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PATENT–RELATED ACTIVITIES IN SERBIA FROM 1921 TO 1995

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In 1883 the Kingdom of Serbia was a co-founder of the well-known Paris Convention dedicated to protection of industrial property. This paper presents the analysis of inventive activities in Serbia in the period from 1921 to 1995. The available patent statistics is analyzed from the aspects of: (a) patenting structure according to the International Patent Classification sections, and (b) patenting dynamics. The findings of analysis indicate: (1) the fields in which technology development potentials are created in Serbia, and (2) the variations in inventors' productivity as a direct consequence of the variation in the country's innovation policy.

1. Introduction

The Kingdom of Serbia, a predecessor of the former and present Yugoslavia, was one among the eleven countries that signed the Paris Convention on the protection of industrial property on March 20, 1883, together with Belgium, France, Italy, and the Netherlands. Great Britain joined the Convention in 1884, the USA in 1887, and Germany in 1903. On the grounds of Serbia's status the Kingdom of Yugoslavia joined the Convention in 1921, and the present Yugoslavia also has the same status on the same "succession" grounds. It is unnecessary to explain in detail the importance of this Convention, because it is a still effective regulation for relationships between countries in the protection of industrial property.

Serbia's openness to the global early-industrialization trends, evidenced by its participation in initiating the Paris Convention, indicates that sound foundations were laid for its subsequent technology development. One of the ways to assume the shape of the trajectory of this development is the analysis of the patent activity, and this is the subjectmatter of this paper. The paper presents that part of a many-year study of various aspects of Serbia's science and technology development (*MPI-STPRC*[1–3]) which refers to the patent activity. This study forms part of the organized, systematic study of

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Serbia's S&T background which has been in progress at the Science and Technology Policy Research Center (STPRC) of the Mihajlo Pupin Institute (MPI) with which this author is affiliated.

The following aspects of patent activity are analyzed: historical aspect, evaluation aspect and forecast aspect. The historical aspect is represented in the paper by the analysis of patenting structure in 5-year periods, from 1921 to 1995, by presenting a series of patent data for 75 years. The evaluation is illustrated by a critical analysis of patenting intensity and dynamics, according to sections of the International Patent Classification (IPC), for the stated periods. The forecast aspect is just indicated through the modalities of the possible application of patent analysis in making strategic decisions in research and development (R&D) activities: making decisions on resources (re)allocation for R&D purposes, construction of R&D infrastructure, etc. Based on data for 1988-1991 period, alternative R&D funding strategies are given with the aim of directing the patent activity to the (assumed) goals of Serbia's Science and Technology (S&T) development.

Patents in a system of S&T indicators

Patent data for the whole world are the contents of the INPADOC database, one of the largest databases for S&T data (over 16 million records, with an annual increase of several hundred thousands of records). In addition to INPADOC, there is a large number of national databases developed in many countries for purposes of their own automated patent data recording. This rich patent information fund allows various analyses to be performed, of which we mention: (1) Analysis of patenting intensity – the analysis of patent statistics (the number of patent applications and patent grants, the number of national and foreign patents) according to the national and/or international patent classification; (2) Analysis of patenting dynamics – the analysis of variations in patenting intensity in selected S&T fields; (3) Analysis of words and co-words – the analysis of patent document contents for the purpose of identifying the patenting subjectmatter and the S&T fields from which a patent originates and for which it is intended; (4) Analysis of citations and co-citations – the analysis of ideas and solutions contained in the patent documentation. The result of these analyses can be presented in the form of patent indicators – quantities indicating the level and forms of the engagement of participants to a national innovation system.

The patent data represented as patent indicators are an important and very reliable source of information about a national S&T system. *Grupp, Schmoch* and *Kuntze*[4] have proposed a series of patent indicators for evaluating the utility of EU research programs. *Grupp* and *Schwitalla*[5] have analyzed the use of patent indicators within the technometric, bibliometric and econometric analyses of S&T development. *Basberg*[6] has described the usage of patent indicators in the measurement of technological change through a survey of 95 reference papers. *Narin* and *Olivastro*[7] have particularly emphasized that patent analysis which uses data about the patents protected in the USA. Arguing that technology has to be measured and explained just as other production factors (labor and capital), *Pavitt*[8] has stated that patent data have the largest potential for technology measurement and description, because they contain a complex and comprehensive picture of a particular technology. According to *Freeman,*[9] the most reliable conclusion about technology development can be reached on the basis of data about innovative activities (about patents). By surveying the extensive available literature, one can identify the following fields of application of patent indicators: (1) Measurement of an industry's technological competitiveness; (2) Evaluation of the effects of a country's S&T policy implementation; (3) Measurement of R&D results; (4) Measurement of the effectiveness of R&D investment; (5) Evaluation of technological capability (of a firm, industry, sector, country); (6) Measurement of innovative activity (of a firm, industry, sector, country). Apart from the stated, an additional reason for studying the patent activity lies in the fact that the theory of technology development (growth) postulates that the accumulation of technological knowledge is a necessary (but not a sufficient) condition for technology development (*Freeman*[10]). Reliable decisions about the directions of further technology development cannot be made without knowing the technology trajectory from the past.

This paper has five sections. After the introductory section, the second section presents the elements of a methodology for determining patent activity intensity and dynamics. The third section presents general framework of patent activity in Serbia in comparison with worldwide patent activity in 20th century. The fourth section contains the results obtained by applying the methodology described in second section to the analysis of patenting in Serbia in 1921-1995 period. The main characteristics and elements of Serbia's technology development trajectory are given. The conclusion (the fifth section) of the paper indicates the guidelines for further research in technology development by applying patent data.

