THE USE OF THE CATEGORIES AND DYNAMIC ELEMENTS OF RESEARCH REQUIREMENTS

By

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It is frequently stated nowadays that the rapid development of science and technology also effects changes in socio-economical relations. *Friss* in one of his papers* discusses the significance of this change which transforms the structure of industry, changes the patterns of settlement, requires new methods of works organisation, brings about new relations between physical and intellectual work, demands the opening up of new avenues in science and research, necessitates new approaches to certain fields of theoretical and practical training, and so forth.

The paper also points out that two main types may be distinguished among the motley pattern of social systems prevalent in the various countries of the world. "In the one the instruments of production, or at least a decisive proportion are socially owned, in the other the decisive proportion of the instruments of production is privately owned." *In the industrially developed countries* of the two *types of society there are, despite the important differences, also obvious similarities to be observed.* In respect to the similar characteristics of development it should be interesting to examine some of the relevant figures for the most highly developed capitalist countries.

Such figures have been published by an American author* who in a discussion of the socio-economic effects of the development of science points out that in *America* during the last century *output per manhour* rose six-fold, while wages increased from some 30 cents an hour, to over two dollars. He believes that economic development in terms of the change in *earnings per head* is affected by three factors: the technological level, the volume of investments per head and works organisation methods. He next proceeds to deal with better methods of works organisation and shows that the average annual

* I. FRISS: A technikai haladás társadalmi-gazdasági következményei (The socio-economic consequences of technical progress). Közgazdasági Szemle, 1956, 11—12, p. 1346.
* Yale Brozen (Chicago University) "Scientific Advance as a Factor in Economic Change" — Scientific Manpower (National Science Foudation), 1957, p. 7.

increase of 2.5 per cent in labour productivity in American firms is made up of three component parts: 0.75 per cent by the better exploitation of the capacities of existing plant, 1 per cent by greater financial effort (mainly investment) and 0.75 per cent by results achieved through scientific research. The *importance of scientific research* to America's economic life is, however, much greater than this quantitative ratio suggests, for it makes it possible more economically to utilise the labour power that is gradually freed from the less productive agricultural sectors, in more productive industrial sectors and thus also provides opportunities for the employment of available supplies of capital in worth-while investments.

The paper also has interesting data on the lucrativeness of American scientific research. Calculations carried out at Chicago University show that some firms increased their annual output by $ 75 for every $ 1 spent on scientific research, purely through a rise in productivity and without further expenditure in wages or equipment.

Rank correlation computations for various sectors of American industry yield a rating correlation coefficient of 0.88 per cent in the case of a number of leading companies between research expenditure for 1953 and its returns in 1954, *i. e.* the probability of the correlation being due to factors extranuous to research expenditure (*e. g.* changing market conditions) is less than 1. Although these figures should, due to the peculiarities arising from the different social systems and to other reasons, be treated with appropriate care, they are by no means irrelevant in our case.

We, too, must be in time to draw the conclusions applicable in our circumstances from the figures and experiences of industrially more developed countries, with regard to the relatively rapid changes in the forces of production due to the development of science and reasearch.

The *first*, and one of the most important of these conclusions is that the rate of our development is in no small measure determined by the extent, the level and the degree of concentration on the most appropriate tasks of our intellectual efforts.

The rate of development may therefore, — among other means — be influenced by the proper planning and organisation of the training of scientists, engineers, skilled workers and other indispensible *technical and economic specialists*. This training frequently sets absolutely novel requirements and needs a new type of approach, but the teaching and the learning of the present are the knowledge of the morrow and good teaching and good learning are among the most rapidly paying and most economical of our investments. It cannot yet be said that the recognition of the problem has lead to the complete triumph of this approach in the practice of everyday decisions. In this respect we must do more to emulate the example of the Soviet organisation of science that has led to such brillant international successes.

The second no less important conclusion for our industrial and development targets is that — within the bounds of our limited resources — we must find the optimal mode of expenditure for our people's economy.

