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The Science and Technology System in the Federal Republic of Yugoslavia

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Summary

On the eve of the collapse of SFR Yugoslavia, industry in Serbia and Montenegro was characterised by a relatively high level of in-house innovation activity, largely focused on the development of new products and processes for the firm involved. But innovation networking, as reflected in intersectoral 'trade' in innovations and patenting statistics, remained weak. What is clear is that by the late 1980s Serbian and Montenegrin business leaders understood the importance of innovations, and in particular understood that there is no technological development without in-house innovation activity. From the birth of FR Yugoslavia as a federation of Serbia and Montenegro, innovation issues were dominated by the sanctions imposed on the new country by the UN, in connection with the conflict in Bosnia. Over the period 1992-96, innovation activity actually increased greatly within firms, in relative terms - because production as such virtually stopped in many cases. In-house innovation activity became the only source of new technology, and was an important factor in limiting brain drain. Thus the innovation activity of the sanctions period has given firms from Serbia and Montenegro a better starting point, now that they are once again able to participate in global economic and technological activity.

Part A: ANALYSIS OF THE SCIENCE AND TECHNOLOGY SYSTEM OF THE FEDERAL REPUBLIC OF YUGOSLAVIA

1 INTRODUCTION

The Federal Republic of Yugoslavia (FRY) was constituted in 1992 from two republics, the Republic of Serbia and the Republic of Montenegro, as a continuation of the former Socialist Federal Republic of Yugoslavia (SFRY), and of the states of Serbia and Montenegro, which entered the first Yugoslavia in 1918. In order fully to understand the current situation in S&T in the Federal Republic, we must look briefly at the national and international political context within which it has developed.

1.1 S&T and Events in the Outside World

The main relevant trends at global level at the end of the 1980s and beginning of the 1990s were:

1 The disintegration of the centrally planned economic system in East Europe and the former USSR, and the confirmation of the superiority of the market economy.

2 The trend to more explicit international co-operation, or globalisation, within S&T, and indeed at the economic level in general. Thus market economies integrate, while non-market economies, including the so-called socialist self-management economies (principally Yugoslavia) - disintegrate.

3 The most vivid example of integration is the creation of the European Union (EU), which has had multiple consequences for political, economic and S&T development in Europe and the world.

4 One of the underlying causes of these trends and developments is the rapid development and application of new technologies, particularly of information technology, as a basis for competing internationally in economic, political and military terms.

5 The ramifications of the development of information technology has led governments to increase their level of control and support in relation to S&T development.

6 With increased recognition that knowledge is the most important "resource" for S&T development, career-long continuous education is more and more the norm.

7 In connection with this, the importance of "intangible" investments (education, R&D, licenses and know-how, software, improvements in organisation and work methods, marketing, etc) within total investment, grows continuously, particularly in the developed countries.

8 One result of these investments is the development of new production systems (Just in Time - JIT, Total Quality Control - TQC, etc) and new methods of work organisation (movement away from Fordism), favourable to the development and application of new technologies.

9 Increasing awareness of the limits to stocks of natural resources, and the degrading effect of production on the life environment, leads to growing investment in environmental protection (development of "clean" technologies, recycling, energy conservation, etc).

10 Intellectualisation of production and work processes in general generates buoyant demand for highly skilled personnel, and intensifies the brain drain from the less developed countries.

1.2 S&T and Events on the Domestic Scene

All these changes in the international environment were either a factor or a consequence of the acceleration of the pace of development of S&T, and of the global economy. They had a marked impact on the domestic environment within FR Yugoslavia. But the impact on S&T development was not always positive, primarily on account of the underdevelopment and weakness of political and industrial system inherited from SFR Yugoslavia.

The main domestic trends were

1 Acceptance of market principles in the conduct of business, and the development of a political and economic system which complied with the requirements of the market economy. Privatisation started in SFR Yugoslavia in 1989.

2 Following the example of the developed countries, the federal and republic governments of the former Yugoslavia, had started, by the mid-1980s, to deepen their engagement in the management and monitoring of S&T development. By the end of 1988, strategies for S&T development up to the year 2000 had been largely completed at both political levels, the implementation of the first phase of the programme for building an S&T

Information System in Yugoslavia had been started, and intensive international S&T co-operation was being developed.

4 Unfortunately, the general economic reforms which had been started in the former Yugoslavia did not go well, and this resulted in the disintegration of the economic system, a large decline in manufacturing, a decrease in savings/investment, an evolution of inflation into to hyperinflation, generalised insolvency, etc, and, later, to the disintegration of the country.

5 The national product declined by 2% per annum over a five-year period (1986-1991), and by a total of 10.8% over the last two years of this period (1989-1991). As a consequence, the resources available for R&D were sharply reduced.

6 In this period, the rate of brain drain from the Yugoslav R&D sector to the developed countries grew to the dimensions of a serious national problem.

1.2.1 Changes in the domestic environment during the period of international isolation

1 Over the period from the imposition of sanctions to the introduction of the programme for economic recovery of FR Yugoslavia, the physical volume of industrial production declined monthly by an average of about 4%. GDP in 1995 was 40% lower than it had been in 1991, and the unemployment rate in 1996 was almost 25%.

2 The structure of industrial production changed significantly over that period. The decline in the output of the metal industry was more than 60%, in production of energy equipment more than 70%, and in the food industry 30%.

3 The export ban seriously affected the development of the S&T infrastructure, the maintenance and procurement of research equipment, procurement of S&T journals and other scientific publications, etc.

4 International S&T co-operation was completely blocked. While researchers from FR Yugoslavia managed to participate in most international S&T conferences, sanctions stopped them from participating in international S&T projects, etc.

5 The federal government programme to bring back researchers from abroad was powerless to stop continued brain drain to the developed countries, in the context of deteriorating living conditions and conditions for scientific work.

6 The sole, "positive" effect of international isolation was an increased interest on the part of industry in R&D work, as a basis for technological import substitution

2 THE S&T SYSTEM OF THE FEDERAL REPUBLIC OF YUGOSLAVIA

According to the federal constitution, it is the republics within FR Yugoslavia that are responsible for science and technology. S&T systems in the two republics are organised in very similar ways, with some differences reflecting regional and economic peculiarities.

2.1 R&D Organisations and Researchers

The S&T systems of the republics consist of:

- Universities (Uni),
- Independent Institutes (II),
- Research and Development (R&D) Units (RDU) in industry,
- S&T Infrastructure.

Tables A.1-A.3 contain basic data on the S&T systems of the two republics, plus aggregate figures for SFR Yugoslavia in 1990 and for FR Yugoslavia in 1994, according to type of institution (Uni/II/RDU) and field of science, and in terms of the following indicators:

- number of R&D organisations;
- total number of employees (Emp);
- number of researchers in FTEs (FTE - full-time equivalent).

The picture of the S&T systems at republic and federal level is completed by figures A.1 through A.4.

Let us look now at some of the specific features of the development of the S&T systems of Serbia and Montenegro that emerge from the data in tables A.1-A.3 and figures A.1-A.4.