2. Patent activity

2.1. Definitions of patent activity indicators

While working on the referred projects (*MPI-STPRC*[2,3]), the MPI-STPRC research team faced a lack of information on the history of technology development on this territory. This was the reason for undertaking a study of patent activities in Serbia and Yugoslavia. After a survey of the original documentation of the Federal Intellectual Property Office (FIPO), in the absence of an appropriate computerized patent database, the STPRC staff created a database which contains, for every patent application submitted to the national patent bureau (starting form the Royal Bureau of Industrial Property Protection, founded in 1921, and ending with the present FIPO), data about: (1) The year of patent application submission; (2) The year of patent grant issuance, or patent application rejection; (3) The author's origin (foreign authors: the country of origin; domestic authors: republic/province according to the former Yugoslavia's territorial organization); (4) The membership of invention in the appropriate IPC nomenclature; for 1921-1970 period, membership according to the then effective national patent classification (*MPI-STPRC*[11]). Having in mind the constraints of the created information base, two patent indicators were defined for purposes of further analysis:

(1) *PATENT ACTIVITY INTENSITY* indicator (*PAI*), which represents the total number of patent applications and patent grants by sections S of *IPC*, in a considered period Δt (one, two or more years) starting with year T, for authors originating from a country C, i.e., *PAI* is a function of the following parameters:

$$PAI = f(S, C, T, \Delta t) \tag{1}$$

If we denote the patent applications by an index a, the patent grants by an index g, PAI_a and PAI_g indicators are calculated according to:

$$PAI_a(S, C, T, \Delta t) = \sum_{i=T}^{i=T+\Delta t-1} PA_i(S, C) \tag{2}$$

$$PAI_g(S, C, T, \Delta t) = \sum_{i=T}^{i=T+\Delta t-1} PG_i(S, C) \tag{3}$$

where: T – the starting year of the period;
PA_i – the number of patent applications in year i;
Δt – the period of patent activity consideration;
PG_i – the number of patents granted in year i.

(2) *PATENT ACTIVITY DYNAMICS* indicator (*PAD*), is the ratio of *PAI* for the period considered to the corresponding *PAI* for the immediately preceding period.
For patent application and for patent grants, one will have:

$$PAD_a(S,C,T_j,\Delta t) = PAI_a(S,C,T_j,\Delta t) / PAI_a(S,C,T_i,\Delta t)\,;\, T_j = T_i + \Delta t \quad (4)$$

$$PAD_g(S,C,T_j,\Delta t) = PAI_g(S,C,T_j,\Delta t) / PAI_g(S,C,T_i,\Delta t)\,;\, T_j = T_i + \Delta t \quad (5)$$

Note: for "zero series" cases (small or zero *PAI* values), a larger value for Δt is taken.

As the created database on patenting in Serbia is numeric, not bibliographic, in nature, it was impossible to perform the analyses of words, co-words, citations and co-citations. This is why only *PAI* and *PAD* indicators were used for the analysis.

2.2. Patent activity analysis

Based on the available patent data, aggregates were formed at the level of IPC sections for patent applications and patent grants. This gave eight data group, each of them consisting of two time series, summing by years, at the level of IPC sections A, B, C, D, E, F, G and H.* These series for all patents in total, for patents whose authors originate from: (a) Serbia; (b) Yugoslavia - total; and (c) other countries (the so-called foreign patents), are illustrated in Figs 1 and 2. The time series cover the 1921–1995 period.

The PAI *indicator.* The sums by years were used to form the *PAI* indicators values for 15 five-year subperiods in the 1921-1995 period (inclusive). The *PAI* indicator values were formed at the level of A, B, C, D, E, F, G and H sections.

The PAD *indicator.* For purposes of this paper, the patenting dynamics was calculated for periods considerably longer (5 years) than those proposed (3 years) usually in the literature (*USPTO*[12]). This was done because of rather small number of patents which could produce non-significant (zero) values for *PAI* and *PAD* indicators. Values produced for five-year subperiods are considerable enough in order to: (1) Permit the presentation of *PAD* indicator values in 15 five-year subperiods that coincide with the periods characteristic of the 20th century; (2) Illustrate the behavior of *PAD* values for IPC sections A through H for five-year subperiods from 1921 to 1995; (3) Make analysis.

* IPC sections are: A - Human necessities; B - Performing operations; Transporting; C - Chemistry; Metallurgy; D - Paper; Textile; E - Fixed construction; F - Mechanical engineering; Lighting; Heating; Weapons; Plastering; G - Physics; H - Electrotechnic. Instead of full names, letters A-H in parenthesis will be used in this paper.

