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Analysis of Expenditures and Outputs of Innovation Activity in Russian Manufacturing Industries

1. Introduction

The work is devoted to research on R&D expenditures and innovation activity in manufacturing industries of Russian Federation in 1995-1997.

The actual situation in Russian Federation may be characterized by a grave crisis started in the middle 1980s and by a process of transition. In these conditions industrial enterprises are concentrated on short-run profit and not on long-run one. So, usually the R&D expenditures are sacrificed.

The situation is aggravated by a crisis in Russian scientific sector, relations between the latter and the industry have being breaking. That leads to disappearance of positive externalities for the productive sector. On the other side, some indicators of *efficiency* of R&D expenditures reveal positive tendencies.

In our analysis we are trying to characterize expenditures and outputs of innovation activity.

The goal of the paper is

At first,

- to study the distribution of expenditures between the industries and within the industries;
- to study the relationship of different types of expenditures;
- to study the differences between the industries expenditures;
- to construct a typology of industries according to their volumes of expenditures;

Secondly,

- to study the outputs of innovation activity of the industries in Russian Federation,
- to classify the industries by output of innovation activity,

And, thirdly, to study the relationship between expenditures on innovation activity and output of innovation activity.

We use industry-level data. On the one hand, decisions are made on firms' level, so our approach leads to a possibility of loosing information because of aggregation. On the other hand, such an analysis may be useful for policy making since it can help to promote a particular activity. Besides, it is interesting in Russian industry, which is highly diversified.

We consider 17 industries of Russian economy for three years. Each industry innovation activity is described using 20 indicators. Official statistics of GOSCOMSTAT (provided by the research center VNIIEPRANT) are used in this study.

Ten indicators were used to describe various types of innovation expenditures, six indicators were used for innovation outputs. All of them were provided by VNIIEPRANT. Another four indicators for innovation outputs were calculated. All expenditures and indicators of production are measured in millions of 1995 rubles, the values were standardized using GOSCOMSTAT inflation index.

The paper contains two main parts.

The first part (sections 2, 3, 4) contains data description and analysis of correlation. The typology of expenditures and of outcomes is explained in section 5.

The second part (section 6) presents the study of correlation between indicators using methods of piecewise constant regressions.

2. Data description

Table 2.1 contains the list of all indicators, table 2.2 contains the list of industries used in the analysis (the classification of GOSCOMSTAT).

In addition to the indicators listed above 3 indicators were constructed in order to evaluate efficiency of innovation activity:

Indicator 1 (INDEF) – Volume of innovative production (in millions of 1995 rubles)/ Overall expenditures on technological endogenous innovations.

Table 2.1. List of indicators.

1	VSEZATR	Overall expenditures on technological innovations (2+3+4+5+6+7+8+9+10)
2	VALZATR	Expenditures on research and development (without depreciation)
3	PRAVASOBS	Expenditures on acquisition of intellectual property rights
4	BEZPAT	Expenditures on acquisition of non-patent licenses
5	NIOKR	Expenditures on designing and engineering
6	TEHPODG	Expenditures on set-up of technologies
7	OBUCHENI	Expenditures on tutoring and staff training
8	CAP_VLOJ	Expenditures on machines, equipment, installations, other fixed capital assets and capital costs, related to introduction of process-innovations and product-innovations
9	MARKETIN	Expenditures on marketing
10	PROCHIE	Other expenditures on technological innovations
11	CHISLO	Number of the enterprises engaged in innovation activity
12	DOLYA*	Share of innovative production in all production of industry
13	OBIEM	Innovative production in sales
14	CHPRNT	Number of the enterprises acquiring new technologies
15	CPPERNT	Number of the enterprises transferring new technologies
16	CHNTIN	Number of new technologies acquired by enterprises
17	CHNTOUT	Number of the new technologies transferred by enterprises

* Constructed indicator.

Table 2.2. List of industries.

The name of industry	Classification number of industry (GOSCOMSTAT)
Electric power industry	2
Fuel industry	3
Iron and steel industry	9
Nonferrous metallurgy	10
Chemical and petrochemical industry	11
Machine-building industry	15
Metal working industry	62
Woodworking and pulp-and-paper industry	63
Industry of construction materials	65
Glasswork and whiteware industry	66
Light industry	67
Food industry	68
Microbiological industry	69
Flour-milling, cereal, and feed-mill industry	70
Medical industry	71
Printing industry	76
Other industries	77

This indicator characterizes efficiency of innovative activity taking into account expenditures.

Indicator 2 (INDEXT) – Number of innovative enterprises / Overall expenditures on technological endogenous innovations.

This indicator reflects inverse value of expenditures on R&D per innovative enterprise.

Indicator 3 (DOLNOVPR) – Volume of innovative production (in millions of 1995 rubles) / Number of innovative enterprises.

This indicator gives average efficiency of innovative activity of enterprises for each industry.

3. Description of indicators

Let us give a description of indicators of expenditures on innovative activity of industrial enterprises. The following notation is used below: each observation is characterized by two numbers: the first one is the number of industry, the second one is the period in question. To describe the period we use number 1 for 1995, number 2 for 1996, number 3 for 1997[1]. For example, expression 15.2 corresponds to Machine-building industry in 1996.

Overall expenditures on technological innovations, VSEZATR.

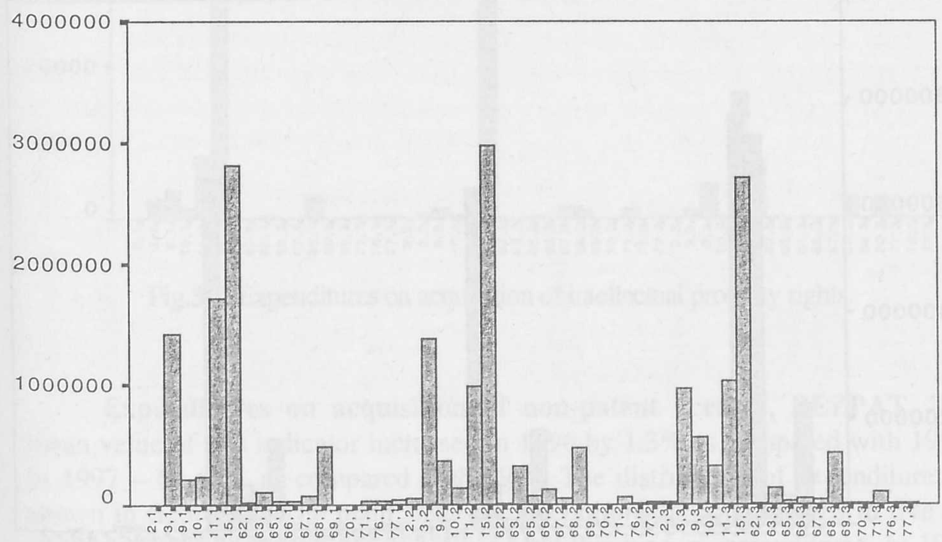


Fig. 3.1. Overall expenditures on technological innovations.

[1] There are no data for 1995 for electric power industry.

The diagram of values of an indicator on industries is shown in Figure 3.1. The mean value of this indicator in 1996 decreased by 9% as compared with 1995, and decreased by 9% in 1997 as compared with 1996. The main part of all expenditures of manufacturing industries was in 3 industries: Machine-building, Chemical and Petrochemical industry and Fuel industry (82% in 1995, 76% in 1996, 73% in 1997). It should be denoted that in 1996 the value of this indicator in Woodworking and pulp-and-paper industry grew sharply, however in 1997 the value was sharply fallen.

Expenditures on research and development (without depreciation), VALZATR. The mean value of this indicator decreased in 1996 by 45%, but in 1997 the mean value increased by 21%. The main part of this type of expenditures (92%) in 1995 was in Fuel industry, Chemical and Petrochemical industry and Machine-building, in 1996 was in Fuel industry, Iron and Steel industry, Chemical and Petrochemical industry, Machine-building (92%), and in 1997 was there and in Nonferrous Metallurgy (97%). These 5 industries cover 95% of this type of expenditures. Thus, in 1996 a sharp drop of gross expenditures in the three most significant industries was observed. So, Chemical and Petrochemical industry decreased these expenditures almost 10 times. In 1997 a growth was observed: in Iron and Steel industry – by 40%, in Nonferrous Metallurgy – 5 times, in Chemical and Petrochemical industry – 2.8 times.

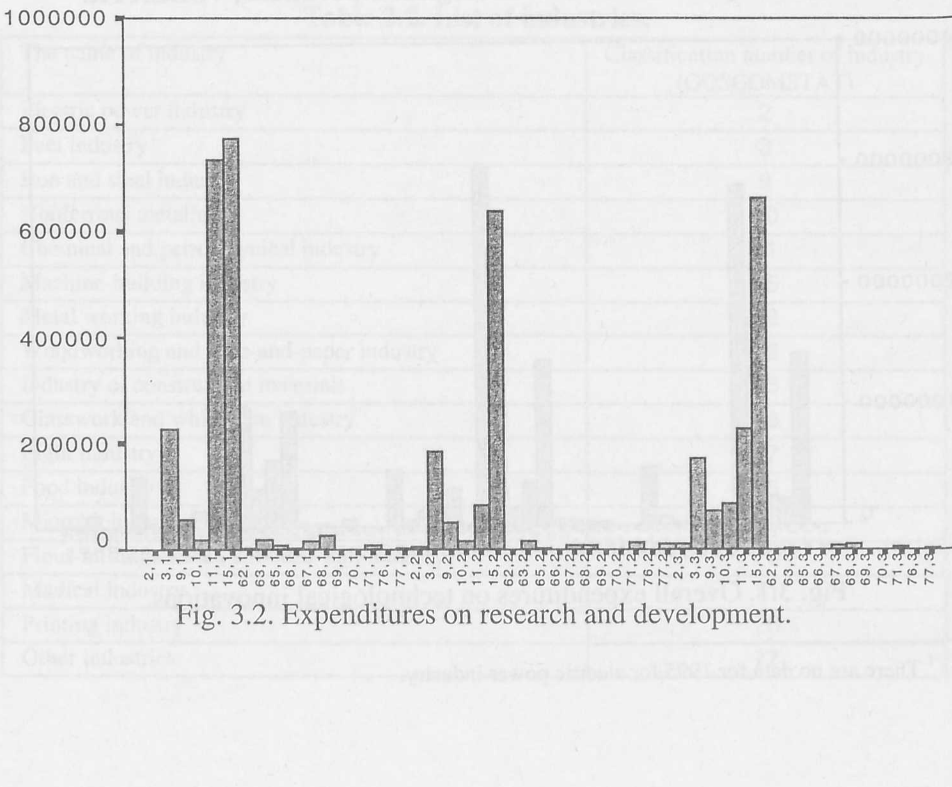


Fig. 3.2. Expenditures on research and development.