2.1.1 Republic of Montenegro

By 1994 the number of researchers had fallen sharply - by almost 20% comparing with 1990. The reason was lack of funding for R&D. Against that background, "informatisation" campaigns have become the main focus of the R&D sector, as it strives to show the way forward in relation to technological development. A second focal point for the R&D sector is

Table A.1: S&T system in SFR Yugoslavia - 1990, and FR Yugoslavia - 1994

Field of science	Type of organis-ation	Number of organisations		Number of employees (Emp)		Number of researchers (FTE)	
		1990	1994	1990	1994	1990	1994
Natural and Mathematical sciences	Uni	32	11	2 930	1 434	615	296
	II	53	15	3 535	1 702	2 003	910
	RDU	12	5	310	86	167	51
	Subtotal	97	31	6 775	3 222	2 785	1 157
Technical sciences and (+) Multidisciplinary sciences	Uni	99	26+3	10 795	4 095 + 135	2 238	784+ 51
	II	117	25+2	15 914	5 232 + 34	5 002	1 609 + 2
	RDU	117	17+1	8 344	1 641 + 9	2 631	225 + 8
	Subtotal	333	68+6	35 053	10 968 +178	9 871	2 618 + 61
Medical sciences	Uni	38	20	9 715	5 519	1 181	638
	II	31	4	4 569	174	942	97
	RDU	43	6	1 712	318	793	58
	Subtotal	112	30	15 996	6 011	2 916	793
Agricultural sciences	Uni	33	10	4 079	1 820	809	324
	II	45	21	3 821	1 201	1 128	361
	RDU	19	12	360	638	144	172
	Subtotal	97	43	8 260	3 659	2 081	857
Social sciences	Uni	66	29	5 646	2 039	1 131	399
	II	76	18	2 679	525	1 346	319
	RDU	16	2	175	30	103	9
	Subtotal	158	49	8 500	2 594	2 580	727
Humanities	Uni	27	18	3 102	2 307	614	480
	II	38	15	1 365	343	842	249
	RDU	6	4	146	87	83	52
	Subtotal	71	37	4 613	2 737	1 539	781
All science	Uni	295	117	36 267	17 349	6 588	2 972
	II	360	100	31 883	9 211	11 263	3 447
	RDU	213	47	11 047	2 809	3 921	575
Total S&T system		868	264	79 197	29 369	21 772	6 994

Sources: Statistical Bulletin No 1926: "Scientific-Technological and Research-Development Organisations 1990", Federal Statistical Office of SFRY, Belgrade, 1991; and Statistical Bulletin No 2083: "Institutions of Scientific-Technological Development 1994", Federal Statistical Office of FR Yugoslavia, Belgrade, 1996

Table A.2: S&T system in SR Serbia - 1990, and Republic of Serbia - 1994

Field of science	Type of organi-sation	Number of organisations		Number of employees (Emp)		Number of researchers (FTE)	
		1990	1994	1990	1994	1990	1994
Natural sciences and Mathematical sciences	Uni	20	10	1 427	1 362	265	279
	II	27	13	1 503	1 663	812	795
	RDU	4	3	81	63	57	47
	Subtotal	51	26	3 011	3 088	1 134	1 121
Technical sciences and (+) Multidisciplinary sciences	Uni	36	22 + 3	3 719	3912+135	690	747+51
	II	48	24 + 1	7 656	5142+16	2 293	1 601+2
	RDU	22	14 + 1	2 009	1 571+9	426	190+8
	Subtotal	106	60 + 3	13384	10 625+160	3 409	2 538+61
Medical sciences	Uni	24	20	6 453	5 519	709	638
	II	4	3	233	155	79	86
	RDU	4	6	56	318	38	58
	Subtotal	32	29	6 742	5 992	826	782
Agricultural sciences	Uni	11	10	1 509	1 820	288	324
	II	22	20	1 966	1 113	572	334
	RDU	9	12	162	638	60	172
	Subtotal	42	42	3 637	3 571	920	830
Social sciences	Uni	26	26	2 281	1 843	461	364
	II	22	17	619	516	374	312
	RDU	3	2	46	30	28	9
	Subtotal	51	45	2 946	2 389	863	685
Humanities	Uni	11	14	825	2 095	165	441
	II	17	14	562	322	356	235
	RDU	4	4	99	87	69	52
	Subtotal	32	32	1 486	2 504	590	728
All science	Uni	128	105	16214	16 686	2 578	2 844
	II	140	92	12 59	8 927	4 486	3 365
	RDU	46	42	2 453	2 716	678	536
Total S&T system		314	239	31206	28 329	7 742	6 745

Sources: Statistical Bulletin No 1926: "Scientific-Technological and Research-Development Organizations 199", Federal Statistical Office of SFRY, Belgrade, 1991; and Statistical Bulletin No 2083: "Institutions of Scientific-Technological Development 1994", Federal Statistical Office of FR Yugoslavia, Belgrade, 1996

Table A.3: S&T system in SR Montenegro - 1990. and Republic of Montenegro - 1994

Field of science	Type of organi-sation	Number of organisations		Number of employees (Emp)		Number of researchers (FTE)	
		1990	1994	1990	1994	1990	1994
Natural sciences and Mathematical sciences	Uni	1	1	56	72	46	17
	II	3	2	73	39	31	15
	RDU	-	2	-	23	-	4
	Subtotal	4	5	129	134	77	36
Technical sciences and (+) Multidisciplinary sciences	Uni	4	4 + 0	116	183 + 0	25	37 + 0
	II	2	1 + 1	136	90 + 18	33	8 + 0
	RDU	2	3 + 0	186	70 + 0	72	35 + 0
	Subtotal	8	8 + 1	438	343 + 18	130	80 + 0
Medical sciences	Uni	-	-	-	-	-	-
	II	1	1	13	19	3	11
	RDU	-	-	-	-	-	-
	Subtotal	1	1	13	19	3	11
Agricultural sciences	Uni	-	-	-	-	-	-
	II	1	1	87	88	24	27
	RDU	1	-	7	-	2	-
	Subtotal	2	1	94	88	26	27
Social sciences	Uni	5	3	299	196	71	35
	II	2	1	27	9	17	7
	RDU	-	-	-	-	-	-
	Subtotal	7	4	326	205	88	42
Humanities	Uni	2	4	44	212	9	39
	II	3	1	38	21	16	14
	RDU	-	-	-	-	-	-
	Subtotal	5	5	82	233	25	53
All science	Uni	12	12	515	663	151	128
	II	12	8	374	284	124	82
	RDU	3	5	193	93	74	39
Total S&T system		27	25	1 082	1 040	349	249

Sources: Statistical Bulletin No 1926: "Scientific-Technological and Research-Development Organizations 1990", Federal Statistical Office of SFRY, Belgrade, 1991; and Statistical Bulletin No 2083: "Institutions of Scientific-Technological Development 1994", Federal Statistical Office of FR Yugoslavia, Belgrade, 1996 environmentally sustainable technological development. Policy in this regard is jointly developed and implemented by the Ministry for the Environment and the Ministry for Education and Science.

2.1.2 Republic of Serbia

The decrease in the number of researchers 1990-1994. was 6%. The brain drain effect (15% of the total research population over the same period) was partly compensated by the recruitment of more than 1000 young researchers, supported by a special government programme. Connections with the international science community were almost completely destroyed by the international isolation of the sanctions period. Now the R&D system is rebuilding these relationships, but this will be long process, dependent on the articulation of political solutions, the rebuilding of economic strength, and the mediation of the interests of all the institutions involved.

Serbia has developed programmes for (a) scientific research up to the year 2000 (mostly fundamental research in natural and medical science, and in social sciences and humanities); and (b) technological development (mostly in technical and agricultural sciences). The second programme is being monitored and evaluated every three years, which gives scope for 'running' modifications and improvements directed to the needs of industry and the technological development of the country.

The innovation system of the country is, still in a formative phase, in which the role of networks between industry and the R&D sector is not yet recognised. The problem stems from the appalling situation in industry, and that situation will not improve until concrete restructuring programmes are implemented. We return to this subject in Part B.

There has been a marked migration of personnel from institutes to universities - as indeed there has been in all the former Yugoslav republics. This could produce a critical mass of R&D activity in the universities at some point in the future.

2.2 Patenting activity

In seeking to provide a comprehensive picture of the evolution of the S&T situation, we can supplement analysis of research personnel trends with an investigation of patent activity statistics for the period 1990-1995 (see table A.4). As a result of the international isolation of the country, the number of foreign patent applications in 1992 fell 59% compared to the year before. The number of foreign patent applications reached its nadir in 1994, with only one-

Table A.4: Patent indicators for the period 1990 - 1995

Patent applications and patent grants		Annual number of patents					
		1990	1991	1992	1993	1994	1995
Patent applica-tions	Domestic	664	547	505	572	574	586
	Foreign	1090	968	570	267	214	221
	Total	1754	1515	1075	839	788	807
Patent grants	Domestic	95	199	64	115	150	151
	Foreign	330	947	236	382	485	329
	Total	425	1146	300	497	635	480

Source: Federal Bureau for Intellectual Property

fifth of the number recorded in 1990. The sharp increase in patent grants in 1991 seems to have been a purely administrative phenomenon.