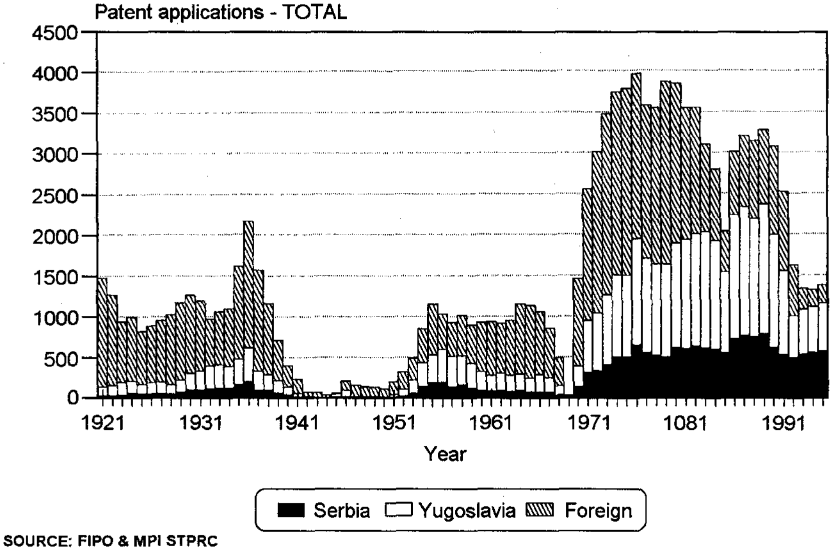


Fig. 1. Patent activity in Serbia in 1921-1995 period-patent applications

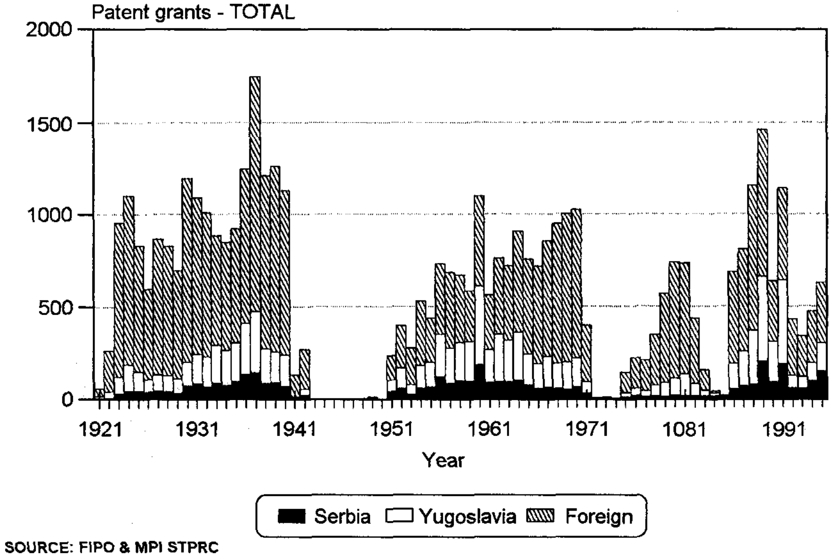


Fig. 2. Patent activity in Serbia in 1921-1995 period-patent grants

A detailed patenting analysis by using the *PAD* indicator requires a follow-up of the values of this indicator in periods not longer than 3 years and at considerably lower IPC levels (subsections, classes, subclasses, groups, subgroups). Such analysis gives a direct insight into the innovation climate in certain S&T fields which, combined with some other S&T indicators, i.e., by simultaneously using numerous S&T indicators and by applying multicriteria analysis methods (*Kutlača*[13]), provides an information base for answering the following questions: (1) What is the effect of R&D investment, measured by the number of patents in particular S&T fields? (*PAI* is used); (2) What are the changes in the S&T system effectiveness, measured by the increment in the number of patents in the considered time period? (*PAD* is used); (3) Which S&T fields are not /are moderately / are very active in technology development? (*PAI* and *PAD* are used); (4) What is (if any) the correlation between the *PAI* and *PAD* indicators, on one hand, and the indicators of the balance of technology payments, the indicators of import dependence (import/export ratio), and the indicators of the presence of particular industrial products on the market (the ratio of production to the sum of production plus imports reduced by exports in a particular industry), on the other hand?

These, as well as many other, questions are unavoidable in creating strategies for the development of particular S&T fields. Illustration of answers to some of these questions, related to Serbia's technology development, represent the conclusion of this paper.

The *PAD* indicator values, as well as for *PAI* indicator, were formed at the level of A, B, C, D, E, F, G and H sections too. Figures illustrate these series, two of them grouped together (for patent application and patent grants under the same IPC sections), are available upon request from the author, and because of limits in length for the article, Figs 3 and 4 illustrate *PAD* and *PAI* indicator for patent applications for IPC Section A.

3. Patent activity in Serbia and worldwide in the XX century – some comparisons and remarks

Patent activity in the XX century in the whole world has a strong increase and very dynamic behavior. Protection of inventions became a crucial element of firm's policies for international competitiveness and struggles for new markets. One side of globalisation of technology is a legal protection of inventions abroad (*Archibugi* and *Michie*[14]). This, costly and time consuming process, usually is undertaken either (1) because of specific firm's expectations to sell license (disembodied technology) or commodities (where invention is embodied in it), or (2) as a firm's strategy to exclude potential competitors from some markets.

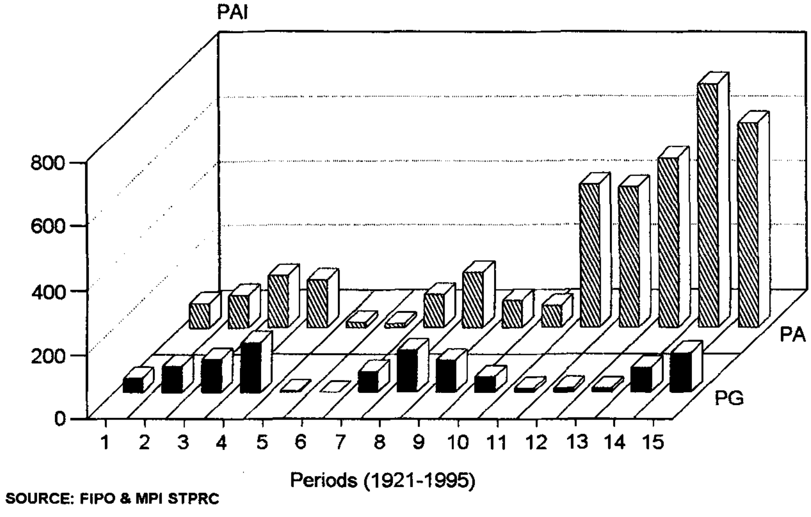


Fig. 3. PAI indicator for Serbia in 1921-1995 period. ICP Section A

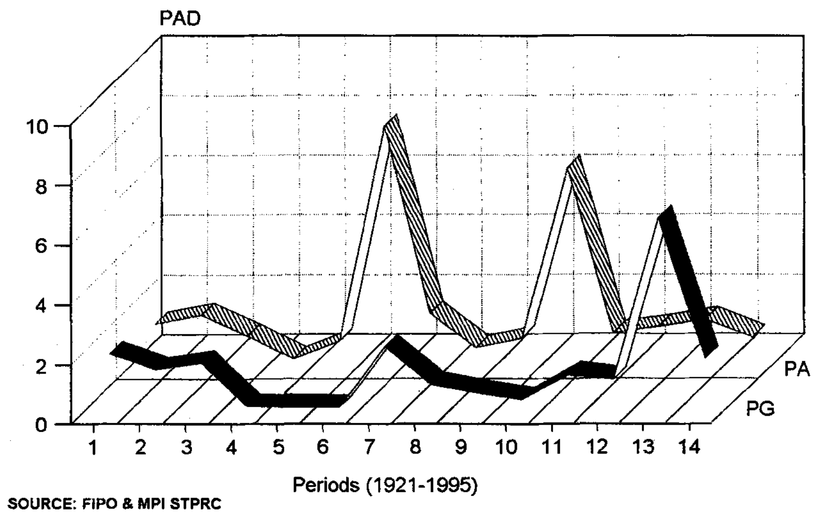


Fig. 4. PAD indicator for Serbia in 1921-1995 period. ICP Section A

Patenting abroad has another one dimension: examinations of R&D capabilities, potentials and results, of the firm, industry or country. Grants for inventions, approved from countries with developed science, technology and industry, where market play a clearing role for all competitors, has much more value than simple price for license. Consequently, patenting in US as a country's external patenting activities, means contribution in world innovation frontier (*Radošević* and *Kutlača*).[15] Patenting in US of inventors from Serbia, in period 1969-1994 (Fig. 5) is compared with some other countries (*WIPO-OMPI*;[16] *SPRU*;[17] *USPTO*[18]). Comparison is made: (a) with countries, Serbia is comparable according to size or level of economic development

