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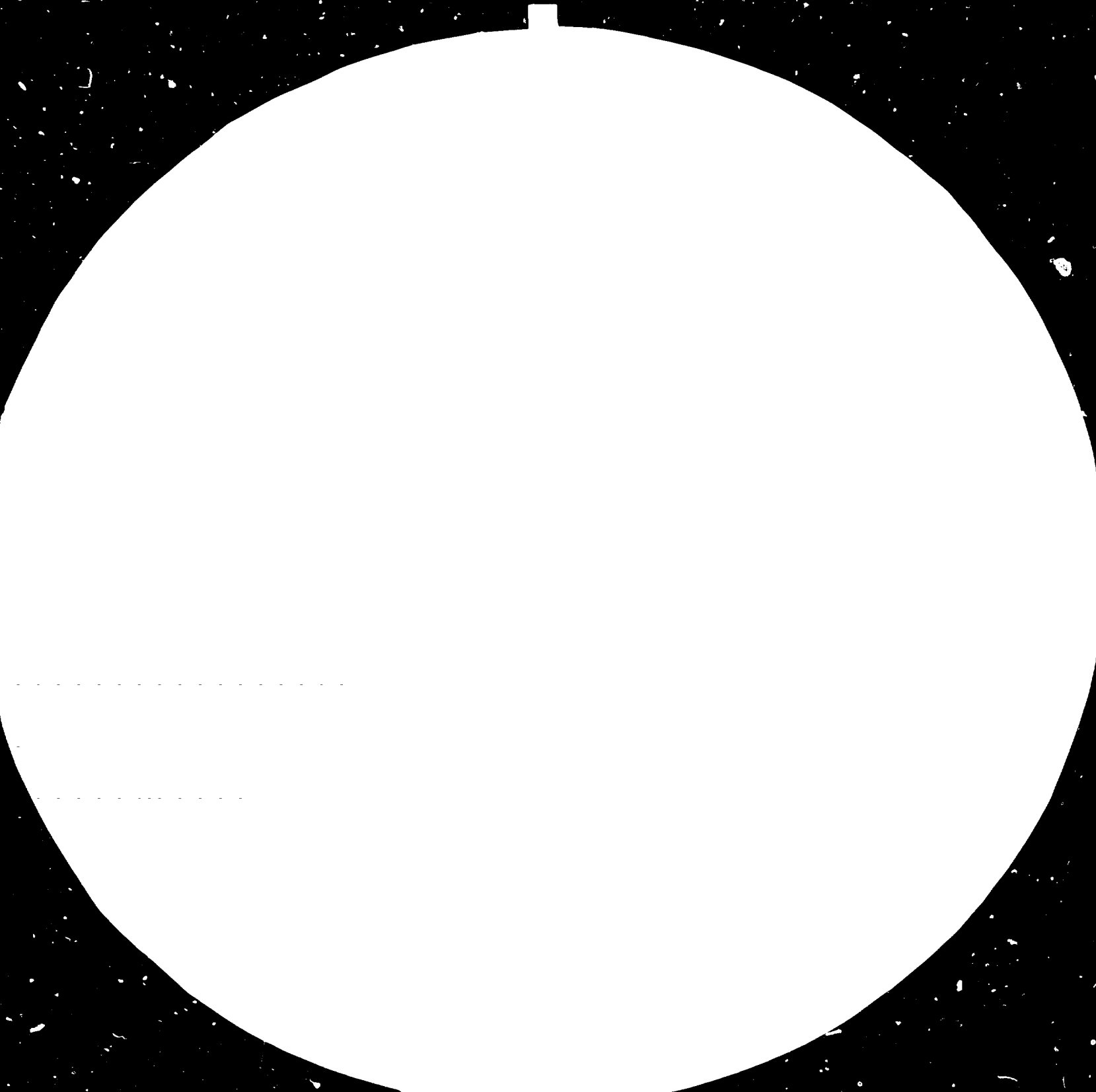
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Workshop on Institutional and Structural  
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TYPES OF NECESSARY AND DESIRABLE CHANGES IN INSTITUTIONS  
AND STRUCTURES IN DEVELOPING COUNTRIES IN ORDER TO ACCEPT  
THE CHALLENGES OF NEW TECHNOLOGIES AND APPROPRIATE POLICIES  
AND MEASURES, WITH SPECIAL REFERENCE TO YUGOSLAVIA \*

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## INTRODUCTORY STATEMENT AND REMARKS

1. We assume that it is recognized that scientific and technological development has become one of the most determining factors of economic growth, industrial stability, international competitiveness, social and human progress and the main basis for the future of the mankind. There is nothing specific to be added as far as developing countries are concerned, except that their chances to solve the existing and, particularly, future problems must be fully based on the acceleration of their technological development.
2. Technological advance in any country is a function of: (a) national technological potential, (b) appropriateness of its allocation for the resolution of national economic, social and technological problems, and (c) effectiveness and efficiency of the utilization and development of technological potential. All three mentioned factors are dependent on the quality of structures, institutions and policies.
3. The central subject of this paper are the structural problems which are in strict connection with technological advances. An attempt will be made in the paper to answer a rather difficult question: which structures (and only partially which institutional arrangements and which policies and measures) are the most appropriate for developing countries in connection with technological advances.