The number of domestic patent applications and grants increased slightly in 1993, and again in 1994 and 1995. This could be explained in terms of the impact of a concentrated government programme of and support for R&D projects and programmes, strictly oriented to technological development and concrete help to industry from the R&D sector. The figures in table A.4 reflect a critical situation in the S&T system in the country, caused by structural disturbance - shift of researchers from independent institutes and industrial R&D units to universities, reduced development capability in industry, emigration of experienced researchers from the country and/or their abandonment of the S&T sector for other sectors. All this has resulted in a low level of aggregate innovation activity in the country, not only in comparison with other countries, but also, and most importantly, in relation to the needs of Yugoslav industry.

2.3 Comparative Analysis of S&T Indicators: OECD Member Countries and FR Yugoslavia

FR Yugoslavia is comparable in terms of population with Belgium, Greece, Portugal, Sweden, Austria and Switzerland. However, all those countries report higher figures for total employment,[1] substantially higher national product, and much higher research and development expenditures, expressed in dollars at purchasing power parity.

GERD as a percentage of GDP in FR Yugoslavia is 1.21% - significantly higher than in Greece and Portugal, somewhat lower than in Austria and Belgium, and considerably lower

[1]Statistics for the FR of Yugoslavia have no data on employment in the private sector and agriculture

than in Sweden and Switzerland. According to this indicator, FR Yugoslavia can be compared with countries with moderately intensive investment in R&D. However, in terms of absolute values, both Greece and Portugal invest almost twice as much, while Sweden and Switzerland invest more than 15 times as much, as does FR Yugoslavia. The reason for that is that GDP in FR Yugoslavia is significantly lower than for the comparator countries.

The number of researchers in FR Yugoslavia is approximately the same or larger, in absolute and relative (ie, as a proportion of total population and total employment) terms, than in the comparator countries. That means that there are too many research workers in relation to (low) GDP. That in turn reflects the very low level of wages in S&T, which provides no incentive for anything except brain drain.

Patent activity indicators (figures A.5 - A.9) indicate that:

- the total number of patent applications in FR Yugoslavia is comparable only with Turkey and Iceland among the OECD countries, and is tiny compared to that of most of the developed market economies

- the number of resident patent applications in FR Yugoslavia is on average half that of the comparator countries, in terms both of absolute values and of the national inventiveness indicator (the number of home patent applications per 10,000 population). This underscores the unsatisfactory level of patent activity in the country

- The number of foreign patent applications in FR Yugoslavia is unsatisfactory in every respect (absolute number, ratio of foreign to home patent applications), and shows that foreigners are not interested in protecting their inventions in FR Yugoslavia. That lack of interest is a consequence of several factors:
    - the unstable situation in the country due to the war on the territory of the former Yugoslavia and the international isolation of the country;
    - the low level of overall technological development of industry in FR Yugoslavia, which provides no competitors or development "dangers" to foreign companies;
    - the difficulty involved in carrying out financial and other transactions with FR Yugoslavia.

2.4 S&T Infrastructure

The Federal Policy for S&T Development of FR Yugoslavia defines the following elements of public S&T infrastructure:

- national laboratories;
- research centres of excellence;
- centres for the diffusion of technology;
- laboratories accredited for testing and attestation;
- the S&T Information System of FR Yugoslavia;
- the gene plant bank;
- centres for the promotion of science and technology;
- federal organisations responsible for standardisation, measurement, intellectual property and informatics;
- The Zvezdara S&T park.

On the basis of the latest information we can state that:

- Not a single laboratory has been vouchsafed the status of national laboratory, ie, institution of national interest within the S&T system of FR Yugoslavia. The same applies to centres of excellence and technology diffusion centres. This is partly due to financial restrictions.

- Within the framework of the federal organisation responsible for standardisation, measurement and precious metals, a group of laboratories has been authorised to carry out tasks in the testing and attestation field. In parallel, within the programme for the introduction of quality systems YUS ISO 9000 being implemented by the Serbian Ministry for Science and Technology, a procedure for the formation of centres for quality control and attestation laboratories was established;

- Development of the S&T Information System of Yugoslavia (STISY) is being implemented in the Republic of Serbia through a programme for the development and functioning of S&T information systems[2] coming under the aegis of the Ministry for Science and Technology of the Republic of Serbia.

- The gene plant bank, which has 100% financial backing from the federal government, is in its final development stages.

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[2] In SFR Yugoslavia, the only common R&D infrastructure built and used by all the scientists in the country was the *S&T Information System* - an academic network which connected all university centres and research organisations in the country with a gateway to world academic information networks. The main host was situated in Maribor (Slovenia), so that with the dissolution of the country, Serbia and Montenegro were cut off from their international networks.

- The centre for the promotion of science and technology has not yet been established;

- Federal organisations responsible for standardisation, measurement, intellectual property and informatics face a number of problems:
  - shortage of trained personnel;
  - relatively poor equipment;
  - inadequate premises;
  - inadequate financing (even though the majority of these institutions generate significant income, none of that income is retained be the institutions);
  - rupture of formal links with corresponding foreign organisations, because of either the international isolation of country, unpaid membership, and/or non-participation in the work of international bodies.

- The development of the Zvezdara S&T park has been postponed for financial reasons, and may be shelved.

Methodological notes on the data presented in the tables and graphs

Figures for "*Employees*" **(Emp)** are not necessarily equal (and in case of the S&T system of FR Yugoslavia are *not* equal) to **FTEs** (full-time equivalents) as defined in the Frascati Manual by the OECD, mainly because they include all researchers in universities: in practice, some of those are involved exclusively in R&D, while others are involved in teaching and other non-R&D activities as well as R&D activities. (University staff who only teach are not included in the figures for S&T employees.) FTEs are estimated by the author, on the basis of the assumption that three university employees involved in teaching and research = 1 FTE. The rationale for this assumption is the fact that the Serbian Ministry for Science and Technology covers one third of the annual costs of employing one university teacher/researcher, with two thirds being paid by the Ministry for Education. The procedure is similar in Montenegro (and in other republics of the former SFR Yugoslavia).

For purposes of statistical analysis, totals for employees are broken down into the following categories:

- researchers,
- technicians,
- administration staff,
- others.

Part B: AN INNOVATION SURVEY OF THE YUGOSLAV METAL-PROCESSING, CHEMICALS AND TEXTILE INDUSTRIES[3]

INTRODUCTION

Innovation surveys for Yugoslavia's metal-processing, chemicals and textile industries were organised and conducted by the Science and Technology Policy Research Center (STPRC) of the Mihajlo Pupin Institute, Belgrade. The users (and sponsors) of this research were the Federal Ministry for Development, Science and the Environment and the Ministry for Science and Technology of the Republic of Serbia. Two innovation surveys were commissioned: the first innovation survey covered Serbia and Montenegro for the period 1987-1991,[4] and the second innovation survey the period 1992-1996, as far as possible with the same sample of firms, but only for Serbia.[5] The methodological foundations of the two innovation surveys were basically the same, though there were some refinements in the second innovation survey based on the experience gained in the first.

Section I: Innovation Survey for the Period 1987-1991

1 METHODOLOGICAL ISSUES

The methodological foundations for this research were:

- The OSLO Manual (OECD, 1992);
- Multiple criteria decision-making methods (MCDM) (Zeleny, 1973, 1975)
- Econometric analysis;
- Decision support systems (DSS): theory and practice.

1.1 The questionnaire

The OSLO Manual was used as the basis for the questionnaire which served as the fundamental source of information on innovation activities in the selected industrial firms.