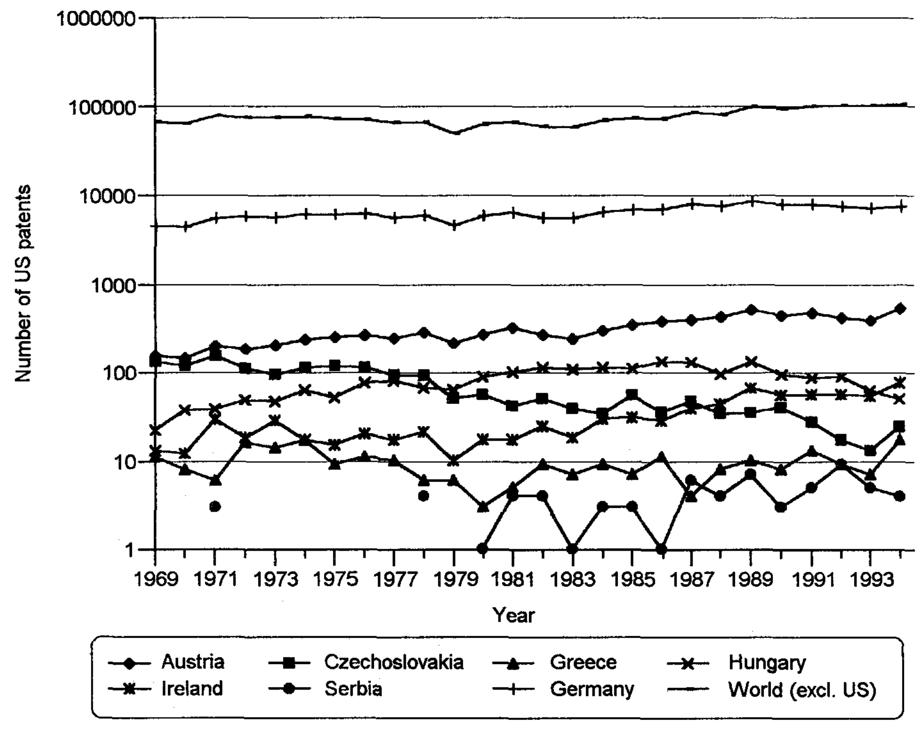


Fig. 5. Patenting in US: Serbia and some other countries, 1969-1994

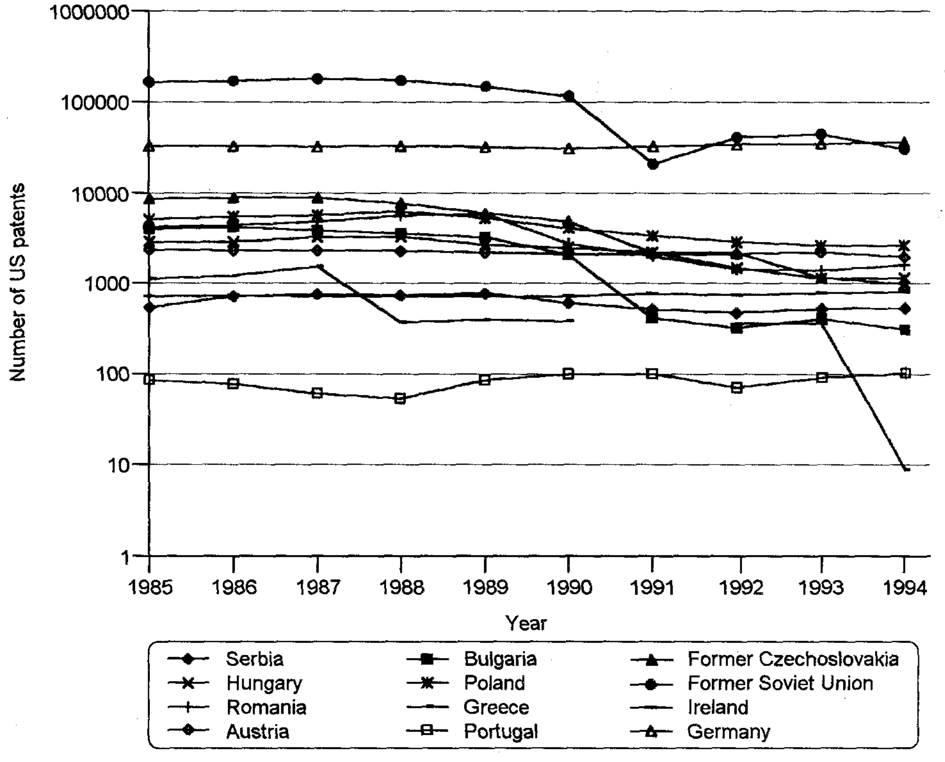
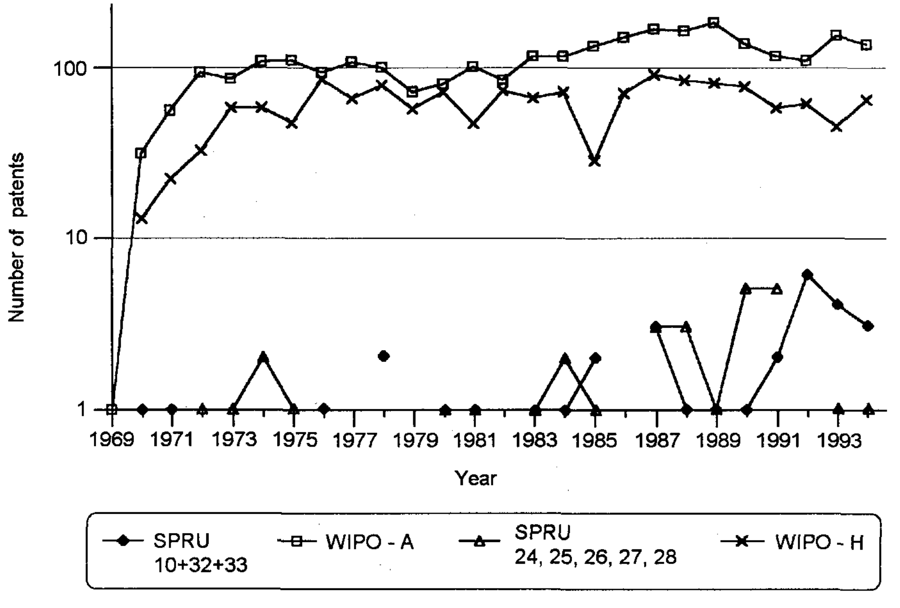


Fig. 6. Domestic (resident) patent applications by selected group of countries, 1985-1994

(Greece, Ireland, Austria, Portugal) or transition difficulties (selected Central and East European countries: Bulgaria, former Czechoslovakia, Hungary, Poland, Romania, former Soviet Union); and (b) with world as a total (excluding US) and Germany, as one of the world leader in technology, because of necessity to make general overview of patenting activities in US.

