 65 cost units (in physical terms) of the second commodity (50 X .26/.2=65).

Table 2. Intersectoral and interpersonal distribution of initial endowments (in physical terms)

	ECONOMIC AGENTS (capitalists)								
	1	2	3	4	5	6	7	8	9
Capital of circulation									
idle money	60	160	60	35	126	32	44	110	61
stocks for sale									
commodity 1	60	160	60	0	0	0	0	0	0
commodity 2	0	0	0	44	160	36	0	0	0
commodity 3	0	0	0	0	0	0	32	80	48
Technol. identific. number	1	2	3	4	5	6	7	8	9
Industry code number	1	1	1	2	2	2	3	3	3
Fixed assets	58	160	62	3	9	1	7	43	22
Production capacity	48	128	48	44	160	36	29	72	43
Labour value of advanced capital (man-years)	289	781	296	128	461	108	161	440	249

Table 3. Indicators of the basal year

	RESOURCES			
	Commodity 1	Commodity 2	Commodity 3	Labour power
Price (monetary units/cost units)	1	0.83	1.37	0.30

	TECHNOLOGICAL MODES								
	1	2	3	4	5	6	7	8	9
Profitability	0.12	0.19	0.26	0.41	0.21	-0.07	0.11	0.23	0.18

Table 4. Some economic indicators of the reproduction on a decreasing scale

	YEAR								
	1	2	3	4	5	6	7	8	9
Demand for labour (man-years) *	487	624	570	598	148	397	147	118	167
Employment (man-years)	487	560	560	560	148	397	147	118	167
Direct labour input (man-years)	481	537	275	148	66	126	36	31	26
Wage rate (monetary units/man-years)	0.26	0.29	0.30	0.32	0.08	0.06	0.04	0.02	0.01
Investments (in physical terms)	59.2	84.6	62.6	152.4	101.8	6.0	3.1	2.6	5.12

* Supply of labour is always identically 560 (man-years).

Let us consider the sequence of synchronised actions of the capitalists.

1.Determining an intermediate demand for means of production and for labour power in physical terms under a rigid budget constraint.

2. Determining an investment demand for capital goods in physical terms for existing and new firms under the constraint of available money. A capitalist may choose for investing any technology according to data on profitability and other relevant information.

3. Determining a commodity supply in physical terms. The agents send only quantity messages. Every capitalist can supply commodities of the second and third sectors produced in the previous year and not yet saled. As for products of the first sector, their supply in the current year cannot be more than an amount produced in the previous year. According to rules of the game supply comprises from 95 to 100 per cent of the cumulative stock of commodities. This restriction softens monopoly effects.

4. Learning actual purchases for intermediate input and for investment.

5. Distributing circulating capital between firms and determining output. It must be equal or more than 98 per cent of the maximal level. This restriction is also done to soften monopoly effects.

6. Choosing firms and technologies to be used in the next year.

At the end of the round players are informed on results of their economic activity in the year of account. New round starts after a necessary pause.

Reproduction on a decreasing scale

Students started to learn the economic theory took part in the first game. Decision-making was decentralized.

The reproduction was characterised by very deep disproportions (see Tables 4 and 5).A market disequilibrium determined uneven dynamics of relative prices. Technical-and-economic efficiency of the economy was extremely low. The operating rate was not higher than 25% in the first sector, 38% in the second one and 32% in the third (from the fourth till the nineth year). The rate of unemployment increased to 70-79% (years 5,7-9), near 45% of employees were inactive (see Table 6). The production was very prodigal with its human and material resources.