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[3]The data presented in this chapter are original data, collected from industrial firms in the Federal Republic of Yugoslavia (Republic of Serbia and Republic of Montenegro). The author is not authorised to divulge the names of the firms surveyed. All findings, remarks and conclusions are presented as the author's personal opinion.

[4]'Science and technology in Europe and their implications on technological, economic and social development in Yugoslavia', first phase, project funded by the Federal R&D Fund, Science and Technology Policy Research Center of the 'Mihajlo Pupin' Institute, Belgrade, 1988-92.

[5]"Serbia's innovation system research', a strategic R&D project sponsored by the Minister of Science and Technology by the Republic of Serbia, S.197, Science and Technology Policy Research Center of the 'Mihajlo Pupin' Institute, Belgrade, 1994-97.

Although the manual was available to researchers involved in this survey, the definitive questionnaire developed by the OECD was not available to them, on account of the international isolation imposed on Yugoslavia at the time when the survey was in its initial phase. For that reason some draft questionnaires, circulated at a time when the author of this report was still a member of the NESTI (National Experts in Science and Technology Indicators) group within the OECD were consulted. The most comprehensive and detailed was a Canadian questionnaire, and this was used as a model by the STPRC researchers.

The final version of the questionnaire, as developed by STPRC researchers, consisted of more than 120 questions, sorted into five groups, each dealing with a specific subject, viz:

1 General profile of the firm;
2 Innovation activity in the firm;
3 The most important innovation for each firm over the reporting period;
4 The technological level of the firm in relation to the "state of the art";
5 Management of the firm and new technology.

The fifth group of questions was actually related to another research project done by STPRC researchers at the same time. The findings of that research project are not directly connected to the analysis of innovation activity in industrial firms and will not be included in the present report. The rationale for the inclusion of Group 5 questions in the questionnaire was purely functional - it saved the researchers having to communicate with the firms in question a second time.

1.2 Multicriteria Analysis of Innovation Activity in Industrial Firms

The multicriteria analysis approach used in the research project encompasses:

- a number of single criterion analyses of specific problems and characteristics of innovation activity;
- use of quantitative measurements for single criterion analyses;
- aggregation of a non-limited number of single criterion analyses findings into one, aggregate indicator of the innovation capabilities of the given firm;
- interpretation of multiple criteria analyses of innovation activity in industrial firms.

The Compromise Programming Method (Zeleny, 1973) (more specifically the Displaced Ideal version of this approach, Zeleny, 1975) was selected as the most appropriate method for this particular programme research.

1.3 Assessment of the Independence of the Single Criteria Used - Indicators of Specific Characteristics of Innovation Activity in Industrial Firms

One of the main conditions for the use of multiple criteria analysis is that the single criteria used should be independent of each other. We tested for this econometrically. Through the application of multiple regression analyses, analysis of heteroscedascity, elasticity and collinearity, we produced a set of linearly independent indicators, suitable for aggregation by MCDM methods.

1.4 A Decision Support System (DSS) for the analysis of innovation activity

A DSS suitable for analysing innovation activity in industrial firms should provide:

- a tool for the visual (3-D, 2-D) presentation of the results of single and multiple criteria analyses of innovation activity;
- a tool for simulation of strategic decision taking, as a basis for finding the optimal trajectory for the technological development of a particular firm.

2 FINDINGS AND RESULTS

2.1 Sample

The sample covered on average 25% of the total work-force in the industries selected for the survey (see Table B-I.1)

Table B-I.1: Sample - Innovation Survey I - Innovation Activity in Industrial Firms 1987-1991

Industry	Number of firms	Number of employees	Share of industry total
Metal processing	29	79 939	25.3
Chemicals	14	27 308	49.1
Textiles	5	25 721	15.5
Total	48	132 968	24.8

2.2 R&D in Industrial Firms

The main R&D activity in the firms analysed was the development of new products; then follows the improvement of existing products. There were some exceptions in the textile industry, where the improvement of existing process technologies accounted for a significant share in total R&D activity (Table B-I.2).

Table B-I.2: R&D by Type of R&D Activity, 1987-1991

R&D	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=40	n=25	n=12	n=3
Basic research	2.5	2.9	1.7	1.7
Development of new products	38.6	37.6	44.6	23.3
Improvement of existing products	27.2	24.1	34.2	25
Development of new process technologies	10.3	10.7	7.9	16.7
Improvement of existing process technologies	12.4	12.4	8.3	28.3
Development of new technological services	3.8	5.2	1.1	3.3
Improvement of existing technological services	4.2	5.4	2.2	1.7
Others	1	1.7	0	0
Total (%)	100	100	100	100

2.3 Product and Process Innovation

The main categories of innovation activity in the firms analysed were product innovations involving no change in process technologies in metal processing and the chemicals industry; and product innovations with changes in process technology in the textile industry. Process innovation is also important for the chemicals industry (Table B-I.3).

2.4 Patterns of Expenditure in Innovation Activity

Internal R&D and trial production are the main items of expenditure within innovation activity for all three industries, with internal R&D particularly dominant within the textile industry. Experimental development is the third most important item of expenditure for all three, and market research comes up into fourth place for the chemicals industry (Table B-I.4).

Table B-I.3: Product and Process Innovation, 1987-91

INNOVATION ACTIVITY	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=39	n=24	n=11	n=4
AVERAGE NUMBER OF PRODUCT INNOVATIONS				
· with no change in process technologies:				
successful innovations - average	9.9	8.9	16	0.3
developing innovations - average	6.2	5.7	9.4	1
unsuccessful innovations - average	1.2	0.9	2.1	0.5
Subtotal	17.3	15.5	13.1	1.8
· with changes in process technologies:				
successful innovations - average	5.3	4.7	7	4.3
developing innovations - average	3.1	3	4.1	1.3
unsuccessful innovations - average	0.3	-	0.9	0.5
Subtotal	8.5	7.7	12.2	6.1
AVERAGE NUMBER OF PROCESS INNOVATIONS				
· without new products:				
successful innovations - average	5.2	6	4.4	2.5
developing innovations - average	1.6	1.6	1.8	-
unsuccessful innovations - average	0.4	-	0.5	-
Subtotal	7.2	7.6	6.7	2.5

Table B-I.4: Main Items of Expenditure for Innovation Activity 1987-91

ITEMS OF EXPENDITURE FOR INNOVATION ACTIVITY	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=44	n=28	n=12	n=4
R&D				
Internal	41.1	39.6	40.9	52.5
External	4.8	5.9	1.7	6.2
Others:				
Technology transfer	3.3	2.6	5.4	1.9
Experimental development	16.7	18.4	12.5	16.9
Trial production	20.1	22.5	15	18.6
Market research	6.3	4.9	10.8	2.5
Training	4.3	4.3	5.4	1.1
Other	3.4	1.8	8.3	0.3
Total	100	100	100	100

2.5 Acquisition of Technologies

The main source for the acquisition of technologies was the purchase of capital equipment (Table B-I.5).

Table B-I.5: Innovation Activity and Acquisition of Technology, 1987-1991

CHANNELS OF ACQUISITION OF TECHNOLOGIES	Number of contracts FR YUGOSLAVIA			
	Tot n=25	Met n=19	Chem n=4	Tex n=2
R&D contract	6	5	1	0
R&D cooperation	9	7	2	0
Licence for:				
patent	5	5	0	0
model	2	2	0	0
design	3	3	0	0
others	2	2	0	0
Information system incorporating new technology	3	3	0	0
Capital equipment	24	19	4	1
Technology-based services	5	2	3	0
New process technologies	9	8	0	1
Parts and materials incorporating new technology	3	2	0	1

2.6 R&D For/With Other Firms

A specific characteristic of the textile industry is that it has no connections with either domestic or foreign partners (Table B-I.6). By contrast, both the metal-processing and chemicals industries have strong connections (contracts, cooperation, etc) with universities and R&D institutes at home, and with clients/customers and suppliers at home and abroad. Joint ventures have been an important form of relationship with foreign partners for these two industries.