Domestic (resident) patenting, as a part of total national patents, in period 1981-1994, for same group of countries (for Bulgaria, Czechoslovakia, Hungary, Poland and Romania data are available to author only for 1985-1994), is shown in Fig. 6 (*OECD*;[19] *MPI-STPRC*[11]).

Patenting in US from Serbia, observing both, 1920-1994 and 1969-1994 periods, and national - domestic patent activities in Serbia in 1969-1995 period, compared with mentioned countries, could be qualified as: (1) Rather small, less than any country did, we compared with. This conclusion is valid for both, domestic and US patents, from Serbia; (2) Sporadic and fragmentary, which means that US market is not achievable target for Serbian economy and, also, Serbian R&D system is not able to produce results competitive to a world innovation frontier, comparable, at least, with countries with less developed R&D system (according to number of FTE researchers and GERD per capita); (3) Small but still constant contribution of patents from developing country, which economy is in transition to the market economy, makes bases for future development and establishing of innovation system in country.



Note: WIPO Section A: Human necessities; WIPO Section H: Electrotechnic; SPRU 10: Food and Tobacco (processes and products); SPRU 32: Textile, clothing, leather, wood products; SPRU 33: Density and Surgery; SPRU 24: Telecommunications; SPRU 25: Semiconductors; SPRU 26: Electrical devices and systems; SPRU 27: Calculators, computers & other office equipment; SPRU 28: Image and sound equipment

Fig. 7. Distribution of US and national patents in different sectors for Serbia, 1969-1994

Table 1
Patenting in US from Yugoslavia by technological fields, 1969-1994

Techn. Code	Year 69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
2	1	2	1	2	1	5	1	3	0	0	4	7	3	1	0	1	3	1	1	2	2	0	0	0	3	1	45
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	1	0	0	1	0	1	3	1	11
7	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	2	0	0	0	1	1	3	6	2	5	5	28
8	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	4
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
12	1	1	1	0	0	0	0	0	1	0	0	1	1	2	0	0	0	0	1	0	1	1	0	0	0	0	11
13	0	0	1	0	0	3	1	0	2	0	0	1	1	1	2	1	0	0	0	2	0	0	1	1	1	2	20
14	1	1	1	0	0	0	0	0	1	1	0	0	0	1	0	1	3	0	1	1	1	2	2	3	0	0	20
15	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	2	0	0	0	0	1	0	0	0	0	7
16	0	0	1	0	1	1	0	0	0	1	0	0	0	1	1	1	0	0	0	1	2	0	1	0	0	1	12
17	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
19	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	5
20	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	6
21	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	1	7
24	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	1	2	0	0	0	9
25	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	1	7
27	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	3	0	1	0	9
28	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	4
30	0	1	0	0	2	0	1	0	0	0	1	0	0	1	2	0	2	0	2	2	3	3	1	1	1	0	23
31	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	1	2	2	2	0	11
32	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	0	6
33	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	1	2	0	3	1	0	0	2	5	2	3	24
34	0	0	1	0	0	0	0	1	1	2	0	0	0	0	0	1	0	2	0	0	1	2	1	1	0	0	13
35	3	6	9	6	5	11	5	9	6	9	6	15	8	10	9	15	16	3	13	16	15	22	22	17	20	15	
36																											291

2: Organic Chemicals; 3: Agricultural Chemicals; 4: Chemical Processes; 7: Drugs and Bioengineering; 8: Plastic and rubber products; 9: Materials (inc glass and ceramics); 10: Food and Tobacco (processes and products); 12: Apparatus for chemicals, food, glass etc.; 13: General Non-electrical Industrial Equipment; 14: General Electrical Industrial Apparatus; 15: Non-electrical specialized industrial equipment; 16: Metallurgical and metal working equipment; 17: Assembling and material handling apparatus; 19: Power Plants; 20: Road vehicles and engines; 21: Other transport equipment (exc. aircraft); 24: Telecommunications; 25: Semiconductors; 26: Electrical devices and systems; 27: Calculators, computers, and other office equipment; 28: Image and sound equipment; 30: Instruments and controls; 31: Miscellaneous metal products; 32: Textile, clothing, leather, wood products; 33: Dentistry and Surgery; 34: Other - (Ammunitions and weapons, etc.); 35: SUBtotal_1; 36: TOTAL

Sectoral aspects of patenting in US from Yugoslavia are shown in Table 1, were patents from Yugoslavia in period 1969-1994 are rearranged in appropriate technological fields (*SPRU*[17]). Numbers of US patents for selected technological fields which are correspondent to WIPO patent sections A (Human necessities) and H (Electrotechnic) are compared with numbers of resident patent applications from Serbia in WIPO sections A and H (see Fig. 7). Despite the fact that classification of technological fields (*SPRU*[17]) and WIPO classification of technical units and patent sections (*WIPO*[20]) are different, Fig. 7 could be used as an indicator of concentration of innovation activities in country.

Following analysis in next chapters are on the national level, were sectoral aspects of patenting activity in Serbia will be described more detailed, but comparison given in Fig. 7 is an illustration of sectoral pattern of resident (WIPO data) and patenting in US (SPRU rearranged US PTO data) from small, developing country with economy in transition to market economy. This pattern should be explained in following points: (1) Number of US patents in country advanced technological fields (for Serbia, this is a case for WIPO section A or SPRU technological groups 10, 32, 33) is a few percent of total number of resident patents in those fields, but it remains during a long-time period. This point expressed the country's accumulated knowledge which is able to contribute to national technological development but, also, contribution to world innovation frontier in small, but persistent way. (2) Number of US patents in world's advanced technological fields (this is a case for WIPO section H or SPRU technological groups 24, 25, 26, 27, 28) from Serbia is a few percent of total number of resident patents in those fields, but it is sporadic during a long-time period. This point expressed the country's awareness of need for this knowledge for technological development, but this is still not enough developed area of innovation capabilities.