4. In order to answer the above question we have at disposal two alternative ways. The first is to construct a complete and reliable theory which can give a certain answer for any set of specific propositions. The second approach is the investigation, elaboration and evaluation of real cases in order to reach conclusions which are then generalized and proposed as guidelines for the resolution of the problems in a similar situation. This approach is very frequently used but, nevertheless, there are a lot of doubts in its reliability.
  
5. The ideal would be if we had the appropriate and sound theory of technological development. However, the main characteristic of present situation is the existence of many alternative theories (none being valid for the whole variability of real-life problems) and an eclectic approach in attempting to integrate them. But we recognize that there is a very rich body of knowledge which can be used in any serious approach to the resolution of the structural problems in connection with technical change.
  
6. To many the case study approach seems to be more realistic, theory-free and thus less scholastic and there are preferences towards it. However, it is a fact and a universal truth that behind any practical approach there is some theory, reliable and sound, or wrong and misleading; so there is no strictu sensu theory - free approach. Having that in mind, we consider it better to have some kind of a paradigm, defined clearly and completely, and then to investigate any real case under the guidelines coming out of such a paradigm. Following these lines, we shall define the elements of the paradigm and afterwards discuss the structural and some other problems of technological advances on the Yugoslav case with the intention of performing some generalisation.

ELEMENTS OF THE PARADIGM AND SOME IMPORTANT FACTS

7. Technological advance is generated by market forces ("demand pull") and by some other mechanisms ("technology push"). Continuous but rather small technical change is mostly determined by market forces, while radical and discontinuous progress is negligibly demand pulled, except in a very general meaning of the term demand. The implication of this statement is that technological advances should be left to a proper market mechanism and directed by appropriate public and governmental policies.
8. Technological development is not fully deterministic because its nature is uncertainty. The uncertainty is higher the more radical the innovation chased is. Positive result of research and development efforts are more probable the more organized scientific and technological activities are, the more appropriate structures and the favorable values of institutional variables are. The main implication of this statement is that technological advance is to a large extent dependent on the behaviour of all actors.
9. Scientific and technological potential (STP) is the ability (of a firm, industrial sector, state, region etc.) to solve (strictly speaking, to increase the probability of solving) scientific and technological problems. STP is a function of science and technology development level (STD) and science and technology capacity (STC). For each aspiration point on a trajectory of technological development there is a corresponding level of minimum necessary STD. For each number of sectors aimed to achieve desired technological advances it is necessary to have some minimum of technological capacity, STC.
10. The slowdown of technical innovation in one industry is a very good indicator that the industry matures. In order to be competitive in such industry, standardization of parts, processes and products is necessary so that automation can come to the fore. However, automation is capital intensive and human knowledge intensive so that a profitable rate of return on investment must be based on large scale highly productive and cost-effective production and thus on large markets.



11. Continuous but smaller technical changes can be performed in industrial structures characterized by small or medium size firms, oriented to local market and without particular governmental policies and measures. Such technological innovations however, are not sufficient to gain advances able to yield international competitiveness through non-price factor and thus to some closer to technologically developed countries. Radical technical advances are mostly performed through oligopolistic market structure and so for ambitious technological development it is necessary to establish indigenous large productive firms.
12. In order to develop large indigenous firms to perform effective transfer of technology it is necessary to have large market, effective transport medium, modern technology of information gathering, processing and transmission and a positive policy for the development of science and technology.
13. The past decades have witnessed remarkable internationalization of production, distribution and markets. All sciences have become international much earlier and the process of technology internationalisation is under way.
14. It is the empirical fact which can be used for forecasting that R+D activities of multinational companies MNC are world-oriented but very rarely world-based. MNC can leave a part of R+D activities to home country only if it has already developed scientific and technological infrastructure and very competent research personnel. In all other cases, which are typical for developing countries, multinational companies base their research and development in home country leaving eventually to the host countries only a small part of applied research mostly for the purpose of product adaptation to the requirements of local market. The lecture to be learned is that transfer of technologies to developing countries through multinationals can eventually be done only if host countries have an adequate scientific and technological potential and active technological policy on national level.

15. The way followed by some of the countries (usually named as late-industrializing) with the objective to converge to technologically developed countries is shortly the following: (a) selection of the product range or industries where radical technological innovation (i.e. new basic technology) has been achieved somewhere, (b) selection of the appropriate method for import of the technology, (c) preparation of domestic scientific and technological potential through an adequate form of concentration for acceptance, application and improvement of imported technology, (d) establishment of sufficiently large domestic firm or firms for cost-effective production run and efficient marketing, (e) modification, improvement and even radical innovation of imported technology to cut the production cost and improve product function and thus achieve competitiveness on international market and (f) export of technology to less developed countries.
  