Table 5. Prices (monetary units/cost units) and other indicators (in physical terms) of reproduction on a decreasing scale by branch

	YEAR								
	1	2	3	4	5	6	7	8	9
Supply of commodity 1	270	213	146	155	54	20	20	11	0.01
Demand for commodity 1	179	152	193	84	187	191	434	770	567
Output of sector 1	221	154	156	56	21	21	11	0.01	8
Production capacity of sector 1	224	177	174	225	122	137	67	53	43
Investments in sector 1	9.2	32.5	24.2	26.0	20.5	0.3	0.1	0	0.03
Supply of commodity 2	234	239	472	408	167	13	25	41	80
Demand for commodity 2	280	317	325	431	229	169	17	12	20
Output of sector 2	236	468	266	165	11	25	35	50	33
Production capacity of sector 2	240	601	1534	2298	3510	2232	93	178	167
Investments in sector 2	27.1	52.1	27.0	74.0	45.6	0.4	3.0	2.6	5.1
Price of the second commodity	0.99	1.32	0.91	0.96	1.32	17.05	14.5	9.42	5.88
Supply of commodity 3	154	184	79	1	22	74	149	160	145
Demand for commodity 3	110	159	186	117	1	27	4	17	21
Output of sector 3	141	47	0	23	54.8	103	17	2	0
Production capacity of sector 3	144	154	9	23	115	237	226	206	167
Investments in sector 3	22.9	0	11.4	52.4	35.7	5.3	0	0	0
Price of the third commodity	0.97	0.84	1.98	242.9	14.91	5.49	2.82	1.56	0.89

Table 6. The efficiency indicators of reproduction on an decreasing scale(%)

	YEAR								
	1	2	3	4	5	6	7	8	9
Operating rate in sector 1	98.7	86.5	89.4	24.9	17.0	15.5	16.7	0.02	19.5
Operating rate in sector 2	98.4	78.0	24.9	17.0	0.3	1.1	37.5	28.1	20.0
Operating rate in sector 3	98.4	30.5	0.0	99.9	47.8	43.5	7.3	0.74	0
Ratio of direct labour input to employment in the economy	98.9	95.9	49.1	26.4	11.8	31.7	24.5	26.3	15.6
Rate of unemployment	13.0	0	0	0	73.6	29.1	73.8	78.9	70.2

Table 7. Ranks of technologies according to their profitability

Technology	YEARS 0	1	2	3	4	5	6	7	8	Sum	Final ranks
1	3	4	4	2	6	5	3	3	3	33	1.5
2	5	5	6	3	5	4	1	2	2	33	1.5
3	8	7	5	4	4	6	2	1	1	38	3
4	9	9	9	5	3	3	9	9	9	65	9
5	6	8	8	1	2	2	7	7	8	49	7.5
6	1	6	7	6	1	1	8	8	7	45	4
7	2	1	1	7	9	9	6	6	6	47	6
8	7	3	3	9	7	7	4	4	5	49	7.5
9	4	2	2	8	8	8	5	5	4	46	5

Table 8. Distribution of investment projects

Tech-nology	YEAR 1	2	3	4	5	6	7	8	9	Sum	Final ranks
1	1	-	1	1	-	1	-	-	1	5	3.5
2	-	1	-	-	1	-	1	-	-	3	1
3	2	2	1	1	1	-	-	-	-	7	6
4	3	2	3	1	1	1	4	1	2	18	9
5	-	2	2	-	-	1	1	2	1	9	7
6	-	1	1	2	1	-	3	1	3	12	8
7	-	-	-	-	2	2	-	-	-	4	2
8	2	-	-	3	-	1	-	-	-	6	5
9	1	-	1	1	1	1	-	-	-	5	3.5

During nine years 69 investment projects were carried out, including 42 (61%) aimed at an extension of given production capacities, 10 (14%) connected with opening of new firms by capitalists in sectors of their previous activity, 17 (25%) represented new entrants.

We think, the fact that nearly two thirds of the number of all projects intended for extended reproduction of existing firms follows from the necessity for compensating the advanced capital embodied in factory buildings, machinery and equipment. Moral depreciation of fixed capital results from unequal profitability of technological modes in every sector. Fixed assets of less profitable modes should be considered morally obsolete. Closing a firm its owner usually suffers losses if capital cost amortization is far from being completed. In addition, there is the important restriction in this game: an owner of two firms loses fixed assets of one or two of them at his discretion after investing to a new technology.