4. Patent activity and technology development in Serbia (case study)

4.1. Characteristics of five-year subperiods

In the years following immediately the end of World War I Serbia was in the early industrialization stage in which, in addition to the reconstruction of the country destroyed by war, technology development potentials and infrastructure were also under reconstruction.

Periods from 1921 to 1940 (1921-25; 1926-30; 1931-35; 1936-40; or periods 1, 2, 3 and 4) are characterized by: (1) The *PAI* and *PAD* indicators are constantly growing - innovation work is motivated by realization and capitalization possibilities (inventors can relatively easily obtain the capital they need to realize their invention and to validate it on the market). The number of foreign patents protected in the Kingdom of Yugoslavia is important in both quantity and constancy (over 14000, which is five times more than the number of patents granted to domestic inventors). As the patents from Serbia account for a third of the total inventive production in the Kingdom of Yugoslavia at that time, and for one half of all inventions from the then "emerging technologies" (technology-intensive fields), a logical conclusion follows that foreign inventors respect the possible competition from Serbia. This, also, reflects the presence of a sound innovation climate which is required for an accelerated technology development "control" over Serbia's technology development by foreign companies was especially emphasized in electrical engineering (H) with the number of foreign patent grants 21 times larger than domestic, and in mechanical engineering (F) where this ratio is 5.6 times; domestic authors have a much better position in section A (Human necessities), where the ratio of foreign to domestic patent grants is not higher than 2.4); (2) Two thirds of inventions fall into sections F, A and B. This shows that, although a predominantly agricultural country (with 70% of its population in agriculture), the Kingdom of Yugoslavia succeeded in developing technical personnel capable of accepting, developing and using up-to-date technologies. This holds especially for the fields of precision mechanics, motors, defense technologies, traffic and transportation, and printing technologies (F,B). In agriculture (A), new plant sorts were developed, especially maize hybrids where Serbia achieved results recognized on a world scale; (3) Serbia had a leading technological position in the Kingdom of Yugoslavia, as one third of all inventions and more than a half on inventions from "emerging" technologies (section F, H, G and E) originated from Serbia.

The characteristics of *1941-45 period* (period 5) are: (1) The war period is a period of "frozen" patent activity. It is lower than 10% of the prewar activity, thanks to years 1941 and 1945 which were, partially, without war; (2) Even in this small number of inventions the trend of the largest patenting in sections F and A was retained, which shows that a part of inventor population was preserved. As for foreign patents, inventions from section H (electrical engineering) were numerous which was an indication of a rapid development of this field in the years to come.

The characteristics of *periods 1946-50 and 1951-55* (periods 6 and 7) are: (1) Changes in the social, economic and political system reflect themselves in the patent activity as well. There are fewer foreign inventors (especially from the West), because the new state has many unknowns, first of all an economic system (centrally-planned) conceived on principles very different from their systems; (2) The first years of the development of new state are rather regressive for Serbia, in the technological sense. A number of factories, together with the personnel and, thus, together with the technologies incorporated in their knowledge, are dislocated to the Western parts – Slovenia, Croatia and Bosnia and Herzegovina, with a justification that this is done for strategic defense reasons (Yugoslavia was under blockade by the INFORMBIRO member countries - East European communist countries). New factories, especially those from defense industry, are being located in the Western part of the country; (3) One of the main characteristics of centrally-planned economy is the isolation of R&D work form industry and the creation of general head offices for all activities. These offices were responsible for organizing R&D work in such a way as to concentrate all development work on one location and then distribute the results to factories for production in prespecified quantities. This was not only a physical isolation of R&D work from firms; the motivation for innovative work was reduced to a minimum. This structural "failure" in R&D work organization remained in effect up to the sixties when, within the already developed selfmanagement system, organization of R&D units in enterprises started, with important government support; (4) In this period, the largest number of inventions from Serbia belong to sections G, C and H. This is quite opposite to the prewar trend (F, A, B) which indicates that the remaining Serbia's technological and development potentials are more interested in theoretical research. R&D personnel is concentrated in institutes and faculties, i.e. outside industrial firms and without proper links with firms.

A global evaluation of patent activity in Serbia in this period is that it is exceptionally restricted, not by technological factors but as a result of the new state S&T policy and the blockade. The dislocation of R&D potentials and technology infrastructure from one region to another is one among the well-known measures that governments undertake in stimulating technology development of particular regions (e.g. Sophia Antipolis, France, a program for establishing and consolidating research centers in Southern Italy, etc.), but taking care of preserving the technological power of the region from which the transfer is performed. In case of Serbia this point was not given proper attention and the result was R&D work performed in laboratories, separated from industry.

The characteristics of *periods 1956-60 and 1961-65* (periods 8 and 9) are: (1) During period 8 the patent activity, "ascends" to reach its prewar level. It was no earlier than 10 years after the end of war that the number of inventions in Serbia became equal to its prewar value. In most IPC sections the *PAI* indicator reaches a high level at the beginning of this period, thus illustrating a growth in inventions, which is followed by a decrease in the total number of patents. This is recognized most easily by the *PAI* indicator behavior which shows a decreasing trend; (2) The patenting structure shows no significant prominence of any IPC sections. However, a more detailed analysis at subsection level indicates a further decrease in the competitiveness of Serbia's inventors in technology-intensive and traditionally developed fields (subsections 1, 45, 61 and 63 of section A; subsections 11, 61, 63 of section B); (3) The presence of foreign inventions is considerably higher, especially in section C (Chemistry; Metallurgy); (4) The development of innovative work is negatively influenced by the uncontrolled import of technologies which was in an upswing in the late fifties and in the sixties. Technologies were purchased without previously checking their up-to-dateness, with license restrictions and with insufficient support to eventual domestic development based on the acquired technologies. The acquired technologies suppress the needs for domestic development - hence a decrease in the patent activity.