16. In order to be efficient and effective in accepting the challenges of new technologies it is necessary to have adequate structures, efficient institutions and appropriate policies and measures. Firstly we shall examine in some detail the problem of industrial structure, organizational structure of the firm and the structure of scientific and technological potential. Secondly, we shall deal with some problems of scientific and technological institutions and the mechanism of their coordination. Thirdly, we shall specify some elements of policies and measures which can be considered as effective, appropriate and valid for typical developing countries cases.
  
17. In order to minimize ambiguities we state:
  - (a) industrial structure is determined by
    - \* Size and number of the firms in each industrial sector
    - \* Size and location of the markets for buying and selling
    - \* Type of competition on domestic and international markets and barriers to entry and exist
    - \* Level of production specialization and product differentiation
    - \* Type and number of intrasectoral, intersectoral and international connections and degree of independence in production factors procurement.

- (b) Organizational structure of the firm is a means to implement firm policy and it is defined by
- \* Resource allocation
  - \* Distribution of management authority
  - \* Decision rules
  - \* Procedures for appraisal.
- (c) Structure of scientific and technological potential is described by
- \* Level of scientific and technological development and capacity
  - \* Functional distribution of scientific and technological potential among fundamental research, applied research, development, transfer of technology
  - \* Organizational distribution of scientific and technological activities among university research units laboratories, public or private research institutes, R+D units inside business enterprise sector
  - \* Outside relationships i.e. the degree of openness vs closeness.
18. Institutional variables such as public agencies, defence programs, national development plans etc. play decisive role even in development of new technologies, not to mention the acceleration of development inside existing technologies. We shall elaborate in some detail three institutional variables on Yugoslav case. The variables are:
- \* Type of institutionalized relationship between users and producers of scientific and technological results,
  - \* Nationwide political approach to the incorporation of technological development objectives in overall social and economic development path,
  - \* Institutionalized approach to the formulation of the national strategy of scientific and technological development.

INDUSTRIAL STRUCTURE - STATE AND NECESSARY CHANGES

19. Yugoslav industry has following structural characteristics:

- (a) In each industrial sector there is a rather great number of firms, somewhere between oligopolistic and perfect competition structure, lower level of concentration and production runs usually below world standards of economic lot size;
- (b) Domestic market of buyers overwhelms international market, but in many industrial sectors and branches import of materials is necessary for a normal production run,
- (c) Competition on domestic market is prevailingly oligopolistic one. Competition on foreign market has been for a long period of time backed by some measures so that products of many industrial sectors are not sufficiently competitive on international markets. That is particularly the case with high technology products. Some of the industrial sectors which have had rather strong domestic competition (textiles, machine tool industry, electric equipment industry etc.) have gained the competitiveness on international markets but prevailingly through cost and price factors,
- (d) Due to the very liberal import of technology and very many incentives for capital investments for a long period, barriers to entry in many industries have been rather low,
- (e) Vertical integration is a rather rare case so that the transfer of basic technologies is less quick than it could have been. A very interesting example is machine tool industry, for which Yugoslavia has labor, knowledge and experience comparative advantages. If this industry had been integrated with some electronic industry, as is the case with very productive and competitive Japanese machine tool industry, much bigger technological and economic results would have been achieved,
- (f) The relationships between end-producer and subcontractors or component manufacturers are characterized by lower responsibility for quality, prices and timing,

(g) Yugoslav industrial structure has been growing very rapidly so that the sole rate of growth has been the generator of some of the structural deficiencies. To this factor one should add deficiency in coordination, absence of tight international competition and rather high protectionism on domestic market.

20. The ability of one national industry to accept the technological advances is not its ability to develop or import technology but to apply and exploit it cost-effectively and competitively on domestic and international markets. To achieve such ability, the industry should have a sufficient level of some basic factors (human capital, fixed capital, scientific and technological potential, qualitative organization etc.) and their appropriate combination. One measure of the appropriateness of industrial structure is the closeness of industrial activities i.e. the existence of tight connections among leading sectors, basic industrial sectors, banking and commercial organizations.

The main deficiency of the contemporary structure of Yugoslav industry is the lack of tight vertical interconnection. Such a structure has been able to buy and import technology embodied in machine and know-how but not sufficiently able to exploit it mostly because of the lack of technological support in raw materials, and so additional import of technology (in materials and components) was induced. The conclusion is: vertically interconnected industrial structure is a necessary structural condition for domestically and internationally competitive technological development. Outside of such an industrial structure, there is a great probability that technological achievements, particularly in developing countries, can be performed only in the short run and at the cost of low wages.

21. Some of the above mentioned features are the same for many countries whose level of development is close to that of Yugoslav industry. So we can make some generalizations and suggest the following necessary and desirable change in industrial structure in order to accept new technologies:

(1) Interconnection of adjacent industrial and other sectors so as to get a qualitative combination of basic factors.