All these aspects make it necessary *carefully to plan research work.*

It should here be clear that the first, *very rough distribution of the expenditure intended for research at a national level is a very difficult task* because any decision may, through all the affected (or not affected) branches of science and of industry, to a certain extent influence the scientific and industrial policies of the whole country.

The problem is rendered complex by the fact that the needs of fields with fairly *divergent characteristics and aims* (the interconnected and proportionate development of the fundamental and applied sciences) should be evaluated according to some *common scale*, while at the same time within the *same field*, *i.e.* that of applied (industrial) research, the *realistic weights* or other suitable coefficients should be found that would facilitate the previous estimation — at least to the most necessary extent — of the probable or possible changes in time of the research expenditure needs, of one or other of the sectors of industry, ear-marked for development in the national interest.

The very divergent nature of the problem has, as far as I know, so far not made it possible either to find a scale that would absolutely suit all of the various fields, nor weights or appropriate coefficients that would serve properly to indicate whatever changes with time took place. Instead some information may be given by *the definition of the various categories of research requirements and the establishment of those dynamic factors* which may, even within the category of time, necessitate *verry different* degrees of intellectual and material effort.

The research requirement of various sectors of industry is generally interpreted as the *positive* economic significance of industrial research to the development of the particular sector and at the same time as a measure of the extent to which the adoption of new products and new technological process derived from industrial research is an indispensible condition of development and the achievement of higher returns in that sector. It also involves a consideration of the significance of the *negative* economic effect that may result from a lack, or an insufficiency of research in a particular sector.

Under a socialist system of production it is necessary to distinguish three categories of industrial research requirements. They are:

1. *Quantitative research requirements* imply qualitatively two kinds of research requirement, that are, however, essentially closely linked with one another. Their boundaries cannot always be indicated clearly, because they frequently impinge on each other.

Let us call the one a quantitative *absolute* research requirement, and let us use this to indicate the research requirements of those sectors of industry which can only be developed by working out and introducing new products and new technological processes more or less every year (*e. g.* the pharmaceutical industry).

Let us call the *second* — for want of a better expression — a quantitative *relative* research requirement, and use this to indicate all those divergent sectors of industry collected under one name (*e. g.* the chemical industry) where

a) the sector includes several *branches with differing research requirements* (*e. g.* the petroleum industry or the electrical industry).

b) Where the extent of research requirements is — apart from the characteristic features of the sector itself — also augmented by the fact that the *sector* concerned is *especially earmarked for development on our plans* for the people's economy (for instance at present the instruments industry or food processing machinery).

Thus the formation of sub-groups for absolute and relative research requirements within quantitative research requirements serves *mainly practical* ends and *not those of theoretical classification*. (The two categories may coincide and therefore do not always form clearly separate classes.)

The two sub-groups do, in fact, provide a means for *partitioning* the largest and most important groups of quantitative research requirements. *Separate attention* may then be paid to those sectors that can throughout the world only be developed by very large material and intellectual research expenditures (*e. g.* the pharmaceutical industry) and separately to those sectors with regard to which, *before decisions are made* on the transformation of the industrial structure of our people's economy, *one of the aspects to be taken into account* is whether a previously *determinable* intellectual and material research expenditure is worth while, compared to the expected economic returns.

2. *Qualitative research requirements*, where a greater material sacrifice seems warranted in the interests of the expected success of some idea that has been adequately substantiated and accepted scientifically or in order to help the work of one or other of our great scientists.

3. *Potential research requirements*, relative to the search for natural resources, such as coal, mineral oils, etc. This includes in the first place research on the basic fuels, the rate of exhaustion of some of which is increasing as a result of their enhanced use by developing technology. Potential research requirements generally involve closely cooperating fundamental and applied scientific research and whichever of the two lags behind the other, the fact may impede successful work. Mineralogy and geology, for instance, have adopted exact chemical and physical methods of measurement and experiment, in place of their former purely descriptive, systematic and comparative approach. It was thus that geochemistry and geophysics developed as independent branches of science which, when potential research requirements arose, helped in the development of new methods of investigation, far more efficient than those

previously employed. The sciences of geochemistry and geophysics are obviously largely fundamental in character, while the development of the various methods of prospecting for natural resources require the practical application of these fruits of fundamental science.