The characteristics of *1966-70 period* (period 10) are: (1) The basic characteristic of this period is the minimum value of *PAI* and *PAD* indicators considering the whole postwar period (1946-1991). This is a result of system changes in the organization and financing of R&D work. At the end of the preceding period, more precisely in 1965, an economic reform was carried out, within which great emphasis was given to contracting of R&D services between the R&D sector and the "users" of its services (industry, government, etc.). This was accompanied by a decreased relative share of budget resources in the total R&D funding, i.e., by a destabilization of the R&D financing system existing up to then. The institutes, mainly government-established, had to accept the new selffinancing system, i.e. to earn their own living through autonomous contracting with the users of R&D services. This system change caused serious disturbances in the work of institutes, some of them were closed down. All these developments reflected themselves a year or two later, in 1966-70 period, through a considerable decrease in R&D output. The innovation production started to increase again only after the R&D system restructuring. There remains, as a serious warning, the fact that the "transient period" to the re-establishment of a "normal operation mode" in the R&D sector lasts 3 to 5 years. Large losses in R&D output are recorded during such periods but this fact is seldom taken into account by reform initiators; (2) As for the patenting structure, non-technology intensive fields (section D, for example) become more prominent, whereas the very important field of electrical engineering (section H) accounts for a moderate share, i.e. does not have the intensity and dynamics required for the development of all other fields; (3) A decrease in the number of foreign patents in this period is explained by the unstable political situation in Yugoslavia (1967-68).

The characteristics of *1971-75 period* (period 11) are: (1) In this period the *PAI* indicator shows a sharp increase in the number of patent applications. This is one among the signs that the R&D system is again in its "normal operation mode", after great system changes in the preceding two periods; (2) The *PAI* indicator of registered patents indicates a very small number of inventions that satisfy the conditions for patent granting. For some IPC sections this number is even smaller than the number of patents granted in the war period. A part of the explanation lies in the fact that the FIPO accepted in this period a new patent classification (IPC); this caused certain adaptations in the procedure of examining whether the conditions for patent granting are satisfied and, naturally, delays in patent application processing. As the number of patent applications in this period was considerably larger, the problem of application examination became a very serious restricting factor in patent activity monitoring.

The characteristics of *1976-80 and 1981-85 periods* (periods 12 and 13) are: (1) The *PAI* indicator indicates a slight increase in comparison with the preceding period, but the *PAD* indicator values indicate a decreasing trend in the number of inventions. This is again an indicator of a new "transient period" which resulted from changes in R&D financing system, from the closure of the Federal R&D Fund and Council (in late 1970) and establishment of the so-called Selfmanagement Communities of Interest in Science (in early 1975) on republic/ province level. Regionalization in itself is a positive trend in S&T development but, as fundamental and applied research is concerned in SFR of Yugoslavia, this regionalization means nothing more than splitting of the already constructed network (infrastructure), multiplication of programs in the same disciplines; all of these, together with considerably smaller amount of resources, lead to a noncompetitive and reduced production in the R&D sector. This transient period also lasted 3 to 5 years and its consequences were somewhat less prominent because R&D organizations had already established appropriate "defense" mechanisms after having "learnt the lesson" from the previous reform when the share of budget resources in the total R&D funding started to decrease in real terms; (2) By analyzing the patenting structure one can note a considerable increase in both number and share of inventions from section H (electrical engineering), which is of great importance for the country's technology development; (3) The reduced "production" of patents, especially pronounced in period 13, is correlated with the country's economic crisis. One among the consequences of this crisis is a further decline in domestic industry's competitiveness which, in turn, decreases the scope of patent activities; (4) Both the number and the share of foreign patenting decrease considerably during these periods. This is explained by the following reasons: (a) as a noncompetitive industry cannot be a serious rival in technology "contest", it is unnecessary to pay the protection of something which potential competitors cannot produce; (b) foreign authors start pursuing a policy of not patenting their inventions but keeping them confidential under industrial property rights. A well defined strategy for searching the patent databases can lead to valuable conclusions regarding the relevant technologies (research concentration, etc.); in this way the act of patenting itself can prove helpful to competitors; (c) acquisition of technologies is being restricted more and more by political decisions, technologies are declared to be "sensitive" and their exportation is prohibited; thus, patenting becomes unnecessary; (d) development of new technologies becomes very expensive and is therefore undertaken under joint projects by number of companies from several countries which later become exclusive technology proprietors; (5) The number of registered patents remains exceptionally small, which means that the FIPO is overcrowded by patent applications and has scarce possibilities for making decision on the status of these applications in a reasonable time. Explanation for this situation is that the FIPO does not possess the computer equipment required for the patent examination and registration procedure as well as for providing information services to the interested patent information users.

The characteristics of *1986-90 period* (period 14) are: (1) The *PAI* indicator shows that the second "transient period" has passed, the number of inventions is increasing again, the *PAD* indicator decreasing trend has lessened. This is a period with the largest number of inventions in almost all IPC sections for all subperiods from 1921 to 1990; (2) The number of registered patents is much larger than the number of patents registered in periods 11, 12 and 13 which is an immediate consequence of the implementation of computer support at the FIPO; (3) As for the patenting structure, it is important to note the increasing patenting trends in the fields which are essential for the country's technology development (sectors H, G, A, B, F).

The characteristics of *1991-95 period* (period 15) are: (1) The *PAI* indicator shows third great breakdown - the number of inventions is decreasing, the *PAD* indicator decreasing trend is very strong. This is a period with the decreasing number of inventions in all IPC sections due to political situation in country - disintegration of SFR of Yugoslavia, war in some of their Republics, situation where Republic of Serbia, together with Republic of Monte Negro, forms rump Yugoslavia state. Other former Yugoslavia's Republics became new bordering countries, and their patents belongs to "foreign patents" specification; (2) The number of foreign patents is highly decreased in this period, due to international isolation of rump Yugoslavia. Slight increase of patent applications in last three years of this period shows stabilization of political situation and reintegration of rump Yugoslavia in world community, formation of new industrial relationships, where industrial and intellectual property law again became important part of business relationships for both sides - foreign and domestic firms and entrepreneurs; (3) As for the patenting structure, it is important to note the slight increasing patenting trends in the years '94 and '95 in the fields which are essential for the country's technology development (G,H,A,F,B). From the foreign patenting activity side, number of patent applications is a bit stronger only in sections C and A.

4.2. Patent analysis applied to the creation of S&T development strategy

S&T development planning is an important aspect of the application of patent analysis results. The approach employed by OTAF (Office of Technology Assessment and Forecast) (*USPTO*[12]), former US Department of Commerce agency, is characteristic. Using data from the Patent and Trademark Office (several tens of millions of files of technological documentation for more than 4 million US patents), the OTAF identifies: (a) active technologies, (b) technologies with the fastest patent growth, and (c) the most active foreign technologies. The indicators determined in this analysis are used in making decisions concerning the national policy in the development of industry, science and technology.