2.7 Innovation Activity and the Firm's Environment

Investigation of the importance of different internal and external factors influencing a firm's innovation activity revealed contrasting patterns for the industries analysed. In the textile industry, it is the firm's financial situation and skilled personnel that are crucial (this helps to

Table B-I.6: R&D for/with Other Firms, 1987-1991

PARTNER	Number of contracts Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=35	n=27	n=8	n=0
Domestic partners:				
Clients/customers	9	7	2	-
Suppliers	6	5	1	-
Joint ventures	4	4	0	-
Other firms	2	2	0	-
R&D institutes	26	21	5	-
Universities	28	24	4	-
Other partners	1	1	0	-
Foreign partners:				
Clients/customers	10	8	2	-
Suppliers	9	7	2	-
Joint ventures	9	6	3	-
Other firms	0	0	0	
R&D institutes	8	6	2	-
Universities	1	1	0	-
Other partners	0	0	0	-

explain the internalisation of all R&D activity in that industry). Management's handling of skilled personnel and management's vision of future development are the most important internal factors for the metal-processing industry. The chemicals industry is similar to the metal processing industry, with an additional stress on the importance of R&D resources within the firm. None of the three industries is particularly concerned with external factors (some importance is attached to external financing for R&D in metal processing, and to external support for capital equipment renewal in the chemicals industry).

2.8 Sources of Ideas/Information for Innovation Activity

The main internal source of ideas/information for innovation activity in metal processing and chemicals is the R&D department. In metal-processing firms the marketing department also plays a prominent role, and in textiles it plays the dominant role (Table B-I.8). External sources are the same as for industrial firms in developed countries: clients or customers,

Table B-I.7: Innovation Activity and Internal/External Environment, 1987-1991

FACTOR	SIGNIFICANCE (1-low → 5-high) Serbia and Montenegro			
	Tot n=44	Met n=28	Chem n=12	Tex n=4
Internal:				
Firm’s financial situation	3.8	3.9	2.9	4.3
R&D capabilities	3.9	4	3.8	2.3
Managerial vision	4.1	4.1	4	3.5
R&D resources	3.6	3.6	3.6	1.5
Pay-back period	2.3	2.2	2.3	1.5
Knowledge of the market	3.5	3.1	4	3.8
Skilled personnel	4	4.1	3.4	4
External:				
Skilled personnel	1.9	1.8	1.8	2
External funds	2.4	2.5	2.1	2
Tax exemptions	2	1.9	2.3	1.8
Support for acquisition of capital equipment	2.6	2.5	3.3	2.5
External financing for R&D	3	3.1	2.5	3
External financing for pilot projects	2.7	2.7	2.5	2
Subsidised loans	2.4	2.2	2.3	3

suppliers, competitors, professional conferences, fairs and exhibitions, technical journals and universities and R&D institutes. The textile industry is, again, more closed, looking mostly to internal sources, and having less developed relationships with the external world.

2.9 Sales and Exports as a Function of Innovation Activity

The contribution to sales and exports of innovation activity averages around 30-40% in the metal-processing and chemicals industries, coming more or less equally from new and incrementally improved products and processes. For the textile industry, the corresponding figure is as high as 70-80% (Table B-I.9).

Table B-I.8: Sources of Ideas/Information for Innovation Activities, 1987-1991

SOURCES OF IMPORTANT IDEAS/ INFORMATION	NUMBER OF FIRMS			
	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=46	n=29	n=13	n=4
Internal:				
Administration	8	5	3	0
R&D department	26	21	5	0
Marketing department	26	17	7	2
Production	15	9	5	1
Other internal sources	1	1	0	0
External:				
Suppliers	5	3	1	1
Clients/customers	33	22	9	2
Other firms	11	9	2	0
Daughter companies	8	8	0	0
Competitors	19	11	7	1
Professional conferences	27	17	8	2
Fairs/exhibitions	35	24	9	2
Patent office/documents	11	7	3	1
Technical journals	36	22	11	3
Software firms	5	4	1	0
Consulting firms	4	4	0	0
R&D institutes	21	16	5	0
Universities	20	17	2	1
Standards	3	3	0	0
Agencies for technology transfer	5	5	0	0
Others external sources	10	8	2	0

Table B-I.9: Innovation and Sales/Exports of Products/Processes 1987-91

PRODUCTS/ PROCESSES	Serbia and Montenegro			
	Tot n=45	Met n=30	Chem n=10	Tex n=5
No innovations				
S1 - Sales	59.9	60.1	72.4	32.7
E1 - Exports	58.5	62.9	71.0	19.0
Incremental improvements				
S2 - Sales	19.8	17.8	12.7	47.1
E2 - Exports	20.2	18.4	10.8	46.0
New products/processes				
S3 - Sales	20.3	22.1	14.9	20.2
E3 - Exports	21.3	18.7	18.2	35.0
S1+S2+S3 = E1+E2+E3 =	100	100	100	100

2.10 Diffusion of Products/Processes to Other Firms/Industries

There are striking intersectoral differences in the way that the results (products/processes) of the innovation activity of the firms analysed are used in other industries/sectors (Table B-I.10). Products/processes coming from metal-processing firms are used in a number of other industries and sectors, in addition to metal processing itself. The chemicals industry provides a smaller, but still substantial number of other industries and sectors with innovations (in most cases, these other industries/sectors have common activities and/or production dependence vis-à-vis chemicals). The textile industry, by contrast, is a closed industry - it is a user of the research results of both metal-processing and chemicals firms, but the results of innovation activities in the textile industry are used only within the industry itself.

2.11 Innovation Activity and Commercial Results

The effects of innovation activity on a given firm's business performance are predictable: an increase in profit and sales, new markets, increased product range, and a decrease in production costs (Table B-I.11). There is no strong effect on marketing expenditures and business risk, because this is still an undeveloped market economy, where firms are protected from competition from outside the country. In these circumstances (the domestic market is "shared" between domestic firms), they can produce and sell all stocks without serious business risk.

Table B-I.10: Diffusion of Products/Processes to other Firms/Industries, 1987-1991

SECTOR OR INDUSTRY	Number of firms - DONORS of innovation			
	Serbia and Montenegro			
	Tot	Met	Chem	Tex
↵	*n=37*	*n=24*	*n=10*	*n=3*
Agriculture, fishing, forestry	11	10	1	0
Mining, oil and gas	10	8	2	0
Industry:				
Food, drinks, tobacco	10	7	3	0
Plastic, rubber	10	5	5	0
Textiles	8	2	3	3
Furniture	4	1	3	0
Paper	4	2	2	0
Publishing	6	1	5	0
Metals	5	3	2	0
Metal products	13	9	4	0
Machine tools	16	13	3	0
Aircraft and parts	7	7	0	0
Cars and parts	17	15	2	0
Telecommunications	5	5	0	0
Electronic devices	7	7	0	0
Computers	4	4	0	0
Non-metallic minerals	3	2	1	0
Oil	6	3	3	0
Pharmaceuticals	6	5	1	0
Scientific equipment	5	4	1	0
Other	8	5	3	0
Water supply	7	6	1	0
Civil engineering	15	11	4	0
Transport	13	13	0	0
Trade	4	2	2	0
Tourism	2	1	1	0
Handicrafts	11	6	4	1
Urban services	6	6	0	0
Banking, insurance	0	0	0	0
Other services	5	3	2	0

Table B-I.11: Innovation Activity and Business Results, 1987-1991

INDICATOR	NUMBER OF FIRMS Serbia and Montenegro			
	Tot n=45	Met n=29	Chem n=12	Tex n=4
Profit:				
decrease	0	0	0	0
no change	9	8	1	0
increase	35	20	11	4
Production costs:				
decrease	30	21	7	2
no change	9	5	4	0
increase	3	1	1	1
Marketing expenses:				
decrease	2	2	0	0
no change	24	18	5	1
increase	14	6	6	2
Salaries:				
decrease	5	2	3	0
no change	25	16	7	2
increase	10	8	1	1
Business risk:				
decrease	13	10	2	1
no change	20	13	5	2
increase	5	3	2	0
Market - total sales:				
decrease	1	1	0	0
no change	9	7	2	0
increase	29	18	8	3
Market - geographical coverage:				
decrease	1	1	0	0
no changes	12	8	3	1
increase	25	17	6	2
Number of products:				
decrease	0	0	0	0
no changes	3	1	2	0
increase	37	26	8	3

2.12 Innovation Activity and Structural Change

The main structural changes observed as innovation activity proceeds are on the technological side - deeper production specialisation and higher productivity. Organisational change is most marked in metal processing; there is some tendency to organisational evolution in chemicals, but none in the textile industry (Table B-I.12).