It follows from this approach that I have made to classification that the *research requirement* is for the greater part not a static, but a *dynamic* concept, changing as a function of the industrial structure and of the given economic circumstances and opportunities of the period concerned. It all leads indirectly to the conclusion that research is *not the only*, uniquely possible path to technical development, for in some sectors the research requirement may be outstripped by, for instance, the design requirement (in engineering).

Finally, the dynamic nature of the research requirement leads to the need for *continuously substantiating industrial research through fundamental scientific work* or, in other words, the timely recognition of the fundamental scientific research requirements of industrial research. We shall return to this aspect in due course.

It is generally desirable to consider the research requirements of a particular sector, if they are warranted by

1. domestic factors (*e. g.* raw material stocks, manufacturing traditions, guaranteed markets, experienced skilled workers and engineers, sufficient power, etc.),
2. the production of new articles for domestic consumption,
3. the reduction of costs,
4. our participation in the international division of labour.

Let us examine the significance of these four conditions in a few branches of industry with typical absolute and relative research requirements.

The classic example of *absolute research requirements* is the pharmaceutical industry, where it is necessary nearly year-by-year to market new products, manufactured by ever more perfect processes, for the economic efficiency of the sale of products manufactured by older procedures decreases rapidly. Thus the quantity and quality of the products of this branch of industry changes swiftly and radically. It is therefore easy to see why, according to foreign statistics, 6—8 per cent (and the most recent figures indicate considerably more still) of the annual product value is, in countries with advanced pharmaceutical industries, spent on research and development. This sector of industry can — at an appropriate level — satisfy a fair domestic requirement and at the same time participate with a relatively large volume of its manufactures in the international division of labour.

The *Hungarian pharmaceutical industry* has, for instance, achieved important successes on the world market with its poppy-seed alkaloids, papaverine and ultraseptil. The desirable conditions for the consideration of research requirements which have been enumerated, did, in fact exist in the case of these three Hungarian medicines. It is a *common feature* of all three preparations that the quantity produced by our pharmaceutical industry is a *considerable portion of total world production*. This fact is of decisive influence on the development of costs. The second *common feature* is that all three medicaments are — in respect to the technology of their manufacture — largely the fruits of *Hungarian research*. The third important feature is that poppy-seed alkaloids are manufactured of home-grown raw material. The production of these medicines therefore led not only to the satisfaction of domestic requirements, but also to the exploitation of big opportunities on the world market and of domestic resources (home-produced materials and Hungarian research) and to the export of the product of our intellectual effort.

The pharmaceutical industry affords a good opportunity for observing how *fundamental and industrial research* are *linked* and how they supplement one another. It was, for instance, observed as early as 1932, using a form of penicillin containing only one percent of the active material, that it had excellent curative effects. Nevertheless, more than ten years had to elapse before this discovery acquired practical significiance. (First, the methods of isolation had to be worked out, which was, properly speaking, a piece of *industrial research*. It was, moreover, necessary to raise the amount of penicillin produced in the fermentation mixture from the initial 1—2 mg/litre first to 200—300 mg/l, later to 1—2 g/l. This, too, was a job for *industrial research*.)

Relative research requirements are presented, for instance, by the *petroleum industry* or by *heavy current electrical engineering*.

The *petroleum industry* may be considered to have relative research requirements because — though in this sector, as is generally the case, the boundaries between absolute and relative research requirements are frequently obscure — the development of various sectors, corresponding to the national peculiarities and needs of each country, may have a different measure and degree of economic importance. We may thus speak of the importance of improving the quality of lubricants, of the introduction of continuous plant processes for gas separation using adsorption procedures with active carbon, of the need to investigate asphalts (bituminous materials) with a view to improving their quality, and possibly of the examination of liquid and gaseous products by various spectroscopic procedures. The *petroleum chemical industry* (the isolation of basic materials from various petroleum products) can also be developed or the chemistry of large molecules may be studied.