The identification of the three stated classes of technologies is performed on the basis of calculating the *PAD* indicator values. The OTAF defines the *PAD* as the increment in the number of patents in two successive three-year periods, whereas in this paper the *PAD* is calculated for two successive five-year periods. The OTAF's approach is applied in a country with the annual increment in the number of patents amounting to over 200.000, in contrast to Serbia where the largest recorded annual increment is 780 applications (about 1500 applications in Yugoslavia).

Active technologies are those for which the *PAD* indicator value is larger than one (the number of patents in the year under consideration is larger than the number of patents in the preceding year under consideration is larger than the number of patents in the preceding year, for the technology analyzed). *Technologies with the fastest patent growth* are those for which the *PAD* indicator values in the period considered are the largest. *The most active foreign technologies* are those for which the *PADm* indicator value are the largest, where:

$$PADm = PAIf(S,C,T_i,\Delta t) / [PAIf(S,C,T_i,\Delta t) + PAId(S,C,Ti,\Delta t)] \qquad (6)$$

where: $PAIf$ – the number of foreign patents,
$PAId$ – the number of domestic patents, calculated for the same time interval T_i.

Using the obtained values of *PAD* and *PADm*, the OTAF forms the ranking lists for all three stated classes of technologies. The position in the ranking list and the numerical value of *PAD* indicates the patent activity level in the technology under consideration. Decision makers in S&T development policy use these data for choosing to allocate budget resources to: (a) the most active technologies to help them develop even faster, or (b) technologies with slower development (small *PAD* value) to give them additional support, or (c) technologies that are mostly "imperiled" by foreign patents (large *PADm* value), etc. These, and numerous alternative, decisions represent alternative strategies for the country's technology development that have been defined using a variety of additional information, data and indicators which constitute a system of S&T indicators (developed and mostly used in creating national S&T policies in the USA and in other OECD member countries).

The analysis of patenting in Serbia in 1921-1995 period shows that number of patent applications in Serbia is incomparably smaller than that in the USA. This is why we have used five-years periods in calculating the *PAD* values instead of three-year periods. Further, by applying the same procedure to determine the classes of technologies, the following *PAD* indicator values, by IPC sections, are obtained for periods 1986-1990 and 1981-1985 (the ratio of the numbers of patents in periods 14 and 13):

PAD(A) = 1.44	*PAD*(B) = 1.16	*PAD*(C) = 1.21	*PAD*(D) = 0.77
PAD(E) = 0.77	*PAD*(F) = 1.27	*PAD*(G) = 1.21	*PAD*(H) = 1.39

Active technologies belong to sections A, B, C, F, G and H, whereas technologies with a negative trend of the increment in the number of patents belong to sections D and E. Sections A and H include technologies with the fastest growth.

The most active foreign technologies are determined using the value of modified *PADm* indicator, calculated for 1986-1990 period (where the total number of patents is the sum of patents from Serbia and from abroad):

PADm(A) = 0.43	*PADm*(B) = 0.52	*PADm*(C) = 0.87	*PADm*(D) = 0.77
PADm(E) = 0.43	*PADm*(F) = 0.31	*PADm*(G) = 0.45	*PADm*(H) = 0.47

The most active foreign technologies belong to C, D and B (the PADm value is larger than 0.50, which means that foreign inventors account for over 50% of the total number of patents), although all other sections also show a very large share of foreign patenting (from 31% to 47%).

Having in mind the identified classes of technologies, alternative R&D financing strategies are defined in order to direct the patent activity to the (hypothetical) goals of the country's S&T development:

Strategy 1. To invest resources into those S&T fields in which a high level of competence and productivity has been attained in order to ensure maximum possible autonomy and higher competitiveness of the activities which utilize the results from those S&T fields.

Actions to be taken under Strategy 1 - R&D financing in the fields belonging to IPC sections: (1) A and H has the highest priority; (2) C, F, G and B is the next priority; (3) D and E is of the lowest priority.

Strategy 2. To invest resources into those S&T fields in which a low-level productivity has been identified in order to raise the competence of those fields and of the activities which utilize the results from those fields.

Actions to be taken under Strategy 2 - R&D financing in the fields belonging to IPC sections: (1) D and E has the highest priority; (2) C, F, G and B is the next priority; (3) A and H is of the lowest priority.

These two strategies illustrate two opposite approaches to the creation of national S&T policy. An actual application of this approach to the creation of national S&T policy requires, as is the case with OTAF, the patent analysis and the identification of technology classes to be performed at the level of IPC classes, subclasses and groups and, perhaps, at the level of IPC subsections. This identifies the level of patent activity in particular technologies, which gives essential information about the engaged resources and achieved results. Strategic goals and orientation must be defined first; having these in mind, the decision makers should then consider the results of such analyses and, respecting the status of S&T resources and the needs in the overall economic and social development, make appropriate decisions.

5. Conclusion

The paper presents a number of modalities of applying patent analysis to studying a country's S&T development trajectory, evaluating S&T development and creating the national S&T policy. The example of patenting activity in Serbia in 1921-1995 period is used to illustrate an actual case of patent analysis application as well as to present in a systematized and argumented manner the history of innovative work in Serbia. S&T fields with accumulated knowledge and experience, results and potentials for the further Serbia's S&T development are identified. The impact of changes in the national innovation policy on innovative work and the effects of structural changes on the country's S&T system are described. The end of the paper points out a number of aspects of employing the patent information fund in the process of creating the innovation policy.

The paper also gives some guidelines for further research in creating and using the patent information fund: (1) To permit a more reliable and comprehensive analysis, it is necessary to create, apart from numeric databases, bibliographic databases on patents (this has already been undertaken at the Federal Patent Office). Data on patent application are required for analyzing words and co-words to obtain reliable information in the state and trends of innovative activity development in characteristic fields of S&T; (2) Patent analysis intended for some actual applications should be performed at much lower levels of patent data aggregation (at the level of IPC classes and subclasses, groups and subgroups); (3) To be able to relate the patenting activity in Serbia in comparison with other countries (comparable with Serbia in size, population, GDP, etc.).

Finally, the presented analysis and its results, as well as the cited examples from the literature, indicate the importance of patent data analysis for a better understanding of the past and shaping of the future S&T development.

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