Table B-I.12: Innovation Activities and Structural Change, 1987-1991

STRUCTURAL CHANGE AT FIRM LEVEL	**NUMBER OF FIRMS Serbia and Montenegro**			
	Tot n=45	**Met n=29**	**Chem n=12**	**Tex n=4**
TECHNOLOGY:				
Deeper production specialisation:				
YES	22	15	4	3
NO	19	12	6	1
Higher productivity:				
YES	31	20	8	3
NO	11	7	3	1
ORGANISATION:				
Introduction of new functions within the firm:				
YES	17	13	4	0
NO	22	12	7	3
New organisational units/departments:				
YES	15	10	5	0
NO	24	16	5	3

2.13 Financing of Innovation Activity

The textile industry financed all its innovation activity in the period concerned by itself. It was the same in the chemicals industry. But in the metal-processing industry almost 35% of the total cost of innovation activity was covered from external sources - mostly government funds (Table B-I.13). The average lead-time for major innovations in the firms studied was almost 2.5 years in the metal processing industry, 1.5 years in the chemicals industry and 7 months in the textile industry (Table B-I.13).

Table B-I.13: Major Innovations - Sources of Finance and Average Lead-Times, 1987-1991

SOURCES OF FINANCE FOR INNOVATION ACTIVITY	SHARE IN TOTAL FUNDING (%)			
	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=48	n=32	n=13	n=3
Internal resources	75.4	66	97.8	100
Other firms (joint ventures)	5.7	7.9	-	-
Holding companies	1.4	1.7	1.1	-
Research funds	2.6	3.6	-	-
Governmental funds	8.2	11.5	-	-
Other sources	6.7	9.3	1.1	-
Total funding	100	100	100	100
AVERAGE LEAD-TIME (months)	23.4	27.1	16.8	7.3

2.14 Patenting of Innovations

None of the firms investigated registered many patents over the period concerned. This was a consequence, partly, of a patent law which allowed patentees to apply for patent grants as individual inventors, without the approval of the firm where they work (that patent law has now been superseded in the Federal Republic of Yugoslavia by one that strictly demands the firm's authorisation). A second explanation is the generally very low level of patenting activity, largely restricted just to protection of inventions, in the country.

Table B.14: Patenting of Innovations, 1987-1991

COUNTRIES IN WHICH INVENTORS APPLIED FOR PATENT GRANTS	NUMBER OF INNOVATIONS			
	Serbia and Montenegro			
	Tot	Met	Chem	Tex
	n=46	n=31	n=11	n=4
FR YUGOSLAVIA	5	5	0	0
USA	2	2	0	0
EUROPEAN COUNTRIES	4	3	1	0
OTHER COUNTRIES	2	1	0	1

3 CONCLUDING REMARKS ON THE FIRST INNOVATION SURVEY

Innovation activity in the industries analysed was mostly financed by and implemented by the firm itself, and was largely focused on the development of new products or processes such as would be likely to improve the position of the firm on the market, increase profits and decrease production costs.

The sources of ideas and information for innovation activity in the firms analysed were the typical sources used worldwide (clients, customers, professional conferences, fairs, exhibitions, academic sector, etc).

Patenting of inventions resulting from these innovative activities remained at a low level, mainly because of an inappropriate national patent law.

Intersectoral analysis gives a picture similar to that found in developed countries: the metal-processing industry develops products and processes for its own needs, but also for a number of other industries and sectors; similar patterns are observable in the chemicals industry; whereas the textile industry is "closed", serving only its own R&D needs.

The effects of innovation activity are visible on all dimensions of business performance (profit, production costs, marketing expenditures, salaries, business risk, etc). Some of these effects are not as strong as might be expected, because the market economy in the country remained undeveloped.

By the same token structural change within firms are clearly observable on the technological dimension, but only weakly on the organisational dimension.

The final conclusion on the innovation capabilities of the industries analysed over the period 1987-1991 is rather optimistic - innovation activity had by that time become an important part of the firm’s activity, leading to better levels of equipment, higher skill levels, and, finally, to a heightened awareness of the necessity of innovation activity as a condition of technological development.

Section II: Innovation Survey for the Period 1992-1996

1 METHODOLOGICAL ISSUES

The second innovation survey for the metal-processing, chemicals and textiles sectors was commissioned by the Ministry for Science and Technology of the Republic of Serbia. Consequently, only firms in Serbia were surveyed.[6] The methodological foundations for this survey was the same as for first innovation survey, but the questionnaire was slightly changed. Changes were made to take account of the experience gained from the first survey; in addition, some modifications were made in the section on patents, to take account of the new patent law introduced in the country in 1995. Finally, in view of the serious difficulties encountered by many firms in the wake of the sanctions imposed by the UN against FR Yugoslavia, a second questionnaire was introduced into the second survey. This second questionnaire is a rearranged "EC Harmonised Innovation Surveys 1992-1993 Questionnaire" (EC 1992, 1994). It was administered to firms with limited production and other functions, but which remained operational and engaged in some innovation activity. The questionnaire asks only 16 questions, but is still reasonably comprehensive.

2 FINDINGS AND RESULTS

2.1 Sample

The sample covered 24% of the total work-force in the industries selected for the survey (see Table B-II.1). The number of surveyed firms is different from the first survey, but the samples in the two surveys are almost identical in terms of number of employees. More than two-thirds of the firms surveyed in the second survey are 'survivors' of the first.

Table B-II.1: Sample - Innovation Survey II - Innovation Activity in Industrial Firms, 1992-1996

Industry	Number of firms	Number of employees	Share of industry total
Metal processing	18	67 663	25.4
Chemicals	10	12 777	24.9
Textiles	5	20 237	20.4
Total	33	100 677	24.2

[6]As footnote 5.

2.2 R&D in Industrial Firms

The main R&D activity 1992-96 in the firms analysed was the development of new products, then followed the improvement of existing products (Table B-II.2). Note that data on type of R&D activity in the textile industry were not available.

Table B-II.2: R&D by Type of R&D Activity, Error! No bookmark name given.**1992-1996**

R&D	Tot	Met	Chem	Tex
	n=18	**n=13**	**n=5**	**n=0**
Basic research	2.67	1.38	6.00	-
Development of new products	37.28	33.92	46.00	-
Improvement of existing products	29.06	26.38	36.00	-
Development of new process technologies	7.56	9.31	3.00	-
Improvement of existing process technologies	13.94	16.62	7.00	-
Development of new technological services	4.56	6.31	0.00	-
Improvement of existing technological services	3.82	4.54	2.00	-
Others	1.11	1.54	0.00	-
Total (%)	100.00	100.00	100.00	-

2.3 Product and Process Innovation

The main innovation activities in this most recent period in the firms analysed was product innovation, with or without changes in process technologies (Table B-II.3). Process innovation as such was a minor activity because of serious obstacles to the acquisition of new technologies from abroad.

2.4 Patterns of Expenditure in Innovation Activity

Internal R&D and trial production were the main items of expenditure for innovation activity in the metal-processing and chemicals industries. Experimental development was the most important one in the textile industry. Low levels of expenditure on external R&D and market research reflected a pattern of autarky, and the absence of any pressure of market competition in the country owing to its international isolation country (Table B-II.4).