- (2) Development of large industrial firms in leading industries able to perform independent technological research and efficient transfer of technology at the stage when the rate of technological return is still high,
- (3) Selective development of industrial sector and very strict identification of attainable technological level for different industrial sectors whenever the market forces are either not at hand or are insufficient to direct the technological development, particularly in case of transfer of technology.

ORGANIZATIONAL STRUCTURE OF THE BUSINESS FIRM  
- STATE AND DESIRABLE CHANGES

22. The contemporary structure of a typical Yugoslav business firm is as follows:

- (1) Productive part of the firm consists of a number of practically independent units (called Basic Organization of Associated Labor - BOAL) which are associated in Working Organization, WO, i.e. firm. More complex associations are Compound Organizations of Associated Labor (COAL). There are also some other forms of association such as for planning, for business co-operation etc.
- (2) The source of decision power and labor managed authority are BOALs where the productive resources are allocated. All decisions on production, development, investment, etc. are brought on BOAL level and coordinated on "higher" levels.
- (3) BOALs can allocate some of their decision authority to WO or to COAL management bodies. Nonproductive units such as marketing, planning, finance, bookkeeping, personnel planning and recruitment and even research and development are organized as services to BOALs with strictly defined and limited decision power.
- (4) The evaluation of firm's activities is done through the comparative analysis of rather traditional economic and other indicators. Each

BOAL pays its employees depending on economic result it has achieved as a nearly independent economic unit in the short run.

- (5) Plans of any range for the whole firm are reached through the process of planning which, institutionally, should start at BOAL level and then through negotiation and coordination fixed for each BOAL and for the firm as a whole.

23. The main characteristics of this structure are:

- (1) Very high decision making independence of BOAL for short run problems and very great coordinative effort in order to reach decisions on firm level, particularly for those which need financial effort of BOALS.
- (2) Increase of economic motivation for efficient production which in case of tight competition leads to cost-effective production.
- (3) Increase of relative importance of short run and local goals and objectives in comparison to long run firm, sectoral and any other overall ones.
- (4) Prevailing influence of market demand in shaping the behaviour towards innovation which prefers to buy technology in contrast to develop it, to slowup technological development whenever there is some sort of justification for that, to employ capital or labor intensive contrary to knowledge intensive technologies.

24. The organizational structure of Yugoslav business firm is not necessarily similar to a typical firm in developing or late-industrializing countries. However, some common features exist so that one can propose the following improvements in organizational structure of the firm, in order to accept succesfully the challenges of new technologies:

- (1) Democratization of management process in the firm is a necessary condition for considering all main consequences of new technologies on firm and other levels. If one technology is not acceptable for employees value system it cannot be considered as a good technology.

Thus the system of complete information on technologies challenges should be developed and should operate.

- (2) Decentralized organizational structure is adequate for production and cost efficiency in the short run and thus for ripe technologies. For the development or transfer of new technologies in early stage it is necessary to concentrate R+D efforts not only on a firm level but on sectorial one.
- (3) In order to be prepared to meet directly or indirectly the challenges of new technologies any non-small industrial firm should establish the consulting body for technological development and be obliged to plan technological development simultaneously with production planning
- (4) In order to be innovative the structure of management personnel in many cases should be improved. It is a scientific fact that one type of managers is appropriate for conservative and positional firms (industry where technical change is slow) and quite different for innovative ones (for instance in electronics). The worst possible but not a rare case is the positional manager in innovative industry and innovative manager in slow changing branch of industry.
- (5) The last but most important change is necessity to introduce and develop an innovative climate into the firm through a sophisticated system of economic and other incentives for innovational results and efforts and through opening of the firm to the influences from environment.



STRUCTURE OF SCIENTIFIC AND TECHNOLOGICAL POTENTIAL

25. Up to now very much has been written and said about scientific and technological potential. In this paper it is also very difficult to avoid consideration of the matter due to the conviction that some of relatively new ideas are to be exposed.
26. Firstly I shall introduce a somewhat different concept of scientific and technological potential. This is due to the conviction that right understanding of this concept leads to the minimization of noneffective use and development of this potential.

The level of national scientific and technological development, STD, is by its very nature cumulative, dependent on the S+T development path, then on the amount of gross domestic product devoted to R+D and on the proportion of population working in R+D. I have found that the aggregate indicator of the level of national STD, denoted by  $P_s$ , is

$$P_s = \sqrt{\text{GDP per capita}} \times \begin{matrix} \% \text{ of GDP} \\ \text{for R+D} \end{matrix} \times \begin{matrix} \text{number of scien. and eng.} \\ \text{per } 10^5 \text{ of population} \end{matrix}$$

The greater  $P_s$  indicates the higher ability to solve the problem on higher level of scientific and technological trajectories. To solve the technological problem of level  $T^k$  it is necessary to have some minimum level of S+T development,  $P_s^k$ .

The national (or some other) scientific and technological capacity, STC, is indicated by  $P = N \times P_s$  where  $N$  stands for the population. The higher  $P$  the greater the number of technological problems that can be solved.

