TECHNOLOGY, WORK ORGANIZATION AND INDUSTRIAL WORK

How a narrow approach to technological advances leads to contradictory findings in social research

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There is little doubt that technological progress has its effects felt, but these effects are an often debated question. The above statement encapsulates the effects of technological progress[1] on work content, working conditions, and the physical circumstances of work in industry, on the basis of contradictory, often diametrically opposed scientific findings. This is not a "neutral" scientific question but one that possesses outstanding political and ideological significance. It brings into question the entire outlook of the working class: what it was like in the past, what it is like at present, and how it will appear in the future. That is why the discussion often exceeds the boundaries of science, and unbiased, objective scientific arguments are thrust into the background by emotions, political and ideological passions; the rational description of the existing realities is obscured by the formulation of a longing for the past, and by expectations concerning the future. As regards the contradictory—at times pessimistic, at times brightly optimistic—views, we cite only one or two well-known examples as illustrations. There is widespread anxiety that technological progress will claim as its victims some of the most highly valued types of industrial work.

Among these victims we could include jobs (mostly in the steel industry, metallurgy, and mining) which have been characterized by the collective undertaking of dangers, the essential necessity of joint efforts, representing the grounds for a high morale and the means of forging strong feelings of collectivity among the workers. The labour movement, it is said, is indebted to such industrial work for its most disciplined, best organized units. There is similar anguish felt about losing traditional industrial work that can be traced back to the medieval guilds, the main characteristics of which are craftsmanship, delicacy, subtlety, a superior knowledge of the whole of technology and individual attention to each item, as well as a highly trained work force. At the same time, we are witnessing the appearance of expectations and dreams concerning the future: the place of dirty, noisy workshops, of jobs often harmful to the health, will be taken over by clean and pleasant factories; workers who are nowadays often uneducated, uncultured and poorly qualified, will be replaced by highly qualified engineers—the workers of the future—who will get rid of not only the unpleasant working conditions and hard physical labour, but their duties will also lose the often routine, primitive, and monotonous character of present-day industrial work and will carry out non-routine, autonomous, independent production tasks requiring a highly qualified staff.

In debating the effects of technological progress on industrial work, the participants put forward various arguments: all of them seem to find their conclusive facts in reality, they quote the examples of this or that workshop, or collective of workers, which "best" represent the consequences of technological progress. In the present paper we have no intention of strengthening the trenches of either the "optimistic" or the "pessimistic" side in this debate; in fact, we do not intend to develop and put forward any point of view regarding the nature of the effects of technological progress in industry on work content, working conditions, etc. Instead, we would like to get to the roots—not so much the political, ideological, but rather the scientific origins—of the discussion. When we face contradictory or even diametrically opposed scientific views in a discussion, there can always be a suspicion that the contradictory, opposing results, as it has often happened in many scientific debates, prove to be of a complementary nature after all, i.e. their seemingly contradictory nature can be due simply to the differing frames of their reference. To quote the well-known story of the blind Hindus: they try to judge the nature of the elephant alternately by its body, legs, trunk, ears, etc. In the case of technological progress, such an attitude is obviously encouraged by the commonplace fact that it has a complicated and differentiated nature; it is a contradictory phenomenon in itself, and it is not and cannot be followed by the transformation—enrichment or impoverishment—of industrial work as a linear and unambigous trend.

As to the effects by technological progress on industrial work, most scientific misunderstanding originates from the fact that the basic question of "what we are speaking about" is not made clear. Industrial work is a very complicated concept (especially if working conditions and the physical circumstances of the job are also included in it). It has numerous aspects, the changes of which are not equivalent with the transformation of the whole nature of industrial work. Thus a scientific description from a narrower point of view, concentrating on one or two aspects of work, often comes into sharp conflict with another picture of similarly narrow nature. It is also difficult to face the complexity of technological progress: there is the danger in this respect as well that a scientific approach will insist on one or two sides of this many-sided process, will declare them to be the most important ones, while neglecting others of similar importance, finally giving a distorted picture of the whole of technological progress. The present contradictory scientific views often stem from the inadequacies of scientific approach and analysis. It often happens that scientific research bites off more than it can chew, its generalizations exceed the limits of empirical evidence, the simplification of the conclusions go far beyond the desirable limits, as it is not rare in the case of scientific analysis carried out under considerable political and ideological pressure.

The alternative approaches of the technical and social sciences

A central problem in all scientific discussions on the social and humane consequences of technological progress is the interpretation of the concept of technology. Almost every scientist represents an individual interpretation and approach. This chaotic situation, which probably plays a central role in the existence of the often contradictory scientific views on the question, is well manifested in the great number of the existing, recognized and used technological development scales and classifications. A starting problem for each investigation is to choose an appropriate approach to technology and technological progress, and to select a scale, a way of classification to distinguish the differing stages of its development. This choice to a great extent predetermines the whole of the further process of the research.