The *choice* between different technological processes at the same time involves research work of a different nature and different costs and may also involve differing lengths of time, etc.

The case of the relative research requirements of the *electrical industry* is well shown by the figures of "Angewandte Forschung in der Bundesrepublik Deutschland" (Teil II. Steiner Verlag GmbH, Wiesbaden. 1957. pp. 21—

30.) relating to the electrical industry in Western Germany. The number of persons employed in the industry is about 1 million, of whom some forty thousand are engineers. The turn-over of the West German electrical industry in 1955 was 11 thousand million DM and its total share of exports was 21 per cent. (This share occasionally reached fifty percent in some branches of the industry.) The electrical industry of Federal Germany takes the third place on the world market. Corresponding to the great importance of this sector, the West German economy devoted some 5 per cent of the product value, about 500 million DM annually, to research and development in the electrical industry. Faculties of electrical engineering have been set up at the 8 technical universities of Western Germany, with special heavy and light current divisions in which a very considerable volume of research work is done. Research is centred on the works laboratories, especially the research laboratories of the various large industrial firms, but there are also co-operative research laboratories, operated by smaller firms. Apart from the sum of 500 million DM which has already been mentioned, further support for electricity as a science, is extend by the State in its endeavour to promote research, both by supplying the appropriate university institutes with up-to-date equipment and by providing in the budget for salaries for the staff and for the costs incurred in training. The State has apportioned a lump contribution of up to 25 million DM and annual budget grants of up to 3.5 million DM for this purpose. It should, moreover, be noted that training has also been developed by the foundation of 10 new chairs of electrical engineering at the 8 existing technical universities. The aim of these subsidies has been set at doubling the supply of engineers.

These figures all go to show that the electrical industry, which generally requires research anyway, is amidst the *peculiar facts of the West German economy* of such special importance that classification as showing relative research requirements is justified.

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Research requirements — considering absolute, relative and potential research requirements — are primarly not only dependent on the various categories that have been enumerated, but attention must also be paid to the development of a host of dynamic factors affecting, for the greater part, the order of magnitude of the necessary expenditure. These factors may show widely divergent aspects with the sector, with the place and the time and their *analysis* is therefore only valuable *in a given sector, at a given time*. The *economic effect* of many of them may be expressed by a cost function in which, at a given instant of time, independent variables, such as the technical level of the whole of a particular sector, the manufacturing technology that has been chosen, the individually differing scientific or research methods, the discovery of certain natural resources or the scale effect being investigated, may be added to qualitatively and quantitatively differing research costs as dependent variables. There are also dynamic factors — the characteristics of the technical level of a particular sector at a given time — that show whether research work should be done at all, or whether the sector concerned has only *documentary requirements*. (The adoption of the patents and plans of existing products and manufacturing processes.) Without striving, by enumerating the various possible dynamic factors belonging to changing degrees of industrial development, to achieve completeness, it is worth discussing some of the now effective, more important factors of the dynamics of research requirements. These, for instance, include the following:

a) *The dynamics of the characteristics of the technical level.*

Technical development may be equally necessary in sectors *below the world standard*, those *approaching the world standard* or also in *sectors that have already attained it*. While, however, *the need for research to develop industries that have attained the world level cannot be disputed and* the importance of the requirement for fundamental scientific research increases within the total requirement (for at the world level, or near it, industrial research alone is generally no longer sufficient), in the sectors that are *way below that level it is not research but the adoption of ready-made solutions* or processes, *e. g.* blueprints or patents, that is appropriate.

To do research in a branch of industry that is below the world standard, instead of adopting a ready-made solution or process, is tantamount to devoting lengthy and costly labour (whose successful issue is frequently doubtful) to "*rediscovering*" what has already been discovered.

b) *The dynamics of the technology of production, manufacture or processing.*

It may happen, though it is not a frequent phenomenon, that the demand for products derived from one and the same raw material undergoes a *complete cycle of revolution* within a relatively short period of time. In the petroleum industry, for instance, after the discovery of kerosene it was used as a medicine and for lighting, to be followed by the utilization of petrol, later of gasoline and the various lubricants. Petroleum chemistry developed and with the discovery of turbo-prop aircraft the large-scale manufacture of the first product, kerosene, has once more come to the fore.