27. To illustrate and even justify above statement I have calculated  $P_s$ ,  $P$ ,  $P_s/P_{sa}$  and  $P/\Sigma P$ , where  $P_{sa}$  stands for average  $P_s$ , for 14 countries for 1979. and for 7 world regions for 1978. Two different data sources have been used for calculations.

Region	$P_s$	P	$\frac{P_s}{P_{sa}}$	$\frac{P}{\Sigma P} 100$
- Africa*	1,48	417	$4,85 \cdot 10^{-3}$	0,05
- Arab States	7,24	1072	$24 \cdot 10^{-3}$	0,12
- Asia*	53,5	73190	$175 \cdot 10^{-3}$	8,35
- Northern America	1835	440400	6,02	50,1
- Latin America	12,2	4100	$40 \cdot 10^{-3}$	0,47
- Europe	734	350120	2,41	40,2
- Oceania	333	7326	1,10	0,84
	$P_{sa} = 305$	$\Sigma = 876625$		$\Sigma = 100$

TABLE 1: Regional S+T level of development and S+T capacity in 1978.

\* Not including the USSR, China, Mongolia, Viet Nam and the Democratic People's Republic of Korea, for which comparable data for 1978. are not available

State	$P_s$	P	$\frac{P_s}{P_{sa}}$	$\frac{P}{\Sigma P} 100$
- United States	2375	524014	1,53	55,8
- Japan	1474	171019	0,95	18,2
- FR Germany	1804	110750	1,16	12,0
- France	806	43117	0,52	4,6
- United Kingdom	495	27742	0,32	3,0
- Netherlands	753	10540	0,48	1,1
- Sweden	1532	12716	0,99	1,3
- Switzerland	3138	19771	2,02	2,1
- Belgium	507	4973	0,33	0,5
- Canada	302	7165	0,20	0,8
- Denmark	532	2666	0,34	0,3
- Finland	425	2038	0,27	0,2
- Ireland	70	238	0,05	0,03
- Yugoslavia	54	1203	0,03	0,13
	$P_{sa} = 1550$	$\Sigma = 937952$		$\Sigma = 100$

TABLE 2: National S+T level of development and S+T capacity in 1979.

28. Countries or regions can be classified according to the level of STD (in absolute sense) and STD (in relative sense). Position of each country according to these two parameters determines the theoretical ability of national or regional sciences and technologies as is suggested in Table 3. and Table 4.

	$P_s$	
(8.3)	4000	A: Science and technology (S+T) so developed that the future can rely mostly on S+T (at present not a single country)
(7.1)	1200	B: S+T very developed but still the future cannot rely mostly on S+T (United States, Switzerland, Sweden, Federal Republic of Germany, Japan, Northern America)
(5.9)	360	C: S+T level of development able to reduce significantly dependence on natural resources (France, United Kingdom, Netherlands, Belgium, Denmark, Europe etc.)
(4.7)	100	D: S+T able to solve technological problems which are not close to basic technologies, so there is very high dependence on natural resources (Canada, Oceania etc.)
(3.5)	30	E: S+T on the level of development able to accept and apply developed technologies, so there is very high dependence on old technologies and natural resources (Ireland, Yugoslavia, Asia* etc.)
(2.3)	10	F: S+T at the very early stage of development, full dependence on natural resources (Latin America, e.g.)
(1.0)	0	G: S+T does not exist as a systematic activity, full dependence on nature (e.g. Arab States, Africa)

TABLE 3: Classes of S+T level of development

\* See TABLE 1.

P/ΣP (%)	1: S+T capacity (STC) which determines the worldwide development behaviour in a very wide range of technologies, particularly in basic ones
35	2: STC able to exploit efficiently most of technologies and to develop some of basic ones
15	3: STC able to perform very quick technical change and many technological refinements and to participate in development of basic technologies
3	4: STC able to exploit cost-effectively basic technologies, to efficiently develop and use technological innovations but careful allocation of S+T efforts in order to gain internationally competitive results is necessary
0,4	5: STC able to accept technological development in a very narrow range of technologies and sectors if it is to gain competitiveness, thus the risk of unapropriate planning technology policy is very high
0,02	6: STC very small and able to accept new technologies in very few sectors so usually deals with old and noncompetitive technologies
0,001	7: STC is negligible and unable to survive without outside aid
0.0	

TABLE 4: Classes of S+T capacity

29. National scientific and technological potential (NSTP) can be globalized, or (widely distributed) or specialized. To be globalized means to undertake scientific and technological activities on the whole range of national development and for all levels of possible technological aspiration. To specialize means to devote S+T potential to selected sectors and for appropriate (maximal possible) level of technological aspirations. NSTP of developing countries cannot be effectively globalized. However, many developing countries attempt to distribute scientific and technological potential to all sectors. The immediate consequence is low efficiency of such globalization and loss of confidence in national scientific and technological potentials. This pattern of behaviour is generated by low NSTP.