Yet venturers can try to set off a loss by means of new endeavours. Tables 7 and 8 list ranks of technologies according to both indicators (a profitability level and a number of investment projects engaged). Spearman's rank correlation coefficient between final ranks was equal to 0.55 (connections were disregarded). This magnitude seems to be significant. I would add that new entrants did not choose any technological mode with the lowest profitability inside a sector.

Table 9 sets out data on relative profitability of the sectors. A flow of capital to sectors with higher profitability was illusrated by the fact that final ranks of sectors ordered according to their profitability, on the one hand, coincided with ranks of these sectors ordered according to cumulated net investment, on the other hand.

Sectoral profitability was also congruent with corresponding firm turnover: the higher profitability, the higher either opening or closing rates (cf. Tabl.10). This finding tentatively suggests profitability as the characteristics of industry that gives rise to across industry differences in turnover (cf. Dunne, Roberts and Samuelson 1988).

A deficiency of resources and/or a low profitability declared to be the immediate reason behind firms closing. Players preffered a partial closing of business with redistribution of resources in favour of more profitable sectors to a whole closing of their firms.

Despite of these signs of rationality on the microlevel, there were two severe crises in this economy. The first one burst up in the second and third years. At that time the third sector was unprofitable because of excess supply of its commodities already in the first and second years. Capital fled this sector. Almost all stocks of its commodities were saled in the third year. Yet a demand for them was brisk and became unsatisfied. The relative price of the third commodity grew followed by profitability of its production. The intersectoral flow of capital radically changed its direction.

A behaviour of the sixth capitalist deserves mentioning. He forestalled his competitors investing capital in the third sector in the third year alone and got an extra-profit two years later. The reduced

Table 9. Ranks of sectors according to their profitability (reproduction on a decreasing scale)

	YEAR									Sum	Final ranks
	0	1	2	3	4	5	6	7	8		
Sector 1	2	2	2	1	2	1	1	1	1	13	1
Sector 2	2	3	3	2	1	2	3	3	3	22	3
Sector 3	2	1	1	3	3	3	2	2	2	19	2

Table 10. Firm turnover over nine years (ranks in parenthesis)

	Initial number of firms	Number of openings	Number of closings	Number of firms in nineth year
Sector 1	3	5 (1)	6 (1)	2 (1)
Sector 2	3.	14 (3)	9 (3)	8 (3)
Sector 3	3	8 (2)	7 (2)	4 (2)
Total	9	27	22	14

Table 11. Dynamics of labour input coefficients (man-years/cost units) by kind and by branch *

	sector 1			sector 2			sector 3		
year	$\sum w_i^t a_{ij}$	l_j^t	w_j^t	$\sum w_i^t a_{ij}$	l_j^t	w_j^t	$\sum w_i^t a_{ij}$	l_j^t	w_j^t
1	0.72	1.00	1.72	0.95	0.50	1.45	1.36	1.00	2.36
2	0.69	1.13	1.82	0.76	0.68	1.44	1.36	0.95	2.31
3	-	-	-	-	-	-	-	-	-
4	0.64	0.73	1.37	0.70	0.55	1.25	1.20	0.75	1.95
5	0.66	0.51	1.17	0.56	0.71	1.27	0.95	0.87	1.82
6	0.73	0.50	1.23	1.04	0.34	1.38	1.00	1.04	2.04
7	0.68	0.51	1.19	0.86	0.43	1.29	1.02	0.94	1.96
8	0.83	1.50	2.33	1.32	0.57	1.89	1.79	1.33	3.12
9	-	-	-	-	-	-	-	-	-

*Coefficients for years 3 and 9 were not calculated because of the work stoppages.

supply of products of the third sector brought about very low capacity utilization in the first and in the second sectors in the third and fourth years.

Transferring capital to the third sector other players miscalculated. Beginning from the fifth year till the end of the game more than 50% of the production capacity in the third sector were not used. After redistribution of productive capital in favour of this and the second sectors capitalists were short of products of the first sector and were forced to reduce output.

Only two firms survived in the first sector. But one of them was practically negligible. An owner of the other one (the monopolist) decided to transfer resources (raw materials and labour power) to his firm operating the most profitable fourth technology in the second sector.