Thus within a sector the importance of some fields of research may decrease in consequence of the need to solve other, more important research problems and there can be a simultaneous growth or decrease in the probability of the success of the research project, the time necessary to achieve results, the magnitude of the expenditure, a growth or decrease in the optimal number of research workers, finally there can also be a change in the appropriate ratio of fundamental and industrial research. All these factors can be of *definite economic significance.*

c) *The dynamics of the manpower capacity needed for research.*

One of the consequences of technical development and of changing standards — as has also been pointed out by István Friss in the article we have cited — is *the gradual shift in the ratios between intellectual and physical work.*

It is recognized throughout the world that the *first* to recognize the practical implications of this change were the educational and industrial policies of the Soviet Union, as a result of which many more engineers and scientists are now being trained annually in the Soviet Union than in either the United States or Britain. By making this recognition *in time* the Soviet Union has overtaken and passed America *not only in numbers* but, as may be gauged from her latest scientific successes, also in *quality*.

The effect of the development of science and technology on the change in the proportions of intellectual and physical work is well shown in figures published by the American National Science Foundation* and various American authors.** According to these the *number of employed persons* in America *has grown fivefold* since 1870. In the same period the number of scientific workers has grown seventeen times as fast, *eighty-fivefold.* Between 1930 and 1957 the number of *engineers* has grown from 215 000 to 700 000, that of *scientist* from 46 000 to 250 000. (The evaluation of the latter figure is difficult, because the authors do not define exactly whom they include in the collective term of "Scientist" and it is also not quite clear, whether the figure for 700 000 engineers includes the 250 000 technical scientists or whether they are indicating a growth of scientific personnel only.)

Furthermore, in 1870 there were more than 1000 *physical* workers to every intellectual worker qualified in science or technology. This *ratio had* by 1930 *decreased* to 231 to 1 and by 1950 to 59 to 1. In 1890 there were 868 physical workers to every engineer. This ratio had decreased to 113 to by 1950.

Even though the accuracy of these figures cannot be controlled and their interpretation is not unequivocal, they are, nevertheless, undoubtedly able clearly to show the *trend of development* and the socio-economic consequences of the technical change in the world's most highly developed capitalist country.***

* Trend in the Employment and Training of Scientists and Engineers. May, 1956.

** I. W. Feiss: "New and Changing Activities of Scientists and the Implications." Scientific Manpower, 1957, p. 12.

*** The above publication of the National Science Foundation also contains further figures of the distribution by occupations of the 700 000 engineers and 250 000 scientists. Thus of 700 000 engineers 75 per cent work in industry, 2 per cent in education, 23 per cent are government or administrative workers. Of the 250 000 scientists 60 per cent work in industry, 20 per cent in education, 20 per cent are government or administrative employees.

We, too, have our tasks in respect to some of the demands of the socio-economic change that is itself accelerating under the influence of the rapid development of technology. They are as follows.

a) If we wish to keep up with developments we must *raise the level* of technical and scientific *training*, increase the *number of engineers* and in co-operation with the industries where the majority of engineers will go, we must see to it that the workshops and laboratories, in fact all the important workplaces, of our scientific institutions are furnished with more up-to-date equipment.*

b) The number of workers with scientific qualifications and the number of scientists in industry must be considerably *increased*. Managers of industrial plants must understand that the success of their work is increasingly more dependent on the technical standards and competitiveness of their products than on the clever use made of momentary situations or marketing possibilities. The latter can at most serve the *present*, while the *future* depends on the former. A failure to recognize this and consistently to take the appropriate measures may have a deadly effect on the fate of research and thus of the industry in world competition, as the possibilities for *supplying scientists and engineers do not allow themselves to be adapted elastically* to momentary needs but require a prolonged period of *time* so that they have to be secured *long before the need arises* by means of *long-range* planning.

c) The socio-economic change arising from the rapid development of technology also demands *a new approach and new patterns of behaviour by scientific workers.*