30. In Yugoslavia one can identify globalisation on federal level, on the level of federal units (republic) and on firm level. The pattern of

recognized behaviour has been the following:

- (a) Up to the mid-sixties the greatest amount of scientific and technological potential has been concentrated in larger industrial organizations and independent research institutes, some of them being "federal" some very local,
- (b) Research and development potential located in business enterprise was reallocated to the production units with the idea that "science and technology should come to the workshop floor".
- (c) The immediate consequences of such globalization have been: (i) lack of critical R+D potential both on workshop level and firm level, (ii) diminishing of the ability to perform research and development tasks, (iii) loss of confidence in own research and development potential which led to reduction of funds for research and development.
- (d) The independent research institutes have become selffinancing what is definitely a good and healthy idea that oriented them to the actual problems of technological innovation in industrial firms. However, very soon they have faced short-run innovation policies of many industrial firms, very heavy impact of imported technology which was internationally oriented but not internationally based (one should have expected that). Besides that they faced lack of bridging institutions, i.e. research and development centers inside industrial firms able to identify long run innovational programs and to accept the abilities of independent research organizations, which in Yugoslav case are very significant. The immediate consequence has been the globalisation of the research and development potential of independent institutes through very rich diversification of research activities and orientation towards short run activities.

31. Conclusions which stem from the above are:

- (a) Lower level of STD and smaller amount of STC, what is typical for developing countries, practically forbids the globalization of scientific and technological potentials.

- (b) Thus, the specialization of this potential is a necessary condition for its development and effective utilization. Specialization requires a very careful search for attainable level of technological goals, sectors and technologies. The concept of market, product and technology niches should be accepted regardless of any political objection to it.
- (c) The only promising way to globalize effectively scientific and technological potentials in developing countries is to integrate this potential on regional or any other level i.e. to establish the system of international co-operation in science and technology.

#### STRUCTURE OF THE SOURCES FOR FINANCING R+D

32. One of the still controversial aspects of scientific and technological development is: which structure of R+D financial resources should be considered as optimal? There is no definite answer to this question. Research and development organizations always claim the scarcity of financial resources.
33. For the purpose of reliable judgments we can use two norms but only to a limited extent. The first norm comes from known R. Kelly's definition of technological intensity which is simply: the product group is technologically intensive if "the percentage of R+D expenditure in value sales of the United States industries exceeds 2.36 percent". Balassa uses two criteria for defining high technology products: that are industries for which R+D expenditure exceeds 3.5 percent of sales and the number of scientific and engineering personnel exceeds 3.5 percent of total employed. The second norm can be derived from the statistical data on research and development funding for different countries. In countries with centralized economic planning, scientific and technological activities are nearly 100% government funded. Researchers in basic sciences usually consider this as the best solution, but the number and competitiveness of technological innovations are not in accordance with that. On the other pole there are the cases of some technology very developing countries where government participates with modest 2-5% of total R+D outlays and that can be

taken as an argument for quite an apposite claim. Thus we cannot derive any reliable proof that a certain structure of financing is the best one. Financial structure is frequently telling us something of plans and wishes and maybe of some misleading concepts.

34. In Yugoslavia financial structure of scientific and technological activities for the last fifteen years has continuously been changing towards the relative decrease of the government funds and later of communities for selfmanagement interest in science (SMCS) being now about 10% of the total earning of all research and development organizations. It is difficult to judge on the quality of such a pattern of financing due to the fact that the main thing is policy and program of scientific and technology research. Nevertheless we can establish the following:

- (a) Orientation towards increase of business enterprise sector participation in R+D financing is certainly a good solution if there are appropriate R+D plans for each sector, branch and at least larger firm.
- (b) However it is very difficult to reach the concensus of all firms so that some sectors or firms give financial support for research and development to other firms and sectors for a longer period. The prevailing behaviour is that each firm spends its R+D financial resources and tries to participate in spending common funds. For the case of nonconcentrated industrial structure each firm has a small amount of R+D resources and thus it is not able to reach the tresh-old (see paragraph.34).
- (c) However, the scarcity and deconcentration of financial R+D resources is firstly a consequence and afterwards a factor of the lack of sound R+D plans. There is empirical evidence that in some firms financial resources for R+D have not been the constraint but clear objectives plans and programs of R+D activities. A similar situation can be met in the communities for selfmanagement interest in science. This type of social approach to science, research and development is promising but in the absence of adequate (right objectives long run, selective, feasible) policies there is the lack of adequate research

programmes besides the enormous number of proposals subjected for financing.

35. The main recommendation concerning the structure of financing R+D is as follows: (a) it is necessary to concentrate financial resources on national or on sectorial level to the relative amount which is proportional to the non-market generation of R+D activities, (b) policies and plans for scientific and technological development are the only norm to judge the appropriateness of concentration of financial resources for R+D, (c) user-oriented financing increases the responsibility for resources utilization and thus one should always prefer such financing, in case of developing countries.