Expenditures on acquisition of intellectual property rights, Pravasobs. The main part of expenditures of this type – 73% – was in 1995 in one industry, namely in machine-building. In 1996 in this industry was 89% of total expenditures. Seven industries did not acquire any IPR. In 1996 mean expenditures increased by 4% because of machine-building. The other industries, as a rule, reduced the expenditures, except Light industry and Medical industry. In 1997 the mean value of this indicator decreased almost 2 times, and the leader (Machine-building) reduced the expenditures more than 4 times. However, Iron and Steel industry and Chemical and Petrochemical industry, as well as Food industry and Flour-milling, cereal, and feed-mill industry increased the expenditures.

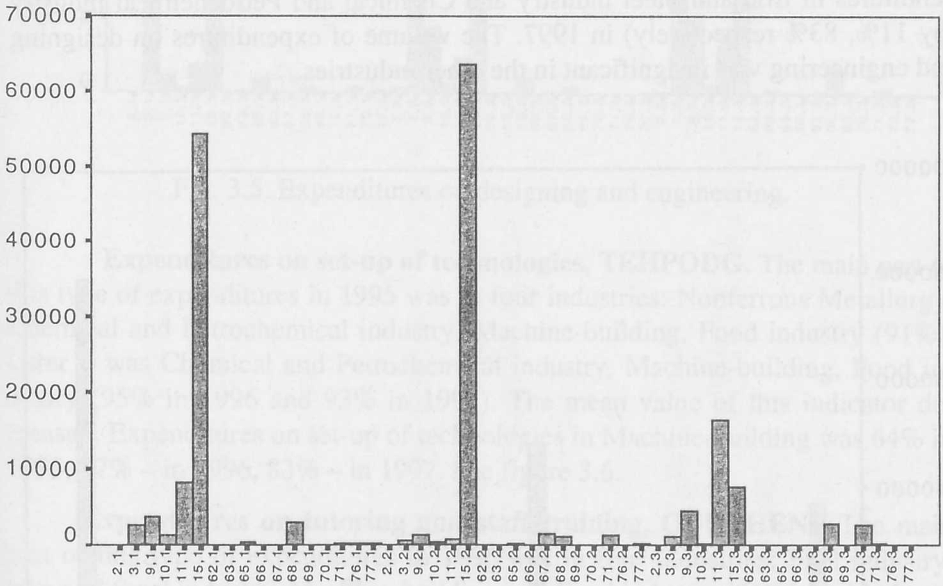


Fig.3.3. Expenditures on acquisition of intellectual property rights.

Expenditures on acquisition of non-patent licenses, BEZPAT. The mean value of this indicator increased in 1996 by 1.3% as compared with 1995, in 1997 – by 65% as compared with 1996. The distribution of expenditures is shown in figure 3.4. The main share of expenditures is concentrated in five industries (89%); eight industries did not have this type of expenditures. In 1996 Iron and Steel industry sharply increased this type of expenditures n 3 times), Medical industry – more than 10 times. The others reduced the expenditures. There was a jump of this type of expenditures in Medical industry (almost four times) in 1997. Fuel industry and Food industry increased this type of expenditures (two times, but their part in overall expenditures of this type is small). Chemical and Petrochemical industry and Machine-building did not change the expenditures.

Expenditures on designing and engineering, NIOKR. The main part of this type of expenditures was in two industries – Fuel industry and Machine-building. The mean value of this type of expenditures increased in 1996 as compared with 1995 by 36%, but it reduced by 16% in 1997. The distribution of expenditures is shown in figure 3.5, a sharp jump of the expenditures in Fuel industry in 1996 may be observed as well as a sharp falling in 1997. The Machine-building reduced the expenditures in 1996 as compared with 1995 (by 16%), but in 1997 the expenditures increased by 39%. We may note a growth of these expenditures in Iron and Steel industry and Chemical and Petrochemical industry (by 11%, 83% respectively) in 1997. The volume of expenditures on designing and engineering was insignificant in the other industries.

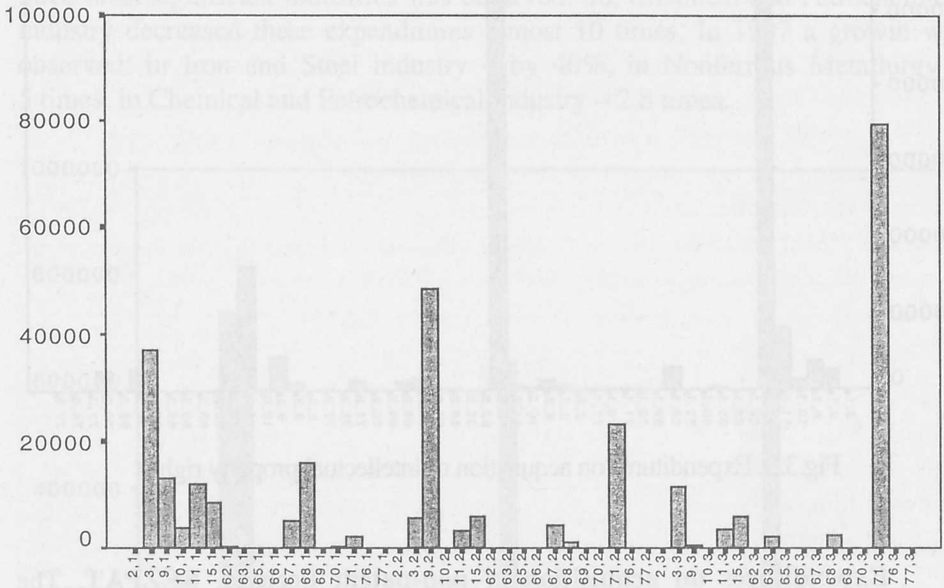


Fig. 3.4. Expenditures on acquisition of non-patent licenses.

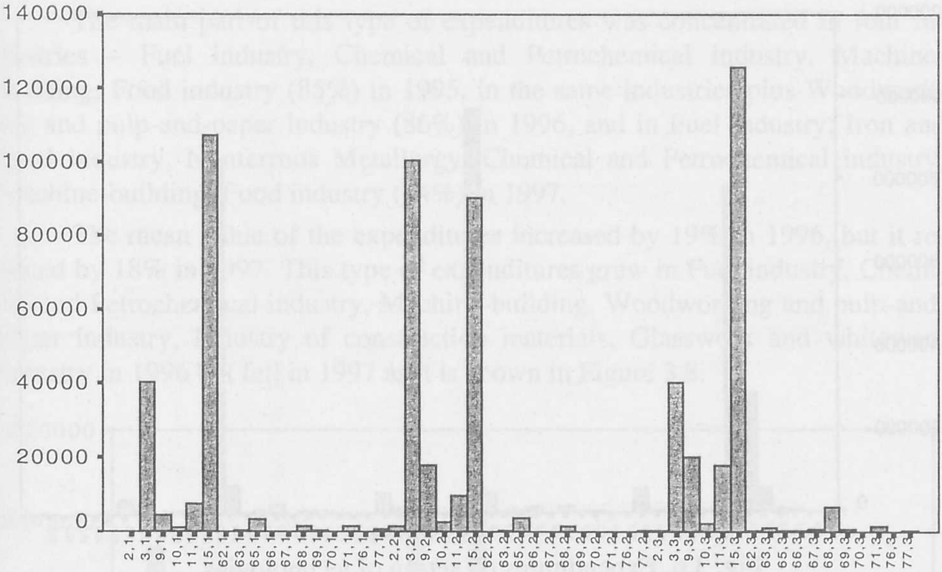


Fig. 3.5. Expenditures on designing and engineering.

Expenditures on set-up of technologies, TEHPODG. The main part of this type of expenditures in 1995 was in four industries: Nonferrous Metallurgy, Chemical and Petrochemical industry, Machine-building, Food industry (91%). Later it was Chemical and Petrochemical industry, Machine-building, Food industry (95% in 1996 and 93% in 1997). The mean value of this indicator decreased. Expenditures on set-up of technologies in Machine-building was 64% in 1995, 87% – in 1996, 83% – in 1997. See figure 3.6.

Expenditures on tutoring and staff training, OBUCHENI. The main part of this type of expenditures in 1995 was in four industries: Fuel industry, Iron and Steel industry, Machine-building and Food industry (81%), in 1996 – in three industries: Fuel industry, Chemical and Petrochemical industry and Machine-building (94%), in 1997 – in five industries – Fuel industry, Iron and Steel industry, Chemical and Petrochemical industry, Machine-building and Woodworking and pulp-and-paper industry (89%) in 1997.

Note that the mean value grew by 49% in 1996 and fell by 44% in 1997. However, a sharp jump of these expenditures is observed in Fuel industry and Chemical and Petrochemical industry in 1996 as well as a fall in Machine-building. The expenditures of Fuel industry and Chemical and Petrochemical industry sharply decreased in 1997 but they increased in Iron and Steel industry, Machine-building and Woodworking and pulp-and-paper industry (see fig. 3.7).

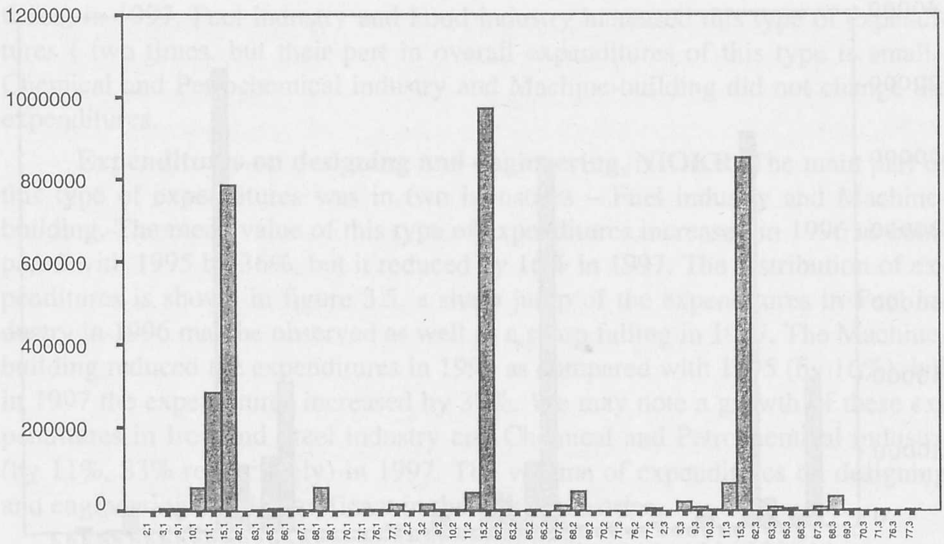


Fig. 3.6. Expenditures on set-up of technologies.