They are burdened by a host of new tasks, such as increased participation in some of the important organs of government, various schemes of co-operation, management functions in industry, high-level training programs for higher education, assistance in raising the general level of education** and the fulfillment of yet a host of smaller or larger tasks. The problems and tasks that arise are, moreover, *becoming ever more complex*. The integration of science and technology that has now followed its differentiation demands *the application of several approaches* and it is therefore necessary to take decisions, especially over some of the complex problems of research and of industry, *in close co-operation between scientists, engineers, mathematicians and economists* and through properly harmonizing their various points of view to avoid the possible damage caused by a unilateral approach.

* I. W. Feiss, who has already been cited, declares with chagrin of American conditions in this respect: "However surprising it sounds, teachers of mathematics and chemistry must sooner or later attain the salaries of football and basket-ball coaches, if we are to attempt to raise the standards of scientific training."

** I. W. Feiss, the American author who has been quoted, cites the panic caused in America by the story of the "flying saucers" as a characteristic example of the superstition of the masses, and, what is tantamount, the low level of their general education. This he attributes to the failure of men of science to *raise the general level of education of the masses.*

The assimilation of this new approach and new outlook in respect to the new and multiple tasks is not easy for the men of science, whom the transcending love of the field they have chosen as a vocation, frequently *prejudices* in favour of their own discipline. This prejudice is meritorius in that it spurs the scientist to live for the advancement of his branch of science, sparing neither time nor effort, but it *becomes a grave error* if he refuses, over the questions of the organisation of science, or of industrial, political and economic problems raised by everyday life, to see anything that is more important and urgent than his own discipline. This *narrow specialist's approach* to the important matters of scientific, industrial or economic policies that arise, is especially harmful in a socialist system, where the costs of a possible error are paid not by an individual boss (an entrepreneur or institution) but by the whole people.

d) The dynamics of the scale effect concern mainly the applicability of the *results of research* and also the economicalness of the expenditure necessary for large-scale realization. The study of the dynamics of the scale effect at the proper *time and place* is therefore also important in respect to economic considerations. The first in Hungary scientifically to examine the gnoseological, technological and economic significance of this problem has been Korach.* He points out that the *magnitude of the scale* has a definite *geometrical significance* and by *scale effect* in general he means the *change* that takes place when, if the scale (order of magnitude) *is changed beyond a certain limit*, physical, and chemical parameters arise that can be neglected *this side of the limit*, or that beyond a certain value of the scale the parameters *may show an abrupt change.*

The importance of the geometrical scale effect — as opposed to the importance of the scale effects of other parameters — is particularly important because it is not a matter for indifference either from the technical or the *economic* point of view to find out what consequences an increase in the dimensions of some piece of equipment may have. *Costs increase with increasing dimensions of equipment* and the proper functioning of the equipment is also the more important economically, the higher its costs were.

The scale effect may, however, have to be considered not only in the transition from a smaller to larger scale, but also in the reverse case, when something that has proved a failure in small-scale experiments, may succeed on a larger scale.

The theory of knowledge should, therefore, clarify the problem which arises in connection with the general consequences of the scale effect, *i. e.* how changes in the dimensions of *geometrically* similar equipment modify the various other parameters.

* M. Korach: „Über den Maßstabeffekt in der chemischen Technologie." Acta Chimica, 20, 345 (1959).

Mosonyi* points out that in hydraulics geometrical similarity does not even imply physical similarity, and this is even less probable — according to Korach — in the case of physical and chemical similarities in chemical technology.

This fundamental fact must also be considered in its *economic implications*, for if neglected it may lead to the undertaking of the burden of illconsidered investments.

The importance of the problem for *design* is also very great. Many designers work in the belief that geometrical similarity also provides adequate *safeguards* in a transition to larger dimensions and do not notice that one of the essential features of the scale effect is precisely the leap from quantitative to qualitative change. According to other designers however, even the *method of gradual approximations* (laboratory experiments, pilot plant and full-scale experiments) cannot provide adequate *safeguards* so that in the last resort the degree of utility of a piece of equipment can only be decided in the course of large-sclae production. Korach correctly points out that *instead of safeguards, we should speak of probability* and this is certain to grow with the method of gradual approximation. Intermediate grades, however, generally increase costs so that it is a matter for *economic consideration* to decide which is the more satisfactory: to *spend more time on setting a plant into operation, with fewer experiments* or a shorter set-up time with more experiments.