STRUCTURE ACCORDING TO DISCIPLINES, TYPE OF RESEARCH ORGANIZATIONS AND TYPE OF RESEARCH ACTIVITIES

36. A reliable judgment requires a somewhat deeper analysis to be performed. Therefore we present in Table 5, 6. and 7. some data on detailed structure for Yugoslav scientific, research and development community for 1980.

	Number of organizations	Number of employees	Number of researchers	Number of accomplished projects		
				Basic research	Applied research	Development
T o t a l	479	32265	11287	2160	7553	3028
Natural sciences + mathematics	59	3884	1694	970	959	409
Engineering and technology	216	17581	5714	338	4887	1791
Agricultural sciences	61	3676	1023	126	558	153
Other sciences	202	7124	2856	726	1149	675

TABLE 5: Independent research institutions (IRI)



	Number of organizations	Number of employees	Number of researchers	Number of accomplished projects		
				Basic research	Applied research	Development
Total	88	3799	1364	36	506	616
Natural sciences + mathematics	6	149	58	6	6	3
Engineering and technology	51	1472	821	11	304	591
Agricultural sciences	3	28	11	-	9	3
Other sciences	28	2150	474	19	187	19

TABLE 6: R+D units inside economic and noneconomic enterprises (RUE)

	Number of organizations	Number of employees	Number of researchers	Number of accomplished projects		
				Basic research	Applied research	Development
Total	258	22644	10513	1392	2398	718
Natural sciences + mathematics	30	2154	1101	464	107	19
Engineering and technology	84	7485	3578	284	1183	451
Agricultural sciences	41	3765	1583	216	693	156
Other sciences	103	9240	4251	428	415	92

TABLE 7: R+D organizations and units inside universities (ROU)

37. The immediate statistical observations are:

- (a) The concentration of researchers is the highest in IRI (23,6 researchers per organization), lower in RUE (15,5) and the lowest in ROU (13,6),
- (b) The above level of concentration is in an absolute sense very low and inappropriate for undertaking significant objectives in new technologies, without very high coordinative efforts,
- (c) Low level of concentration in RUE is a consequence of already established low level of concentration in industrial structure,
- (d) There is preference towards basic research so that in IRI on 1 project in basic research there are only 3.5 projects in applied and 1.4 projects in developmental research. Research at ROU is very basic oriented, what is traditionally expected but what does not seem to be justifiable for the county of that level of technological development,
- (e) The number of the accomplished projects per researcher is slightly over 1 in IRI, slightly less than 1 in ROU and 1.3 in ROU. That is the sign that small projects prevailed in 1980.

38. For analytical reference one should mention that in most industrialized countries more than a half of national R+D effort is done by private firms, public enterprises and research institutes serving industry. This concentration is the greatest in Switzerland, where more than 3/4 of Gross Expenditures for Research and Development (GERD) are spent by business enterprise sector. This figure seems to be the most appropriate for developing countries.

39. Having in mind given statistics and with the help of some experience with the empirical cases, one can recommend the concentration of personnel, financial resources and organizational efforts in industrial sector or strictly for selected industrial sectors if any noninferiour feasible objective in accepting new technologies is to be achieved.

INSTITUTIONAL VARIABLES

40. Institutional variables may play a very important role in generating or at least stimulating the development and application of new technologies. The more the science and technology are a determining factor, the greater the meaning of these variables. We shall consider in some detail three institutional variables which are supposed to influence decisively the acceptance of new technologies in Yugoslavia.
41. The first institutional variable are the self-managing communities of interest in science. The basis of this variable is the principle of the Yugoslav society according to which workers have an inalienable right to decide on allocation of the income they realize. The immediate consequence of this principle is the abolishment of any government fund for research and development and the establishment of self-managing communities of interest in science (SMCIS). The main objective of these communities is to establish direct relation between those who use the results of research and development (industrial and other organizations) and those who produce them (R+D organizations). Producers and users of R+D results can establish SMCIS for republic, province or region and for a particular branch sector or group of industrial organizations. Bodies of these communities decide on R+D plans, projects for implementing the plans, financial and other resources formation and allocation. Besides this system through which it is financed about 20% of total outlay for R+D, there exists a system of direct commissioning a system of joint ventures between user and producer called the system of direct exchange of labor. The last system is expected to be most powerful because its idea is to put together very tightly users and producers of R+D results so that both sides take the risk and advantages of scientific and technological development. Presently over 70 percent of the total R+D work is done through direct commissioning of the research and development projects.
42. The main features of the first institutional variable are: (j) increase of interests in science and technology through demetropolisation of the concentration of R+D resources, (b) more strict control of the resource utilization, (c) increase of stimulus for the establishment of research

units inside business enterprise sector to serve as bridging institutions or to perform the R+D activities by themselves and (d) increase of interest of R+D organizations outside industrial firms; dealing with applied and developmental research contrary to the inclination towards basic sciences and larpourlartistic behaviour. However, there are very high barriers to be overcome in order to benefit fully all of the promising features of this institutional variable. First of all the problem of coordination has become very heavy, secondly, informational aspects have become very decisive, necessity for a strict methodology may lead towards some kind of organizational dogmatism and as was expected there are tendencies for bureaucracy of a special sort to develop.