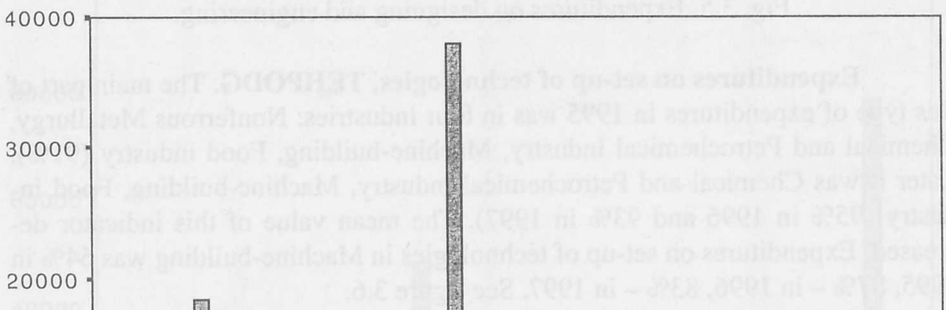


Fig. 3.7. Expenditures on tutoring and staff training.

Expenditures on machines, equipment, installations, other fixed capital assets and capital costs, related to process-innovations and product-innovations, CAP_VLOJ. All industries use this type of expenditures representing more than 40% of the total expenditures.

The main part of this type of expenditures was concentrated in four industries – Fuel industry, Chemical and Petrochemical industry, Machine-building, Food industry (85%) in 1995, in the same industries plus Woodworking and pulp-and-paper industry (86%) in 1996, and in Fuel industry, Iron and Steel industry, Nonferrous Metallurgy, Chemical and Petrochemical industry, Machine-building, Food industry (94%) in 1997.

The mean value of the expenditures increased by 19% in 1996, but it reduced by 18% in 1997. This type of expenditures grew in Fuel industry, Chemical and Petrochemical industry, Machine-building, Woodworking and pulp-and-paper industry, Industry of construction materials, Glasswork and whiteware industry in 1996 but fell in 1997 as it is shown in Figure 3.8.

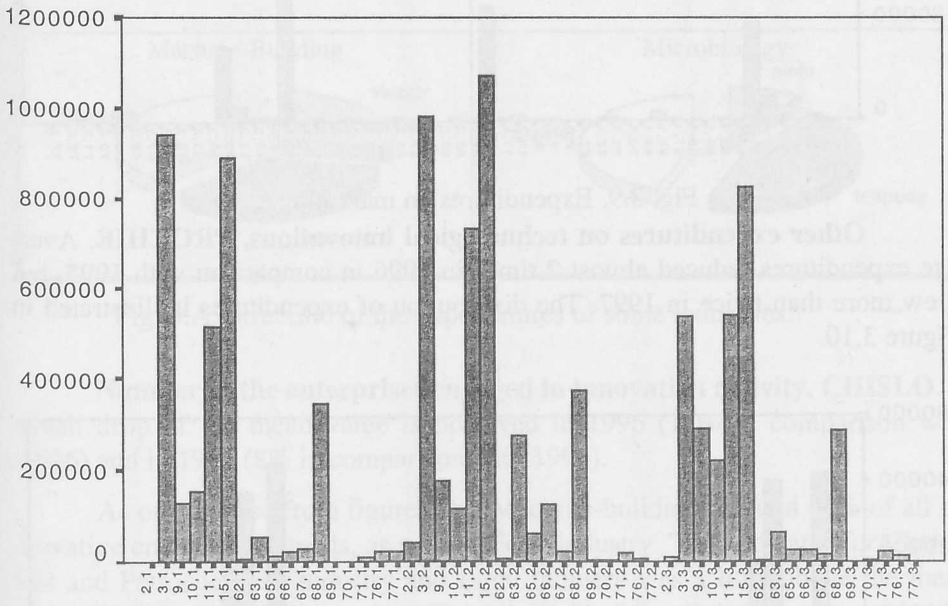


Fig. 3.8. Expenditures on machines, equipment, installations, other fixed capital assets and capital costs.

Expenditures on marketing, MARKETIN. The expenditures on marketing are not important in comparison with other types of expenditures. Their share was 0.4% of total expenditures in 1995 and 1996, but 2% in 1997. For the main part of industries this type of expenditures was very small.

The main share of expenditures was in Chemical and Petrochemical and Machine-building industries (81%) in 1995. In 1996 only one industry – Machine-building spent 80% of all manufacturing industries. In 1997 Fuel industry and Machine-building industries spent 91% (see fig. 3.9).

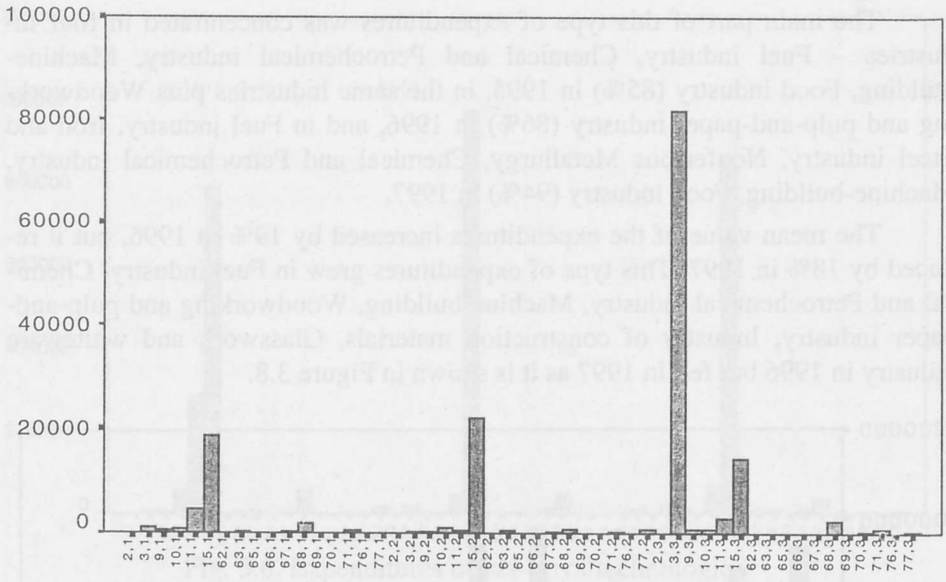


Fig. 3.9. Expenditures on marketing.

Other expenditures on technological innovations, PROCHIE. Average expenditures reduced almost 2 times in 1996 in comparison with 1995, but grew more than twice in 1997. The distribution of expenditures is illustrated in Figure 3.10.

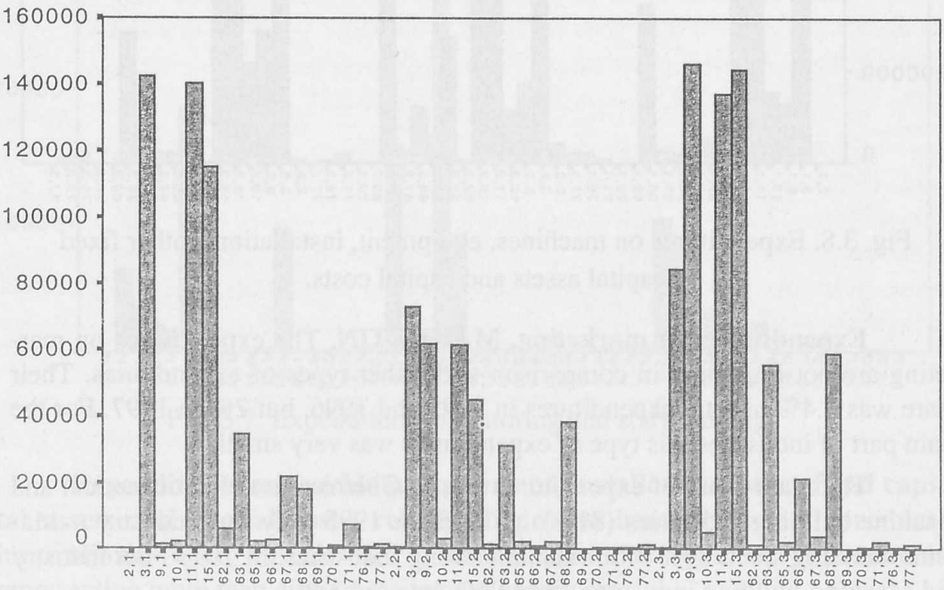


Fig. 3.10. Other expenditures on technological innovations.

The structure of the expenditures of 3 industries with sufficiently big expenditures (Fuel, Chemical and Petrochemical and Machine-building) as well for a high-tech industry, namely Microbiology, are represented in Figure 3.A.

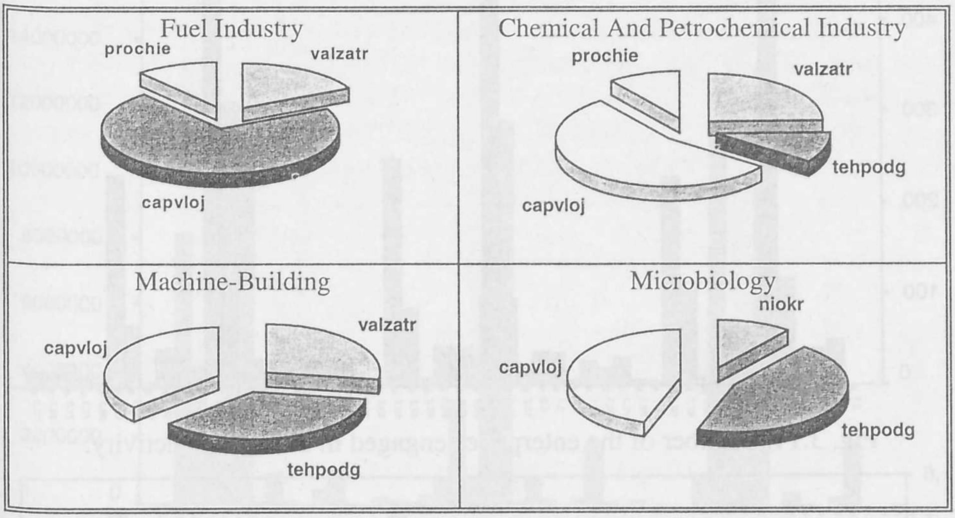


Fig. 3.A. Structure of the expenditures of some industries.