In one year after production practically ceased in the first sector there were work stoppages in the third and second sector as a result of raw materials deficiency.

The third year was the last one more or less favourable for workers suffering from miserable living conditions at the end of the game. In the nineth year a nominal wage rate was 26 times less than it was in the first year. This outcome reminds us of Marx's conclusion that wage is a function of capital accumulation. Buying cheap labour power capitalists were not interested in labour-saving technical change.

For individual labour values, technologies 3,5 and 9 posted the lowest levels for respective sectors. Still these technologies attracted only 21 investment projects (30%) of 69. On the other hand, the sixth technology, which was socially most ineffective (the value of its output hardly covered the relating production cost in labour value terms), attracted 12 investment projects. These facts illustrate collective irrationality again.

Table 11 sets out the sectoral dynamics of direct labour input coefficients (l_j^c), indirect labour input coefficients ($\sum w_i^c a_{ij}$) and total labour input coefficients (w_j^c). A certain decline of these indicators in the fourth year was not consolidated in the subsequent period. The dominant tendency was, obviously, retrogressive.

Expanded reproduction

This case study demonstrates the improved outcome. A degree of cooperation was determined endogenously by experienced players. The game consisted of 11 rounds. Being limited by space, we omit here some illustrative tables.

Technical-and-economic efficiency was higher than in the previous case (cf. Tables 6 and 12). Moreover, main economic indicators (output, accumulated capital, employment and others) displayed an increasing scale of reproduction.

Table 12. The efficiency indicators of reproduction on an increasing scale (%)

	YEAR								
	1	4	5	6	7	8	9	10	11
Operating rate in sector 1	99.6	98.5	100.0	48.5	52.7	91.8	94.6	95.3	82.7
Operating rate in sector 2	97.1	84.7	63.8	83.4	53.7	65.5	84.2	87.9	98.1
Operating rate in sector 3	99.3	77.2	53.4	68.8	96.1	86.2	98.1	84.5	71.2
Ratio of direct labour input to employment in the economy	99.0	96.6	93.3	96.5	98.3	88.9	95.0	91.6	91.8
Rate of unemployment	12.9	0	11.6	0	4.6	0	0	0	0

Table 13. Dynamics of labour input coefficients (man-years/cost units) by kind and by branch

year	sector 1			sector 2			sector 3		
	$\sum w_i^t a_{ij}$	l_j^t	w_j^t	$\sum w_i^t a_{ij}$	l_j^t	w_j^t	$\sum w_i^t a_{ij}$	l_j^t	w_j^t
1	0.71	1.00	1.71	0.94	0.50	1.44	1.36	1.00	2.36
2	0.69	0.94	1.63	0.71	0.66	1.37	1.23	1.02	2.25
3	0.69	0.85	1.54	0.65	0.69	1.34	1.22	0.97	2.19
4	0.66	0.64	1.30	0.55	0.72	1.27	1.02	0.90	1.92
5	0.66	0.61	1.27	0.55	0.71	1.26	0.99	0.91	1.90
6	0.64	0.50	1.14	0.50	0.72	1.22	0.91	0.90	1.81
7	0.65	0.50	1.15	0.46	0.78	1.24	0.91	0.90	1.81
8	0.62	0.50	1.12	0.60	0.56	1.16	0.91	0.87	1.78
9	0.61	0.50	1.11	0.64	0.49	1.13	0.89	0.88	1.77
10	0.61	0.50	1.11	0.66	0.45	1.11	0.90	0.87	1.77
11	0.61	0.50	1.11	0.64	0.49	1.11	0.88	0.89	1.77

I think the second game can be divided into two connected stages: the first one from the year 1 to the year 6, the second one from the year 7 to the year 11. An economic crisis in the sixth year established a border between both stages.

At the beginning of the second game the first and second (more profitable) sectors were expanding, while the third one was shrinking. Uneven development of these sectors caused disturbances in reproduction. Thus, in the years 5 and 6 output affected by a deficit of the first commodity decreased while unemployment and excess production capacity rose.