43. Present world and national problems have caused the formation of Federal Commission for Stabilization of Economy which is designing a long-range stabilization programme. One working group of this Commission has prepared a document entitled The Grounds for the Strategy of Technological Development. The document appeared three months ago with the following results to be mentioned here: (1) Recognition that technological development is the necessary condition for economic stabilization and development, (2) Description of the main characteristics of future scientific and technological trends and the general actions which have to be undertaken in order to deal with this development, (3) Recognition that some of the technological development problems have necessarily to be resolved on the federal and some on lower levels, (4) Very great stimulus to the very wide public, to many organizations and institutions, to political and governmental bodies to take participation in nationwide discussion on many problems of technological developments. The document has already given the main yield: the high awareness of all shortcomings in past technological developments and of significance that the future technological development should be very carefully shaped and backed with appropriate structural and institutional features.
44. The third variable we want to consider is the institutionalized creation of the strategy of scientific and technological development. It is recognized that the strategy for scientific and technological development in Yugoslavia should be formulated but in the process of interplay and interactions with the formulation of strategies for S+T development of

republics, provinces, industrial sectors, large industrial firms etc. At present the programme for formulation of the Strategy of S+T Development in the Socialist Republic of Serbia is fully completed. The mentioned Strategy of S+T Development is to be formulated under the guidance of Council of the Project and under the auspices of the Assembly of the SR of Serbia, Chamber of Commerce of the SR of Serbia and the Self-management Community of Interest in Science of SR of Serbia. The Project should formulate the S+T Strategy for the next twenty years and establish the system and institutional arrangements for adaptive reformulation of the Strategy. The Project is to be realized during the next two years involving more than ten research institutes and over 250 scientists and researchers. The main parts of the projects are (diagnosis and development programme): microelectronics, telecommunications, robotics, genetic engineering and biotechnology, chemical industry; material technology, energotechnologies, metalworking industry, food production. Besides that, the following four important common problems are to be resolved in the Project: (1) Formulation of the methodology for the design of S+T Strategy, (2) Investigation of the main cultural, ecological, educational and other aspects of new technologies, (3) Design of appropriate structures, institutional conditions and behaviour for successful implementation of the Strategy and (4) Long-range programme of basic science for the purpose of technological development. The research activities in the Projects are coordinated by Science and Technology Policy Research Center.

45. In parallel with the Project mentioned above, three complement projects are under way: (1) Strategy of Production and Technology Development of Car Manufacture "Zavodi Crvena Zastava" up to 2000 (investigated by Science and Technology Policy Research Center), Development Strategy for Machine-tool Industry (Faculty of Mechanical Engineering, Belgrade) and Development Strategy of Chemical Industry (Institute for Chemistry, Technology and Metallurgy, Belgrade). In due course are negotiations on similar projects for electronic industry, agriculture and food industry. We consider this to be a very meaningful way to institutionalize technological development on all appropriate levels.
46. Finally, I would like to expose one statement which seems to be of high interest and importance for the acceptance of new technologies in deve-

loping countries. The level of technology in noneconomic sectors in government and administration is an important macro element while a contemporary worker is opposed to technological development whenever outside factory walls he is to meet old, conservative, nonefficient way of doing things. Technological development is not only cumulative but also a complementary process. In the same line is the influence of innovative climate in micro area. Anybody concerned with technological development needs the adequate quality of all factors in order to accept the technology. Thus, new production methods and new products can be introduced if there already exists a new commercial behaviour, appropriate methods of planning, new management behaviour, and adequate attitudes towards all peculiarities of new technology. In short, what is mostly needed is the innovative climate in all sectors and segments of the society.

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#### References and data sources

1. Dosi G., Structural Adjustment and Public Policies under Conditions of Rapid Technical Change, The Semiconductor Industry in Western Europe, Brighton, Sussex European Papers, University of Sussex, 1981.
2. Matejić V., One Method For Multicriteria Measurement of National R+D Potential, Paper of National Conference on Operations Research, Herceg Novi, 1982.
3. Matejić V., Policy of R+D Activities Integration in Associated Labor, Institute Mihailo Pupin, Belgrade, 1976.
4. Mistal J. (ed), Vers une nouvelle division international du travail? Revue d'Economie Industrielle, No. 14. 1980.
5. Rosenberg, N., Perspectives on Technology, Cambridge, Cambridge University Press, 1976.
6. OECD, DSTI/SPR/83.13 Part 2, International Trade in High Technology Products: An Empirical Approach, 1983.
7. UNESCO, Statistical Yearbook 1982.
8. OECD, DSTI/SPR/81.27, Trends in Science and Technology in the OECD Area During the 1970s.
9. Saopštenje Saveznog Zavoda za Statistiku, Broj 341, God. XXV od 29.12.1981.