Number of the enterprises engaged in innovation activity, CHISLO. A small drop of the mean value is observed in 1996 (12% in comparison with 1996) and in 1997 (8% in comparison with 1996).

As one can see from figure 3.11, Machine-building (around 40% of all innovative enterprises) stands, as well as Food industry. This indicator for Chemical and Petrochemical industry and Light industry was a little above the mean value. Value of this indicator is sufficiently stable for each industry for each year in question. We observe the increase of the number of the enterprises engaged in innovation activity in Food industry in 1996 and in Chemical and Petrochemical industry in 1997.

Share of innovative production in all production of industry, DOLYA. The mean value of this indicator was 17% in 1995 and 1997, and 16% in 1996. Let us note a big variation for industries in different years (see fig. 3.12). The value is high for Microbiological industry. Its growth was 47% in 1996 and 2% in 1997. This indicator is rather high in Chemical and Petrochemical industry (but decreasing by 30% in 1996 and 19% in 1997). Important variation is observed in Nonferrous Metallurgy (-18% and 179% respectively).

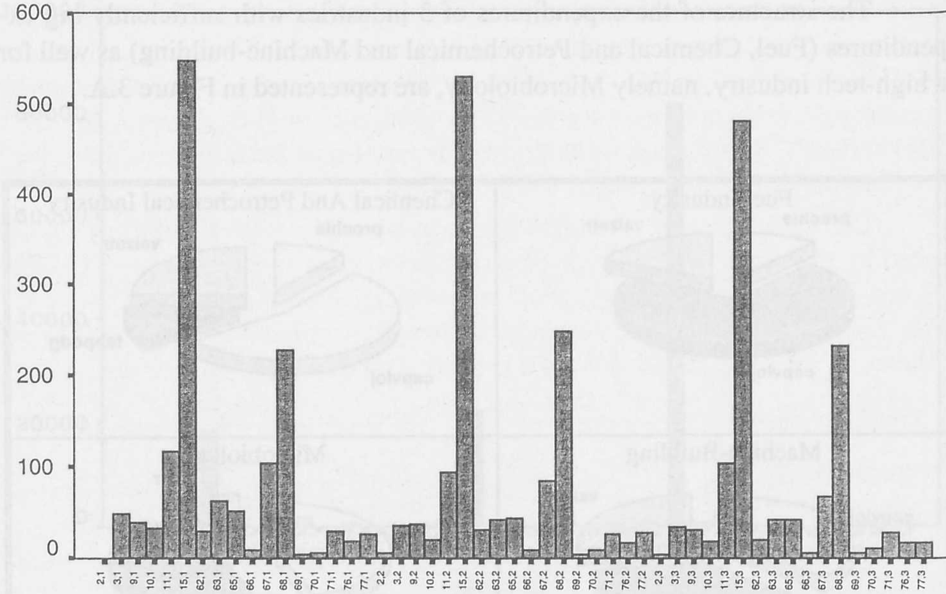


Fig. 3.11. Number of the enterprises engaged in innovation activity.

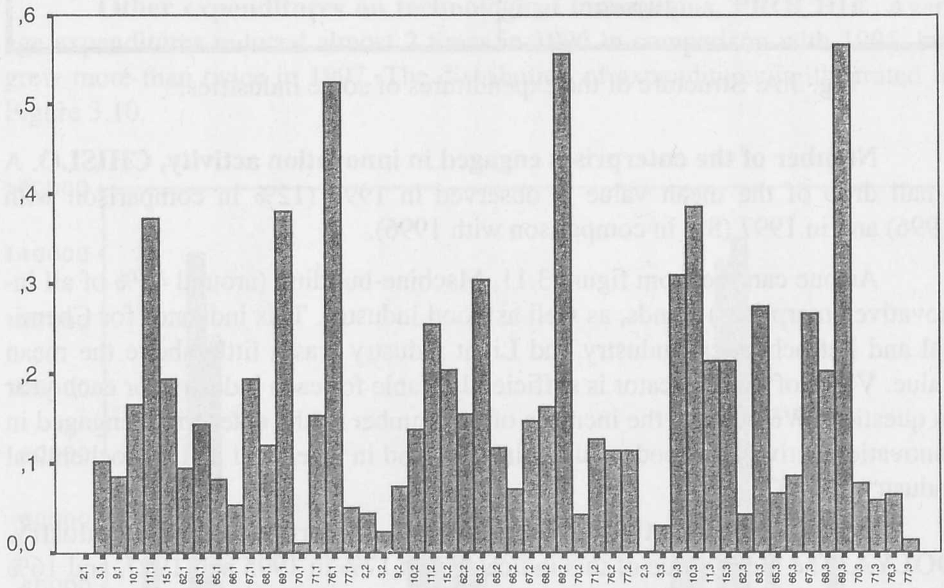


Fig. 3.12. Share of innovative production in all production of industry.

Innovative production in sales, OBIEM. The mean value of this indicator decreased in 1996, but almost reached the level of 1995 in 1997. Such dynamics of the mean value is determined by sharp falling in Fuel industry and

Chemical and Petrochemical industry (-89% and -48% in 1996, +9% and -24% in 1997), by growth in Iron and Steel industry (15% and 254%) and by growth in Machine-building in 1997.

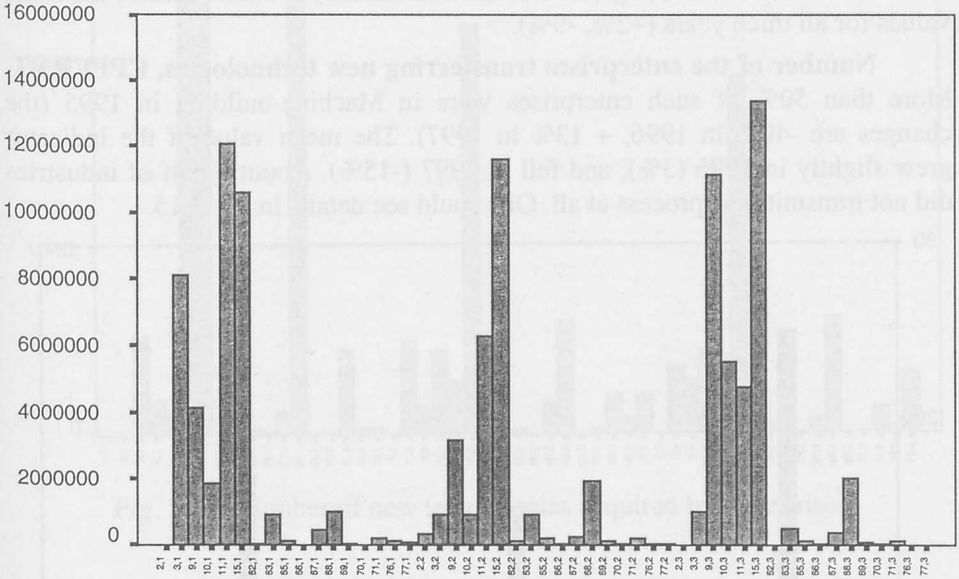


Fig. 3.13. Innovative production in sales.

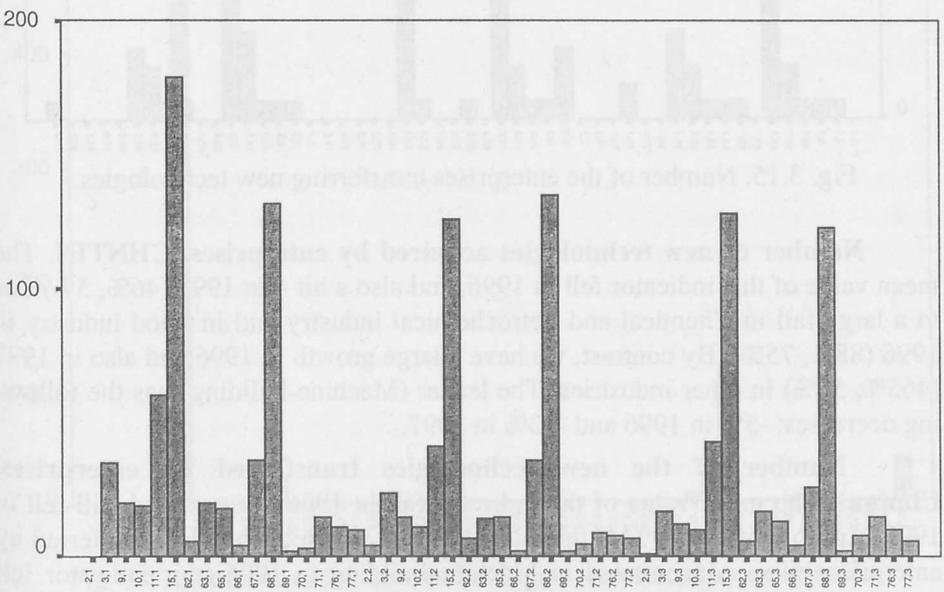


Fig. 3.14. Number of the enterprises acquiring new technologies.

Number of the enterprises acquiring new technologies, CHPRNT. The mean value of this indicator decreased in 1996, and still decreased in 1997. There are two leaders: Machine-building and Food industry, despite of a falling in 1996 in Machine-building (-30%). In Food industry we have almost the same values for all three years (+2%, -9%).

Number of the enterprises transferring new technologies, CPPERNT. More than 50% of such enterprises were in Machine-building in 1995 (the changes are -40% in 1996, + 13% in 1997). The mean value of the indicator grew slightly in 1996 (3%), and fell in 1997 (-15%). About a half of industries did not transmit new process at all. One could see details in fig. 3.15.