From the first till the sixth year the technologies 1,2,6,7, that did not belong to effective ones according to both criteria of efficiency (profitability and a level of individual value), were removed from production. Note that relative efficiency of a technological mode is to a great extent invariant to changes of prices and values of commodities. In the subsequent years these technologies were not applied too.

The first stage of the game showed that behaviour of players became both individually and collectively more rational than in the first game. The higher profitability of a technology or of a sector was, the greater number of investment projects it attracted. Most profitable technologies attracted the main share of all investment projects. For instance, there were 21 of the total number of 44 directed to the fourth technology, which was the most profitable.

The third technology was the most efficient one in the first sector according to both our criteria. In the second and in the third sectors the minimal individual labour values could be achieved by application of the technologies 5 and 9, yet they did not engage investments. This fact illustrates that the contradiction between individual and social interests is characteristic of market economy.

At the end of the sixth round the players decided to coordinate closely their behaviour in order to achieve reproduction on an increasing scale. A new deal, like the New Deal of the Roosevelt government, was an attempt to pull economy out of the crisis. Decision-making was to a great extent centralized, which could possibly change the very nature of social relations.

Players closed four firms with the fourth technology (it had been most profitable) and sumiltaneously invested into the fifth one, which was more effective in regard to total input of labour. By this way excessive production capacity in the second sector were reduced. Owing to investments in the technologies 8 and 9 the deficit of the third commodity was eliminated in the nineth year.

We made a comparison between final ranks of three sectors ordered by a number of investment projects, on the one hand, and by a profitability level, on the other hand. Their coincidence on the first stage of the game was not an outcome yet .

After some kind of the Schumpeterian "creative destruction" our players used only the most effective technologies (3,5,8 and 9) in each sector at the end of the game (the year 11).

The extended reproduction was achieved. For the period from the first to the eleventh year the highest growth was recorded for the first sector (+40%) while the second and third sectors showed lower increases (+30% and 36%, respectively). Pre-critical maximums of output were exceeded in the first and in the third sectors, yet an adverse effect of over-production took place in the latter one.

The pre-critical maximum of output was not achieved only in the second sector. Still to the end all its stocks of commodities were sold out and its production capacities rose at the first time after the seventh year.

This experiment seems to confirm that total output and employment are more easily maintained if decisions are centralized. It is not yet settled whether the keeping full employment necessary implies over-production in some branches of the economy (cf. Pasinetti 1981, 239-240).

Total capital rose by 28% in regard to the first year and by 39% in regard to the basal year. All capitalists but one (the sixth) became richer. The sixth capitalist was hardly a loser as he was possessed of two profitable firms with their effective technologies (3 and 8) at the end of the game instead of the unprofitable firm with its superseded (sixth) technology at the very beginning.

In consequence of the transition to more effective technologies magnitudes of labour value approximated by total labour input coefficients were substantially reduced for all kinds of commodities (see Table 13).

At the end of the game there were 8 firms in the first sector, 3 firms in the second and 6 firms in the third one (the sum was equal to 17). Firms that applied effective technologies during the whole game were three in number, the others were imitators.

Conclusion

We have seen that market relations did not provide a stimulus to technological progress under the conditions of deep disproportions of reproduction in the first case study. The "invisible hand" did not help our aggressive and short-sighted players to utilize fully a potential of this economy. National income narrowed down as compared with the initial one. Small profits, perhaps, also contributed to non-cooperative behaviour of players. Viable technical change was not socially progressive. But practice is the best master. The second case study testifies that students not only improved cooperative behaviour but they learned to analyse consequences of possible actions and to give preference to a long term gain over a short term one.

Having got a deeper insight into the simulation model they made a number of suggestions about its further development. It was found reasonable to incorporate endogenous Science and Technology (mainly in-house R&D) into the model to reflect the relationship between science, technology and the market place. Following principles of scientific

abstraction much work should be done in order to make use of the factors initially disregarded thus strengthening the relevance of the model to the real world.

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