Finally — to quote Korach's words — the corpses of innumerable badly designed and thus unsuccessful plants litter the battle fields of the history of technology, despite all the care that has been taken. The reason has been the lack of development of applied scientific and technological methods, not least, an insufficient appreciation of the scale effect.

It is a long way from the final reports on a "successfully" completed research project to large-scale production, making use of the results of a piece of research and the road to the hell of bungled plants is not infrequently paved with the application of the "sterile ideas" of enthusiastic research workers. In a study of the changes in the dynamic factors of research requirements it is *therefore worth while dealing with the consequences of changes in scale effects*, even to an extent that may at first sight appear beyond that warranted by the significance of the subject.

The following main results of the qualitative analysis of the various categories and dynamic factors of research requirements may be used as first informative approximations in planning the distribution in the people's economy of the material expenditure intended for research:

* E. Mosonyi: A méretarány szerepe a kisminta kísérletezésben (The rôle of the scale in experiments on models.) Az Építőipari és Közlekedési Műszaki Egyetem Tudományos Ülésszakának Előadásai 1955. nov. 11—12. Tankönyvkiadó, Budapest 1957, p. 115.

1. The designation for development of various sectors of industry *belonging to different categories in respect to their research requirements* gives a first rough approximation of the distribution of the planned total of research expenditure, according as the various sectors ear-marked for development have absolute, potential or relative research requirements, moreover according to the expenditure need of the development of each of the sectors with relative research requirements and their *total* needs compared to the expenditure needs of the sectors with absolute and potential research requirements. The figures also give a rough idea of the extent to which the satisfaction of qualitative research requirements is justified, if appropriate proportions are to be maintened.

2. *The dynamics of the characteristics of the technical world level* may help to improve two ratios that are also important to the people's economy, on the one hand by marking out the appropriate limits for research, documentary or adaptation work (the adaptation of patents, and products processes) on the other by outlining the volume and fields of research activity, while also affording an opportunity for drawing some conclusions with regard to the appropriate proportions of the necessary research work to be concerned with fundamental scientific, and with industrial research.

3. A thorough, scientific investigation of the dynamics of *production, manufacturing and processing technologies* may mainly afford useful information to those preparing *long-range research plans* in *determining the main research problems of the plan*, while by setting up the *best order for applying the various technologies* it provides information on their research requirements and also the approximate order of magnitude of the necessary expenditure.

4. The careful *preliminary* investigation of *the dynamics of the scale effect* in the course of various research projects also provides information on the methods and cost of the large-scale realization of a laboratory experiment and on whether it appears more economical to increase the number of experiments and thus obtain results faster, or to take longer but save costs.

5. Finally statistical investigation of the *dynamic changes of the necessary labour force* for both the longer and the shorter periods can furnish useful material for the better and safer long-range planning of our manpower economy.

The consideration of the dynamic factors that have been discussed can, of course, only give *very rough* information on long-range research requirements and the problems of economic significance connected with them. In order correctly to assess long-range research requirements it is indispensible to have at least an approximate knowledge of the aims of the *long-range plans*, for without this the economic significance of the expected changes of the dynamic factors *cannot be comparatively measured* and there is *no real basis* for considering them in time. If to govern is equivalent to foresight, then the direction of research also requires a certain amount of foresight into the prospects of both technical and economic development. This foresight, and even more the *timely* deduction of the appropriate conclusions, is *only possible in a socialist planned economy*. It is obvious that in our age — this age of relatively swift technical and social changes — these long-range projects for the future need *correction nearly every year*, but there is a great difference in the economic consequences, too, between a situation where *there is something to change* and correct, and where for its lack the harmful and burdensome consequences of annual improvisations have to be borne.

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