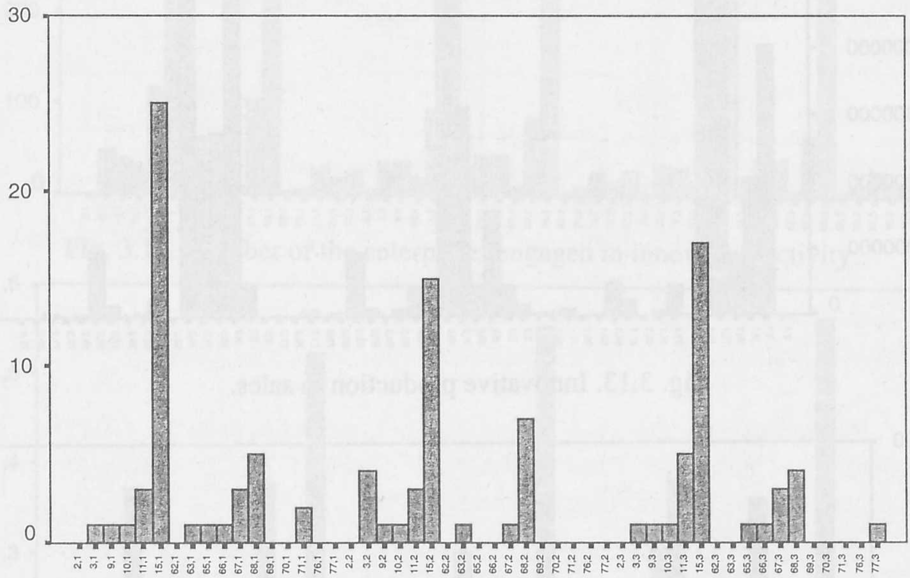


Fig. 3.15. Number of the enterprises transferring new technologies.

Number of new technologies acquired by enterprises, CHNTIN. The mean value of this indicator fell in 1996, and also a bit – in 1997 (46%, 5%) due to a large fall in Chemical and Petrochemical industry and in Food industry in 1996 (88%, 75%). By contrast, we have a large growth in 1996 and also in 1997 (465%, 58%) in other industries. The leader (Machine-building) has the following decreases: -5% in 1996 and -13% in 1997.

Number of the new technologies transferred by enterprises, Chntout. The mean value of the indicator fell in 1996 3 times, and still fell in 1997. Approximately 90% of the number of the new technologies transferred by enterprises were concentrated in Machine-building in 1995 (this indicator fell 5 times in 1996 and grew by 52% in 1997 in Machine-building).

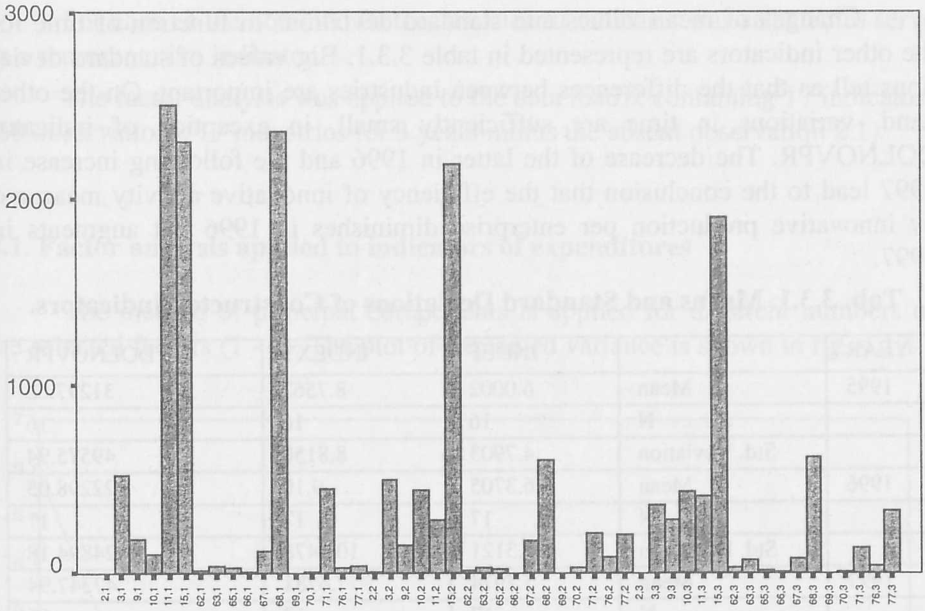


Fig. 3.16. Number of new technologies acquired by enterprises.

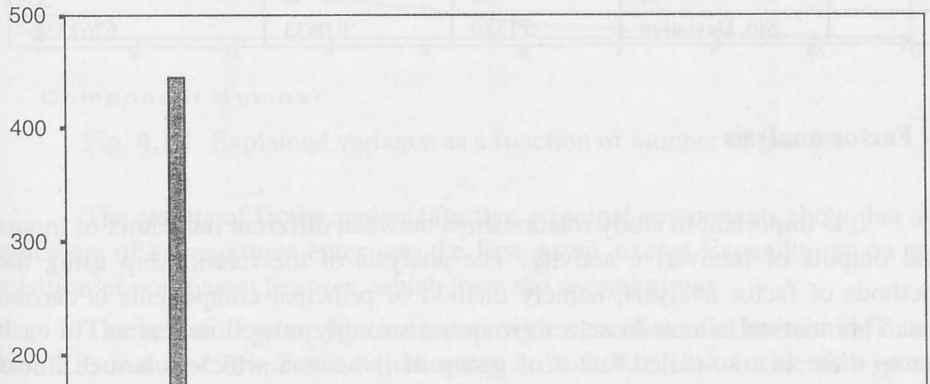


Fig. 3.17. Number of the new technologies transferred by enterprises.

Changes of mean values and standard deviations in function of time for the other indicators are represented in table 3.3.1. Big values of standard deviations tell as that the differences between industries are important. On the other hand, variations in time are sufficiently small, in exception of indicator DOLNOVPR. The decrease of the latter in 1996 and the following increase in 1997 lead to the conclusion that the efficiency of innovative activity measured by innovative production per enterprise diminishes in 1996 but augments in 1997.

Tab. 3.3.1. Means and Standard Deviations of Constructed Indicators.

YEAR		INDEF	INDEXT	DOLNOVPR
1995	Mean	6.0002	8.7562	31297.62
	N	16	16	16
	Std. Deviation	4.7903	8.8150	49575.94
1996	Mean	6.3705	9.10	22298.05
	N	17	17	17
	Std. Deviation	7.3121	10.8478	24894.18
1997	Mean	5.7974	7.6781	47347.94
	N	17	17	17
	Std. Deviation	6.4010	7.7383	103647.70
Total	Mean	6.0571	8.5055	33694.88
	N	50	50	50
	Std. Deviation	6.1580	9.0633	67632.96

4. Factor analysis

It is important to study relationships between different indicators of inputs and outputs of innovative activity. The analysis of the relationship using the methods of factor analysis, namely method of principal components is carried out. This method allows to select groups of strongly related indicators. In each group there is a so-called factor of group of indicators which is a such linear combination of initial indicators that is the closest one to all indicators of the group. It is reasonable also to choose an initial indicator which is strongly correlated with the factor. Usually such indicator is named as the representing indicator of the group. We use the following scheme:

Separately indicators of expenditures and output indicators were analyzed.

For each such subset of indicators the factor analysis was made. The best factor structure and the best quantity of factors were chosen according to the formal statistical criterions (residual variance) as well as according to interpretation criteria.

For each of the obtained factors the closest indicator was selected to serve as a representative indicator.

The factor analysis was applied to the data matrix containing 17 indicators (50 observations, 17 industries for 3 years minus the absent observation 2.1).

4.1. Factor analysis applied to indicators of expenditures

The method of principal components is applied for different numbers of the selected factors (1 - 4). The plot of explained variance is shown in fig. 4.1.1.

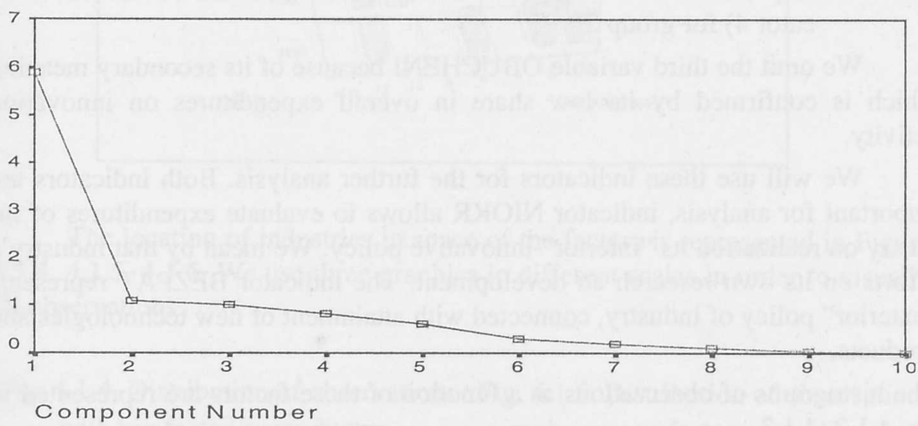


Fig. 4.1.1. Explained variance as a function of number of factors.

The results of factor analysis for two principal components show that all indicators of expenditures enter into the first group, except Expenditures on acquisition of non-patent licenses, which form the second group.

The kernel of group (the indicators with a coefficient of correlation more than 0.8) includes 6 indicators (indicators 1, 2, 3, 4, 5, 8)[2]. Inside this group there is a subgroup of indicators 7, 9 and 10, standing a bit alone (average coefficient of correlation with the factor of these indicators – 0.6). The second factor and second group of indicators accordingly is designed by one indicator – Expenditures on acquisition of non-patent licenses (coefficient of correlation with the factor is equal 0.7).

We have the following groups for three principal components: the first group contains indicators 1, 2, 3, 5, 6, 8, 9, 10. Inside the first group the kernel is

[2] See the definition of indicators on page 90.

indicators 1, 2, 3, 5, 6, 8, coefficient of correlation with the factor is 0.8, subgroup of indicators 9 and 10 (average coefficient of correlation is 0.6) is selected. The second group is represented by indicator 7 (Expenditures on tutoring and staff training, coefficient of correlation with the factor is 0.6, but the other coefficients of correlation are lower than 0.4). The third group contains one indicator -- 4 (Expenditures on acquisition of non-patent licenses), the coefficient of correlation with the factor is close to 1.

As representatives of groups the following indicators are selected:

- ♦ Expenditures on designing and engineering (NIOKR, indicator 5) for group 1,
- ♦ Expenditures on acquisition of non-patent licenses (BEZPAT, indicator 4) for group 2.

We omit the third variable OBUCHENI because of its secondary meaning which is confirmed by its low share in overall expenditures on innovation activity.

We will use these indicators for the further analysis. Both indicators are important for analysis, indicator NIOKR allows to evaluate expenditures of industry on realization its “interior” innovative policy. We mean by that industry’s efforts on its own research an development. The indicator BEZPAT represents “exterior” policy of industry, connected with attainment of new technologies and products.

The histograms of observations as a function of these factors are represented in fig. 4.1.2, 4.1.3.