Table B-II.3: Product and Process Innovation, 1992-96 Error! No bookmark name given.

INNOVATION ACTIVITY	Tot n=17	Met n=10	Chem n=6	Tex n=1
AVERAGE NUMBER OF PRODUCT INNOVATIONS				
· with no changes in process technologies:				
successful innovations - average	6.82	8.30	5.33	1.00
developing innovations - average	7.24	8.60	6.17	-
unsuccessful innovations - average	2.06	2.50	1.67	-
Subtotal	16.12	19.40	13.17	1.00
· with changes in process technologies:				
successful innovations - average	15.35	25.30	1.17	1.00
developing innovations - average	1.65	2.00	1.33	-
unsuccessful innovations - average	0.24	0.40	-	-
Subtotal	17.24	27.70	2.50	1.00
AVERAGE NUMBER OF PROCESS INNOVATIONS				
· without new products:				
successful innovations - average	1.94	2.20	1.83	-
developing innovations - average	1.00	0.60	1.67	1.00
unsuccessful innovations - average	0.53	0.90	-	-
Subtotal	3.47	3.70	3.50	1.00

Table B-II.4: Main Items of Expenditure for Innovation Activity, Error! No bookmark name given.**1992-96**

INNOVATION ACTIVITIES	Tot n=25	Met n=16	Chem n=8	Tex n=1
R&D				
Internal	34.26	23.53	57.68	11.00
External	6.64	5.94	8.88	9.00
Others:				
Technology transfer	1.10	0.45	2.56	-
Experimental development	18.34	20.93	9.06	50.00
Trial production	30.45	38.41	15.19	25.00
Market research	7.27	8.54	5.00	5.00
Training	1.73	1.88	1.63	-
Other	0.21	0.32	-	-
Total	100.00	100.00	100.00	100.0

2.5 Acquisition of Technologies

The main source for the acquisition of the technologies necessary for innovation activity was contracts for technology-based services. The purchase of capital equipment was pushed into second place, mainly because of the international isolation of the country (Table B-II.5).

Table B-II.5: Innovation Activity and Acquisition of Technology, 1992-1996

CHANNELS OF ACQUISITION OF TECHNOLOGIES	Number of contracts Republic of Serbia			
	Tot n=25	Met n=19	Chem n=4	Tex n=2
R&D contract	5	2	1	2
R&D co-operation	6	1	1	4
License for:				
patent	2	-	2	-
model	-	-	-	-
design	-	-	-	-
other	1	-	1	-
Information system incorporating new technology	2	1	-	1
Capital equipment	8	1	3	4
Technology-based services	12	5	2	5
New process technologies	1	-	1	-
Parts and materials incorporating new technology	1	1	-	-

2.6 R&D For/With Other Firms

A specific characteristic for all the industries analysed over the observed period is the much closer relationship than previously with domestic R&D institutes and universities (even for the textile industry, which was wholly self-organised in the previous period). There were also sporadic connections with foreign companies, but no formal contracts with foreign R&D institutions (Table B-II.6).

2.7 Innovation Activity and the Firm's Environment

Internal factors are of dominant importance for the firms analysed. Assessment of the importance of the various factors influencing a firm's innovation activities did, however, reveal contrasting patterns for the individual industries. The firm's financial situation, and management's vision of future development and ability to handle skilled personnel are crucial

Table B-II.6: R&D Error! No bookmark name given. **for/with Other Firms, 1992-1996**

PARTNER	Number of contracts			
	Republic of Serbia			
	Tot	Met	Chem	Tex
	n=33	n=18	n=10	n=5
Domestic partners:				
Clients/customers	6	2	3	1
Suppliers	-	-	-	-
Joint ventures	2	1	1	-
Other firms	2	1	-	1
R&D institutes	18	11	5	2
Universities	20	11	6	3
Other partners	-	-	-	-
Foreign partners:				
Clients/customers	2	2	-	-
Suppliers	3	1	1	1
Joint ventures	2	1	-	1
Other firms	2	2	-	-
R&D institutes	-	-	-	-
Universities	-	-	-	-
Other partners	1	1	-	-

for all three industries. R&D capabilities are an important internal factor for the metal-processing industry too. The chemicals industry is similar to the metal-processing industry, with market research coming through as particularly important. None of the three industries analysed were very much concerned about external factors (some importance is attached to external financing for R&D and pilot-projects in the metal-processing and textile industries, and to support for the acquisition of capital equipment for the chemicals industry).

2.8 Sources of Ideas/Information for Innovation Activity

As for the previous period, the main internal source of ideas/information for innovation activity in 1992-96 was in-house R&D departments (Table B-II.8). There is also a strong contribution by marketing departments in metal-processing and chemicals firms. External sources are as in the previous survey, with textiles remaining more closed than the other sectors.

Table B-II.7: Innovation Activity and Internal/External Environment, 1992-1996

FACTOR	SIGNIFICANCE (1-low → 5-high)			
	Republic of Serbia			
	Tot	Met	Chem	Tex
	n=20	n=13	n=6	n=1
Internal:				
Firm's financial situation	4.30	4.38	4.00	5.00
R&D capabilities	4.20	4.15	4.17	5.00
Managerial vision	4.55	4.54	4.67	4.00
R&D resources	4.05	3.85	4.33	5.00
Pay-back period	3.00	3.00	2.83	4.00
Knowledge of the market	4.05	3.85	4.33	5.00
Skilled personnel	3.70	4.15	4.33	4.00
External:				
Skilled personnel	2.83	2.64	3.00	4.00
External funds	2.45	2.69	1.83	3.00
Tax exemptions	2.40	2.46	2.33	2.00
Support for acquisition of capital equipment	2.75	2.69	2.83	3.00
External financing for R&D	3.05	3.08	2.67	5.00
External financing for pilot projects	3.25	3.62	2.50	3.00
Subsidised loans	2.70	3.00	2.00	3.00

2.9 Sales and Exports as a Function of Innovation Activity

Non-innovatory products and processes bulk larger in total sales and export figures in this period by comparison with the previous period. Within the innovatory group, however, new products and processes contributed more to sales and exports 1992-96 than incrementally improved products and processes (Table B-II.9). The textile industry is an exception to these general patterns, with 60% and 80% respectively of total sales and exports coming from new products. This is because the textile industry acquired a number of new technologies right at the end of the previous period.

Table B-II.8: Sources of Ideas/Information for Innovation Activity, 1992-1996

SOURCES OF IMPORTANT IDEAS/ INFORMATION	NUMBER OF FIRMS Republic of Serbia			
	Tot n=33	Met n=18	Chem n=10	Tex n=5
Internal:				
Administration	6	3	2	1
R&D department	20	11	7	2
Marketing	13	7	4	2
Production	10	6	2	2
Other internal sources	1	-	-	1
External:				
Suppliers	3	1	1	1
Clients/customers	15	9	4	2
Other firms	3	-	2	1
Daughter companies	2	1	1	-
Competitors	12	7	4	1
Professional conferences	12	7	3	2
Fairs/exhibitions	12	7	3	2
Patent office/documents	4	1	2	1
Technical journals	15	8	5	2
Software firms	3	-	1	2
Consulting firms	4	3	1	-
R&D institutes	8	3	3	2
Universities	8	3	3	2
Standards	6	4	1	1
Technology transfer agencies	1	-	-	1
Other external sources	1	1	-	-

2.10 Diffusion of Products/Processes to Other Firms/Industries

As we found in the first survey, there are strong intersectoral differences in the extent to which the results (products/processes) of innovation activity obtained in the firms analysed are transferred to other industries/sectors (Table B-II.10). Thus products/processes originating from the metal-processing industry firms are used in that industry, but also in a number of other industries and sectors. The chemicals industry channels innovations to a smaller, but still substantial number of other industries and sectors. The textile industry remains a closed industry, using innovations from other industries, for offering nothing in return.