Fig. 4.1.2. Histogram of BEZPAT indicator.

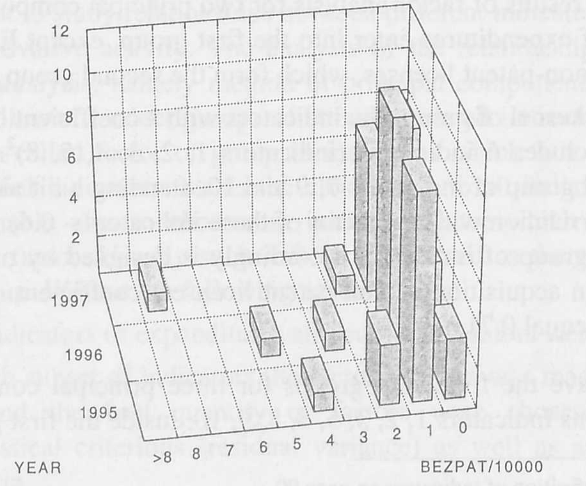
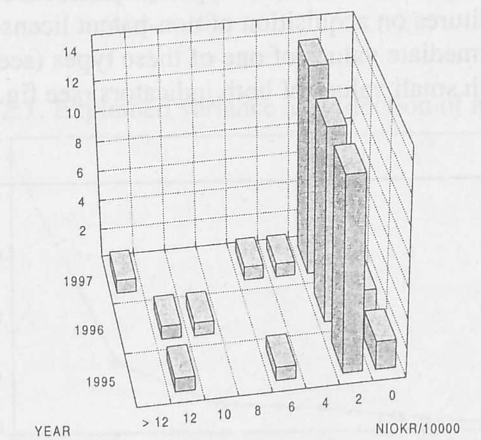


Fig. 4.1.3 Histogram of NIOKR indicator.



The location of industries in space of the factors is represented in Figures 4.1.4, 4.1.5, 4.1.6. We use three graphics in different scales in order to visualize all observations.

Fig. 4.1.4. Distribution of observations with big factor expenditures.

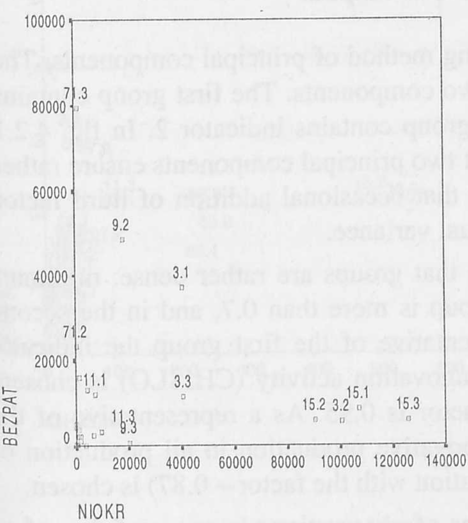
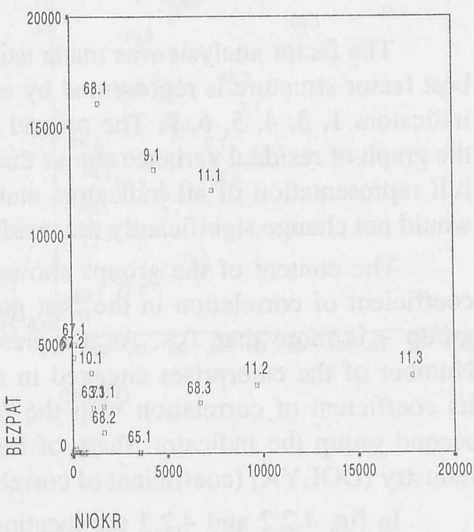
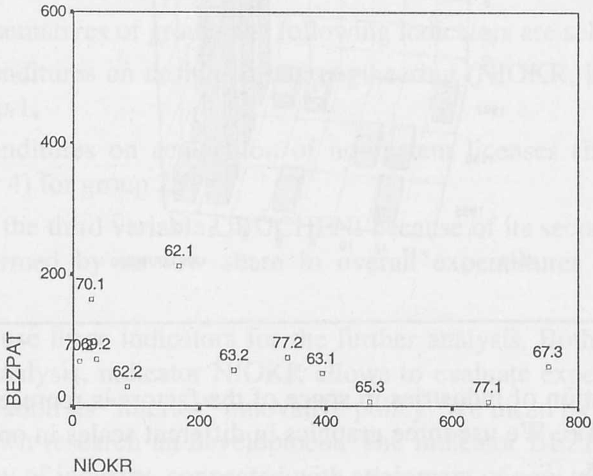


Fig. 4.1.5. Distribution of observations with average factor expenditures.



These graphs show us that there are two rather small clusters of industries with large expenditures of one of these two types (expenditures on designing and engineering or expenditures on acquisition of non-patent licenses, see fig. 4.1.4), two clusters with intermediate values of one of these types (see fig. 4.1.5), and a rather large cluster with small values of both indicators (see fig. 4.1.6).



4.2. Factor analysis applied to indicators of outputs

The factor analysis was made using method of principal components. The best factor structure is represented by two components. The first group contains indicators 1, 3, 4, 5, 6, 7. The second group contains indicator 2. In fig. 4.2.1 the graph of residual variance shows that two principal components ensure rather full representation of all indicators and that occasional addition of third factor would not change significantly the residual variance.

The content of the groups shows that groups are rather dense: minimum coefficient of correlation in the first group is more than 0.7, and in the second group – is more than 0.8. As a representative of the first group the indicator Number of the enterprises engaged in innovation activity (CHISLO) is chosen; its coefficient of correlation with the factor is 0.95. As a representative of the second group the indicator Share of innovative production in all production of industry (DOLYA) (coefficient of correlation with the factor – 0.87) is chosen.

In fig. 4.2.2 and 4.2.3 the locations of observations in space of these factors are shown. One could see that large values of these indicators are grouped along axes (see fig. 4.2.2), and for small values of indicators it is rather uniform. It is possible to see a condensation of observations along the diagonal.

Fig. 4.2.1. Explained variance as a function of number of factors.

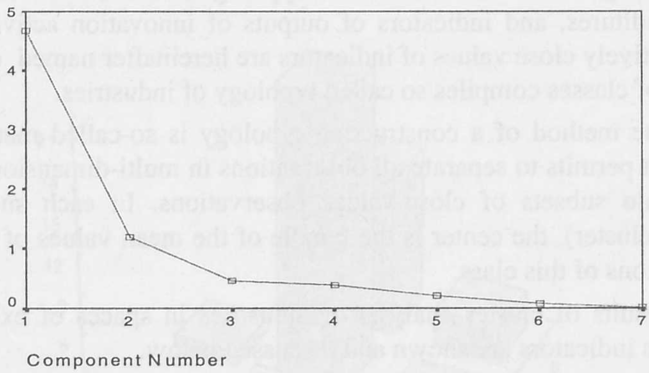


Fig. 4.2.2. Distribution of all observations.

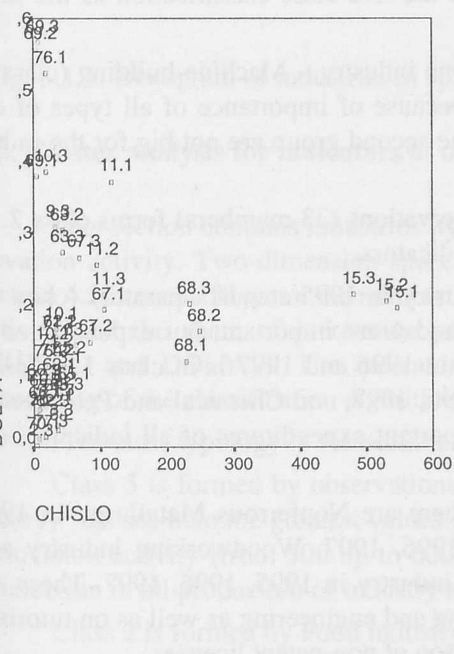
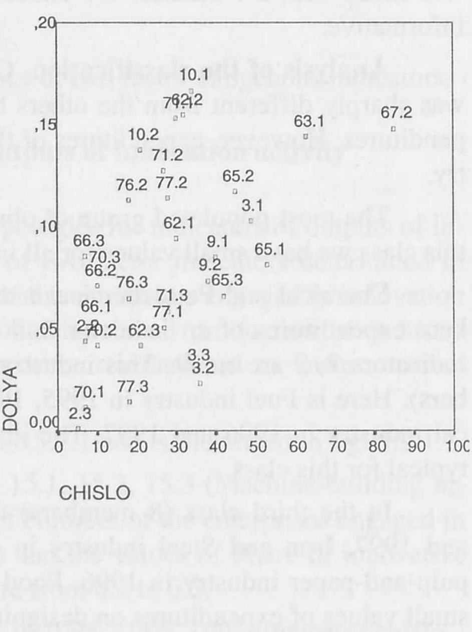


Fig. 4.2.3. Distribution of observations with average factor outputs.



5. Typologies of industries

The industries are heterogeneous both by expenditures on innovation activity and by outputs of innovation activity.

This gives us a reason to make typologies of observations using indicators of expenditures, and indicators of outputs of innovation activity. Observations with relatively close values of indicators are hereinafter named classes (clusters). The set of classes compiles so called typology of industries.

The method of a construction typology is so-called method of K-means cluster. It permits to separate all observations in multi-dimensional space of indicators into subsets of close-values observations. In each such subset called "class" (cluster), the center is the bundle of the mean values of all indicators for observations of this class.

Results of cluster analysis of industries in spaces of exogenous and endogenous indicators are shown and discussed below.

5.1. Cluster analysis for indicators of expenditures

The cluster analysis of industries in space of indicators of expenditures was made with 2-7 classes. We choose the five-class classification as the most informative.

Analysis of the classification. One industry – Machine-building (class 5) was sharply different from the others because of importance of all types of expenditures. However, expenditures of the second group are not big for the industry.

The most populated group of observations (33 members) forms class 2. In this class we have small values for all indicators.

Chemical and Petrochemical industry in 1995 stands separately (class 4), here expenditures of an indicator 2, 4 and 6 are important, but expenditures of indicators 7, 9 are small. This industry in 1996 and 1997 is in class 1 (5 members). Here is Fuel industry in 1995, 1996, 1997, and Chemical and Petrochemical industry in 1996 and 1997. The important expenditures of all indicators are typical for this class.

In the third class (8 members) there are Nonferrous Metallurgy in 1995 and 1997, Iron and Steel industry in 1996, 1997, Woodworking industry and pulp-and-paper industry in 1996, Food industry in 1995, 1996, 1997. There are small values of expenditures on designing and engineering as well as on tutoring, and rather large expenditures on acquisition of non-patent licenses.

The histogram of industries in space of two factor exogenous indicators is shown in fig. 5.1.1.

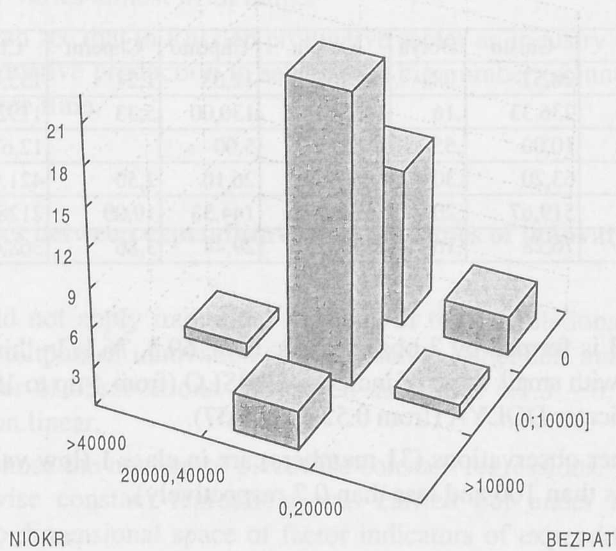


Fig. 5.1.1. Histogram of industries in space of two factor exogenous indicators.

5.2. Cluster analysis for indicators of outputs of innovation activity

This section contains industries' typologies for indicators of outputs of innovation activity. Two-dimension space of two factor indicators determined in section 4.2 is used. They are the number of the enterprises engaged in innovation activity and the share of innovative production in all production of industry (CHISLO and DOLYA). The indicators were standardized to ensure correct processing of the classification algorithm.

Five-class typology is shown in table 5.2.1 and is illustrated in fig. 5.2.1.

Class 5 is formed by observations 15.1, 15.2, 15.3 (Machine-building industry). We see here the greatest values of Number of the enterprises engaged in innovation activity (from 500 up to 600) and the values of Share of innovative production in all production of industry are from 0.2 to 0.3.

Class 2 is formed by Food industry in 1995, 1996, 1997 (indicator chislo – from 200 up to 300, indicator dolya – from 0.1 up to 0.2), class 4: observations

9.3, 10.3, 11.1, 11.2, 11.3, 63.2, 63.3, 67.1, 67.3, 69.1 (10 members). In this class there are industries with values of indicator chislo from 5 up to 105, and indicator dolya – from 0.2 up to 0.4.

Table 5.2.1. Characteristics of five-cluster typology.

		Chislo	Dolya	Obiem	Chprnto	Chpernt	Chntin	Chntout
1	Mean	28,52	,08	748965	12,03	1,27	135,45	4,67
2	Mean	236,33	,16	1658611	130,00	5,33	1192,67	21,67
3	Mean	10,00	,55	118139	5,00		12,67	
4	Mean	63,20	,30	4208066	26,10	2,50	421,90	9,00
5	Mean	519,67	,20	11865771	144,33	19,00	2128,67	212,67
Total	Mean	76,28	,16	2124523	29,44	3,86	368,40	29,14

Class 3 is formed by 3 observations: 69.2, 69.3, 76.1. In this class there are observations with small value of indicator CHISLO (from 4 up to 19), but high values of the indicator DOLYA (from 0.52 up to 0.57).

All other observations (31 members) are in class 1 (low values of both indicators – less than 100 and less than 0.2 respectively).

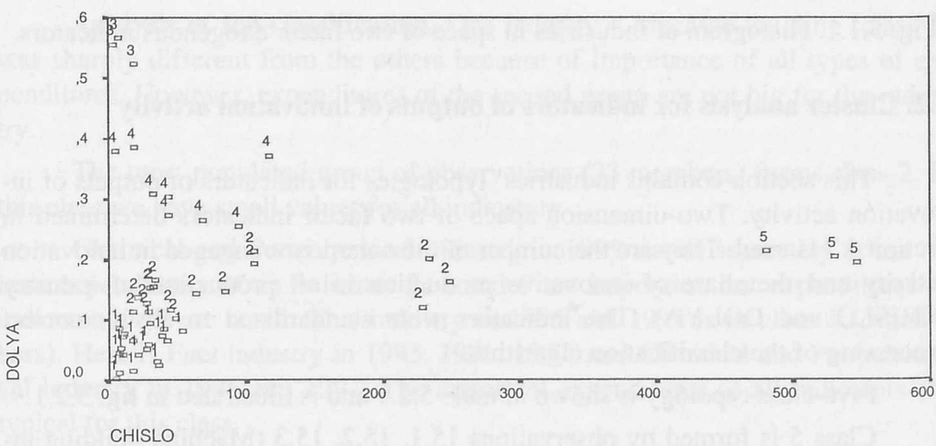


Fig. 5.2.1. Graphical representation of five-cluster typology.

So the constructed typology demonstrates that we have two types on industries like in the case of typology created for expenditures.

In the first type the share of innovative production in all production of industry is almost the same (from 0.15 up to 0.25) but the number of enterprises engaged in innovation activity varies almost in range.

In the second type the number of enterprises engaged in innovation activity is small (less than 50), and the share of innovative production in all production of industry varies almost in all range.

So, we can see that in Russian productive sector an industry cannot have a big part of innovative production in sales and a big number of innovative enterprises at the same time.

6. Dependencies between expenditures and outcomes of innovation activity

We could not apply traditional methods of testing relations between expenditures and outputs of innovation activity such as panel data analysis because of small number of observations. Moreover, as figures 6.1.3 – 6.1.5 show, the relations are non linear.

So, we chose the method of piecewise constant regressions. The construction of piecewise constant regressions was carried out under the following scheme. In two-dimensional space of factor indicators of expenditures we construct a typology. For each class the mean values of indicators of outputs and mean values of constructed indicators are calculated. The dependence of these mean values on the centers of classes is named piecewise constant regression.

Some results of data analysis.

At the first stage all observations are classified; we chose a 4 classes classification as the best one (see fig. 6.1.1). The first class is characterized by intermediate values of both indicators (2 observations), class 2 – rather small values of indicator Expenditures on designing and engineering (NIOKR) and large values of indicator Expenditures on acquisition of non-patent licenses (BEZPAT) – 2 observations. In class 3 there are many industries with rather small values of both indicators. Class 4 (4 observations) is characterized by the large values of indicator NIOKR and small values of indicator BEZPAT.

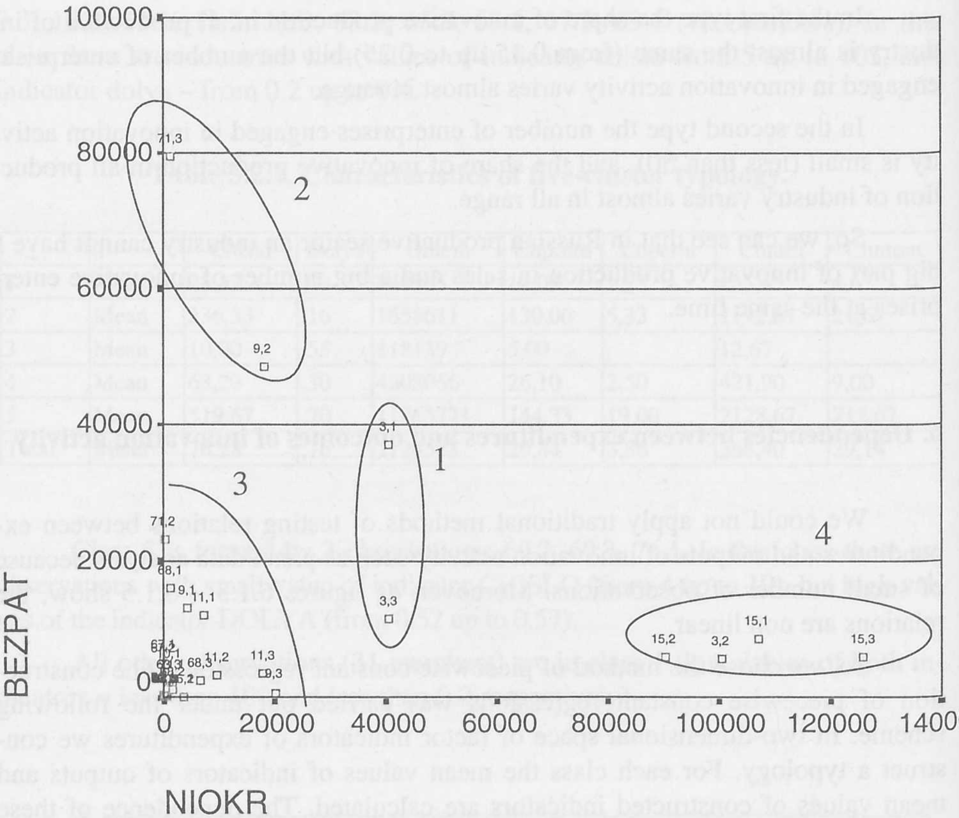


Fig. 6.1.1. Graphical representation of four-cluster typology.

At the second stage the large class 3 is divided into 3 subgroups (see fig.6.1.2). In the group 1 there are 21 observations with small values of both indicators. Group 2 (4 industries) – with small values of indicator Expenditures on designing and engineering and large values Expenditures on acquisition of non-patent licenses, group 3 (2 industries) – with large values Expenditures on designing and engineering and small – Expenditures on acquisition of non-patent licenses. These piecewise constant regressions are shown in tables 6.1 and 6.2.

Table 6.1. Piecewise constant regressions of results of innovation activity.

		CHISLO	DOLYA	OBIEM	CHPRNT	CPPERNT	CHNTIN	CHNTOUT
1	Mean	63,10	,17	791865,1	27,05	2,33	141,05	6,5833
	N	21	21	21	21	12	21	12
	Std. Deviation	64,81	,12	1416699	35,64	1,83	190,44	10,7658
2	Mean	103,00	,18	4354863	55,25	3,00	1314,25	9,3333
	N	4	4	4	4	3	4	3
	Std. Deviation	92,31	,13	5406637	55,66	2,00	1291,98	11,0151
3	Mean	68,50	,26	7959271	27,50	3,00	347,00	16,5000
	N	2	2	2	2	2	2	2
	Std. Deviation	51,62	,07	4528379	21,92	2,83	89,10	21,9203
Total	Mean	69,41	,18	1850636	31,26	2,53	330,11	8,2353
	N	27	27	27	27	17	27	17
	Std. Deviation	67,25	,12	3232042	38,17	1,84	631,43	11,6487

Table 6.2. Piecewise constant regressions of constructed indicators.