Table B-II.9: Innovation and Sales/Exports of Products/Processes, 199-96

PRODUCTS/ PROCESSES	Republic of Serbia			
	Tot n=25	Met n=15	Chem n=9	Tex n=1
No innovations				
S1 - Sales	61.50	63.73	64.38	5.00
E1 - Exports	67.37	67.27	75.71	10.00
Incremental improvements				
S2 - Sales	17.13	17.07	17.50	15.00
E2 - Exports	15.11	15.82	11.86	30.00
New products/processes				
S3 - Sales	21.37	19.20	18.12	80.00
E3 - Exports	17.52	16.91	12.43	60.00
S1+S2+S3 = E1+E2+E3 =	100	100	100	100

2.11 Innovation Activity and Commercial Results

The effects of innovation activity on commercial results are very much as in the first survey (Table B-II.11). The only difference is that international isolation, rather than the underdevelopment of the domestic market, comes through as the dominant factor dampening the impact of innovation activity on business risk.

2.12 Innovation Activity and Structural Change

In contrast to the findings of the first survey, there is no difference in the second period in the relative importance of technological and organisational change, and indeed the distributions of firms responding positively and negatively to the relevant questions are equal in each case (Table B-II.12).

Table B-II.10: Diffusion of Products/Processes to other Firms/Industries, 1992-1996

Error! No bookmark name given.Error! No bookmark name given. SECTOR OR INDUSTRY	Number of firms - DONORS of innovation Republic of Serbia			
	Tot	Met	Chem	Tex
↵	*n=21*	*n=13*	*n=7*	*n=1*
Agriculture, fishing, forestry	3	3	-	-
Mining, oil and gas	2	2	-	-
Industry:				
Food, drinks, tobacco	5	4	1	-
Plastic, rubber	4	2	2	-
Textiles	1	-	-	1
Furniture	3	2	1	-
Paper	3	2	1	-
Publishing	1	-	1	-
Metals	1	1	-	-
Metal products	4	4	-	-
Machine tools	5	5	-	-
Aircraft and parts	1	1	-	-
Cars and parts	9	8	1	-
Telecommunication	1	1	-	-
Electronic devices	1	1	-	-
Computers	-	-	-	-
Non-metal minerals	3	2	1	-
Oil	3	3	-	-
Pharmaceuticals	2	1	1	-
Scientific equipment	1	1	-	-
Other	4	1	3	-
Water supply	2	2	-	-
Civil engineering	6	4	2	-
Transport	2	2	-	-
Trade	1	-	1	-
Tourism	1	1	-	-
Handicrafts	2	2	-	-
Urban services	3	3	-	-
Banking, insurance	-	-	-	-
Other services	1	1	-	-

Table B-II.11: Innovation Activity and Commercial Results, 1992-1996

INDICATOR	NUMBER OF FIRMS Republic of Serbia			
	Tot	Met	Chem	Tex
	n=19	n=13	n=6	n=0
Profit:				
decrease	1	1	-	-
no changes	8	5	3	-
increase	10	7	3	-
Production costs:				
decrease	8	5	3	-
no changes	8	5	3	-
increase	3	3	-	-
Marketing expenditures				
decrease	1	1	-	-
no changes	8	7	1	-
increase	8	4	4	-
Salaries:				
decrease	1	1	-	-
no changes	12	8	4	-
increase	4	3	1	-
Business risk:				
decrease	6	4	2	-
no changes	8	6	2	-
increase	2	2	-	-
Market - total sale:				
decrease	1	1	-	-
no changes	4	1	3	-
increase	14	11	3	-
Market - geographical coverage:				
decrease	1	1	-	-
no changes	10	7	3	-
increase	6	4	2	-
Number of products:				
decrease	1	1	-	-
no changes	3	1	2	-
increase	13	9	4	-

Table B-II.12: Innovation Activity and Structural Change, 1992-1996

STRUCTURAL CHANGE AT FIRM LEVEL	NUMBER OF FIRMS Republic of Serbia			
	Tot n=20	Met n=13	Chem n=6	Tex n=1
TECHNOLOGY:				
Deeper production specialisation:				
YES	9	6	2	1
NO	11	7	4	-
Higher productivity:				
YES	9	5	3	1
NO	9	7	2	-
ORGANISATION:				
Introduction of new functions within firm:				
YES	7	4	2	1
NO	11	8	3	-
New organisational units/departments:				
YES	10	6	3	1
NO	10	7	3	-

2.13 Financing of Innovation Activity

The chemicals industry financed all its innovation activity by itself 1992-96, as it had done in the previous period. The metal-processing industry availed itself of external sources (mainly governmental) as in the earlier period, but to a lesser extent - 15% (Table B-II.13). The average lead-time for major innovations 1992-96 was almost two years in the metal-processing industry and just eight months in the chemicals industry (Table B-II.13). No data on any of these variables for the textile industry are available for 1992-96.

2.14 Patenting of Innovations

None of the industries analysed did much patenting 1992-96. But in contrast to the earlier period, this is not a consequence of patent legislation - for a new patent law was introduced in the Federal Republic of Yugoslavia during the later period. Rather it has to be explained in terms of the generally low level of patenting in the country as a whole.

Table B-II.13: Major Innovations - Sources of Finance and Average Lead-Times, 1992-1996

SOURCES OF FINANCE FOR INNOVATION ACTIVITY	SHARE IN TOTAL FUNDING (%) Republic of Serbia			
	Tot n=18	Met n=12	Chem n=6	Tex n=0
Internal resources	82.87	84.30	80.00	-
Other firms (joint ventures)	2.67	4.00	-	-
Holding companies	8.00	2.00	20.00	-
Research funds	1.00	1.50	-	-
Governmental funds	5.46	8.20	-	-
Other sources	-	-	-	-
Total funding	100	100	100	100
AVERAGE LEAD-TIME (months)	18.22	23.42	7.83	-

Table B-II.14: Patenting of Innovations, 1992-1996

COUNTRIES IN WHICH INVENTORS APPLIED FOR PATENT GRANTS	NUMBER OF INNOVATIONS Republic of Serbia			
	Tot n=33	Met n=18	Chem n=10	Tex n=5
FR YUGOSLAVIA	4	4	-	-
USA	1	1	-	-
EUROPEAN COUNTRIES	1	1	-	-
OTHER COUNTRIES	-	-	-	-

3 CONCLUDING REMARKS REGARDING THE SECOND INNOVATION SURVEY

- Over the period 1992-96, innovation activity was effectively often the main activity for the firms analysed, and in all cases the only source of new technology.

- The main task of innovation activity was technological import-substitution.

- Innovation activity was a factor tending to reduce brain drain.

- The government programme for technology development was the main support (financial and moral-psychological) for innovation activity in industry.

- The firms analysed firms used mostly domestic sources of ideas and information for innovation activity (clients, customers, professional conferences, fairs, exhibitions, academic sector, etc). Communication with the outside world was, of course, severely limited.

- Innovation activity was an important factor in preserving the technological capabilities of the firms analysed.

The final conclusion on the period 1992-1996 is that for many firms innovation became, in this period, the main (and, in some cases, the only) form of activity. That at least gives them a better starting point for future technological development, now that sanctions have been lifted and Yugoslav industry is again able to compete in the international technological race.

4 THE MAIN DIFFERENCES BETWEEN THE TWO PERIODS SURVEYED

In the first survey innovation activity is identified as an important aspect of the activity of the firms concerned. In the second survey, that activity is the main (in some cases virtually the only) activity;

In the earlier period, in-house innovation activity was only one source of new technology among several - there was also a market in technology (domestic and foreign). In the later period, in-house innovation activity was the only source of new technology;

In-house R&D departments were not very important parts of the firm in the earlier period. In the subsequent period, these departments became core organisational parts of the firm, holding on to human resources and reducing brain drain;

Communication with the outside world was routine in the earlier period. In the later period, communication was limited to domestic institutions and organisations. The resultant lack of information and exchange of experience, and limited access to new technologies, led to technological regression in the industries analysed.

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ANNEX A