		INDEF	INDEXT	DOLNOVPR
1	Mean			
	N	21	21	21
	Std. Deviation	6,5392	,9443	17518,0122
2	Mean	8,0065	,2962	54770,7963
	N	4	4	4
	Std. Deviation	7,7521	,2014	56062,3097
3	Mean	12,3688	,0801	197049,0435
	N	2	2	2
	Std. Deviation	10,9003	,0319	214595,8107
Total	Mean	7,0437	,9872	32160,1032
	N	27	27	27
	Std. Deviation	6,8627	,9304	69738,0958

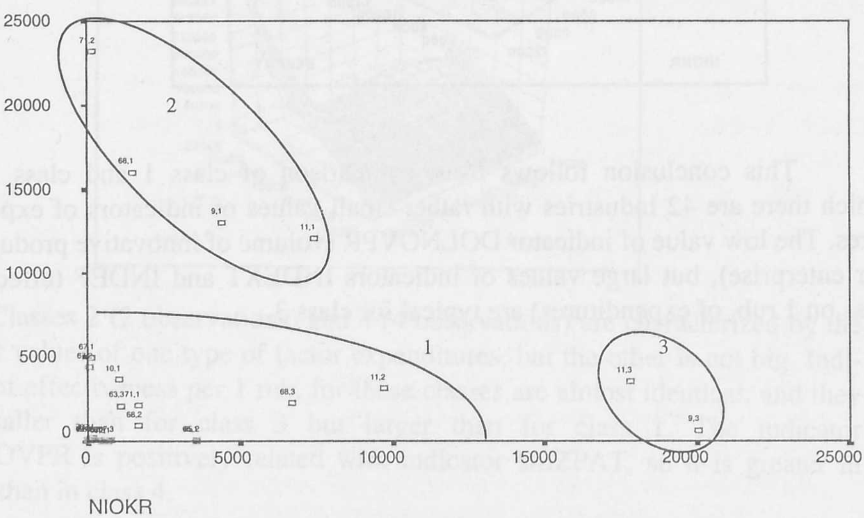
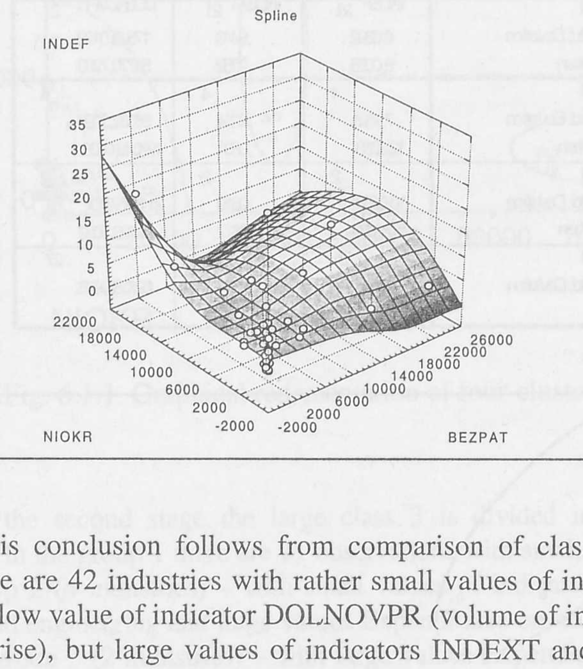


Fig. 6.1.2. Graphical presentation of three-cluster typology.

Let us describe the results of the 4-classes piecewise regression.

Class 1 (observations 3.1 and 3.3 – Fuel industry) is characterized by intermediate values of both factor indicators of expenditures, by small number of innovative enterprises, by small share of innovative production, big number of bought new processes, and small number of the transferred new processes. The values of indicators INDEXT and INDEF are small, but the value of indicator DOLNOVPR – is large. This proves that rather large expenditures on R&D allow to achieve big volumes of innovative production, but through a drop of efficiency, measured per unit of expenditures.

Fig. 6.1.3. Indicator INDEF as a function of factor expenditures.



This conclusion follows from comparison of class 1 and class 3, in which there are 42 industries with rather small values of indicators of expenditures. The low value of indicator DOLNOVPR (volume of innovative production per enterprise), but large values of indicators INDEXT and INDEF (effectiveness on 1 rub. of expenditures) are typical for class 3.

Fig. 6.1.4. Indicator INDEXT as a function of factor expenditures.

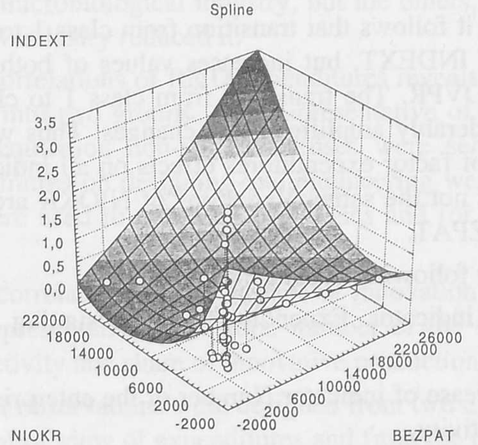
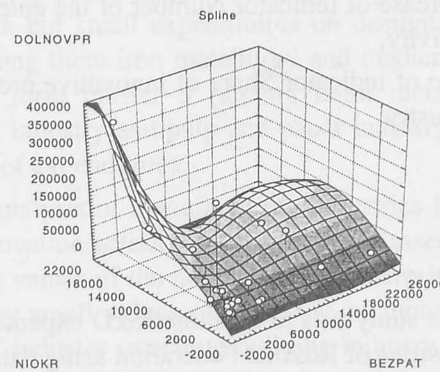


Fig. 6.1.5. Indicator DOLNOVPR as a function of factor expenditures.



Classes 2 (2 observations) and 4 (4 observations) are characterized by the greatest values of one type of factor expenditures, but the other is not big. Indicators of effectiveness per 1 rub. for these classes are almost identical, and they are smaller than for class 3 but larger than for class 1. The indicator DOLNOVPR is positively related with indicator BEZPAT, so it is greater in class 2 than in class 4.

These dependencies between efficiencies of innovation activities and expenditures are illustrated in the fig. 6.1.3 – 6.1.5.

Let us consider now influence of indicators of expenditures on indicators of efficiency of innovative activity for industries with small values of indicators of expenditures (3-classes classification).

From table 6.2 it follows that transition from class 1 to class 2 reduces a value of an indicator INDEXT, but increases values of both indicator INDEF and indicator DOLNOVPR. The transition from class 1 to class 3 keeps these tendencies, but considerably amplifies these changes. Thus we see that the increase of both types of factor expenditures effects on all indicators, but the degree of this impact is not the same. Variations of NIOKR are more significant than variations of BEZPAT.

So, we have the following dependencies:

Increasing of indicator Expenditures on designing and engineering leads to:

- a small increase of indicator Number of the enterprises engaged in innovation activity,
- significant increase of indicator Share of innovative production in all production of industry.

Increasing of indicator Expenditures on acquisition of non-patent licenses leads to:

- significant increase of indicator Number of the enterprises engaged in innovation activity,
- a little increase of indicator Share of innovative production in all production of industry.

7. Conclusions

The purpose of this study was to examine R&D expenditures and innovation indicators in 17 industries of Russian Federation using data for 1995 – 1997.

1. R&D expenditures are described by ten indicators. The analysis of this indicators shows that Russian manufacturing industries tend to reduce the expenditures on innovations (-9% in 1996, -9% in 1997). However, this reduction varied across industries. The number of the enterprises engaged in innovation activity also reduced (10% per year), as well as the number of the enterprises acquiring new technology and the number of the enterprises transferring new technology. As to the volume of innovative production and the share of innovative production, they change insignificantly. At the same time, a positive dynamics of the efficiency of innovation activ-

ity may be highlighted: the indicator Volume of innovative production Number of innovative enterprises reduced in 1996 by 30% but overshoot the 1995 level in 1997. A few industries increased their innovation activity, among them microbiological industry, but the others, such as chemical and petrochemical industry reduced it.

2. Analysis of correlations of R&D expenditures reveals that all of them could be separated into two groups. As a representative of the first group expenditures on acquisition non-patent licenses were selected, for the second group expenditures on designing and engineering were selected. These two indicators were used to construct typologies and for analysis of dependencies.
3. Analyses of correlations of the outputs of innovation activity also led us to select two representative indicators: number of the enterprises engaged in innovation activity and share of innovative production in total production.
4. Typologies of observations were designed from two different points of view: from the point of view of expenditures and from the point of view of results of innovation activity.

   Four-clusters typology using expenditures data was constructed. Cluster 1 is formed by machine-building industry with big value of expenditures on designing and engineering and with small value of expenditures on acquisition non-patent licenses. Industries with large expenditures on acquisition non-patent licenses but small expenditures on designing and engineering form cluster 2 (among them iron metallurgy and medical industry). The majority of industries form cluster 3 (among them metal working industry and woodworking industry and pulp-and-paper industry). They had small values of both types of expenditures.
5. Typological analysis of manufacturing industries from the point of view of results of innovation activity gave three big classes. The first one is characterized by big values of the number of the enterprises engaged in innovation activity but by small values of the share of innovative production in total production of industry (machine-building industry, food industry). The second class is characterized by small values of the number of the enterprises engaged in innovation activity but big values of the share of innovative production in all production of industry (microbiological industry, chemical and petrochemical industry, printing industry). The majority of industries (third class) had small values of both indicators.
6. The dependencies between expenditures and outputs were investigated. This dependencies are significant but non-linear. As a rule, they are even non-monotonic. Nevertheless, one may see that the increasing of expenditures on designing and engineering provides the increase of innovative production; if

the expenditures on acquisition non-patent licenses are large, the number of enterprises engaged in innovative activity is also large, but the share of innovative production in total sales remains constant.

References

MAMUNEAS, T.P., NADIRI,M.I., (1996), Public R&D Policies and Cost Behavior of the U.S. Manufacturing industries, Journal of Public Economics, 63,

GOKHBERG, L., (1994) Basic Research in Russia: Human Resources and Funding, Economic Systems, vol 18 (2),

RADOSEVIC, S., (1994), Strategic Technology Policy for Eastern Europe, Economic Systems, vol 18 (2),.

SPSS Guide.