By the nature of the scientific approach we can distinguish two main types among the interpretations of the concept of technology, and two main ways of classifying the stages of its progress. The first is pursued by *the technical sciences,* while the latter is characteristic of *the social sciences.*

As regards the approach of the technical sciences (e.g. engineering), it is concentrated on the "man-machine relationship" and classifies the stages of technological progress according to the levels of the *mechanization of the direct and indirect production activities,* i.e. on the basis of the advancement of machinery, production of equipment. This is a highly suitable approach for the treatment of technical and technological problems (and some questions of work organization) which is indeed its basic function. A characteristic and well-known example for such an approach is that of *Bright.* He constructed a much used 17-point technological scale which has as one extreme manual work, or work done by other parts of the body (e.g. glass-blowing, manual wrapping, etc.), while as the other extreme both the direction of the work process is determined, and the required regulation is carried out, by the machine (examples for such machinery are space rockets that automatically correct the path of their flight; there are developments in this direction in the oil industry, in the field of automated refineries).[2] As to the essence of the approach, there is very little difference between Bright and the 11-point scale of *Auerhan.* He also places manual work and work with hand-operated tools at one end of his scale, while the other end —representing the most developed technology—is taken by automated machinery which "solve not only the technical, but also the economic control of the production process".[3]

In order to increase the comparability of the technological stages described by the various technological development scales, *Ulrich* made an analysis of their interrelations. As a result, he also constructed a new and very simple technological scale which distinguished only four major stages of technological progress. All the more refined stages in other technological scales examined by Ulrich can be fitted into one of his four stages. The dividing lines between the degrees of development in technological progress in his approach are as follows: the end of man's function: (1) as an energy supplying engine, (2) as a machine tool, (3) as a controlling, measuring and switching mechanism, and (4) as an optimizing mechanism.[4] The various levels of technological progress distinguished by the technical sciences pose differing physical and mental requirements for the workers. Given full knowledge of the characteristics of the various stages, these requirements can be formulated with great exactness.[5]

Thus, technological classifications and scales developed by the technical sciences supply us with information of great importance about the effects of the development of machinery and technological processes on a few significant features of work content.

Examples for approaches in social science

The approach of the social sciences, by their very nature, is basically different: it is not restricted to the investigation of the "man-machine relationship", but is concentrated on the general features of the entirety of the system of production (including, among others, the characteristics of work organization) and tries to give a broader picture of the transformation of work and working conditions as a consequence of technological progress. As a result, the distinctions made by the social sciences of various levels of technological development lacks the precision of those worked out by the technical sciences and thus they are not suitable for solving the everyday problems of technology and work organization. While the technical sciences describe one (although very important) side of the phenomenon, the social sciences try to approach it from many angles.

This broader approach sometimes leads to such extreme methodological solutions as that followed, for example, by *Hickson* and his colleagues: while investigating relations between technology and organizational structure, they renounced working out preliminary criteria for classification, and tried instead to select a group of criteria by factor analysing their empirical data and distinguishing technological stages on that basis. Thus, various types of technology are described by Hickson and his colleagues by the obscure criterion of "work-flow integration".[6] *Woodward* has constructed a less bizarre technological classification; in fact, her well-known "technical complexity scale" is a clear and good example of the social sciences' approach. In her description, single unit or small batch production to the customers' individual demands represents the oldest and simplest way of production, while the most developed type of technology is the automated continuous-flow production process of so-called dimensional goods (chemicals, etc.). Between the two extremes can be found the mass production of standardized goods (e.g. automobiles, television sets, etc.). Woodward states that progress from one stage of technological development to the next makes man more and more capable of predicting the results of his production activities and of controlling the physical limits of production.[7] *Perrow's* approach is similar in essence to that of Woodward: he keeps to the "routineness of work" as a classifying criterion and suggests the "folding" of the original Woodward scale so that one extreme could be represented by assembly production, a characteristic type of mass production (Woodward's middle stage), and the other extreme could be traditional single unit or batch production and automated continuous-flow production. Although this scale does not properly reflect the historical process of technological progress (in fact it contradicts it), it seems to sum up the transformation of industrial work in connection with technology in terms of routineness very well.[8] The assembly line in fact represents an extreme phenomenon in industrial work; its short-cycle work tasks, the unceasing repetition of simple work operations, result in a very high level of monotony and routineness,[9] while, on the other hand, the individual attention and craftsmanship in single-unit or batch production to individual demand, or the complexity and delicacy of jobs in continuous-flow production, allow very little routineness.

The investigations and arguments of Woodward, Perrow—but also those of *Naville, Touraine*[10] and others—give goods examples of the approach of the social sciences; by its very nature, this approach does not restrict itself to the investigation of "man-machine relationship" in interpreting the transformation of the content of industrial work, but it endeavours to carry out this task by considering the general features of the changes in the whole system of production. That is why classifications used by social scientists are not technological scales in the real technical sense of the term, but descriptions of the major historical periods of technological progress. That is why they can give a picture about the transformation of the content of industrial jobs not only in the narrow terms of mental and physical requirements, but also in such wider concepts as variety, responsibility, autonomy, routineness and the like.

The system of production as a target of research

If we concentrate on the system of production, our analysis should take into consideration not only direct production activities (control of the machines and equipment), but also such very important indirect ones as the supply of material, the moving of the product (that is, transport within the workshop), the supply of tools, the maintenance of machines, and the like. Such indirect activities are often neglected in the description of technological progress. (This situation was referred to by Bright, when he pointed to the illusions of society as to the existing level of automation. He stated that automation cannot be viewed as the automation of direct production *only*.) Both a realistic technical and a social scientific approach exceed the narrow limits of direct production. Description by the social sciences, however, goes even further. It also goes beyond the invisible threshold which separates the technical and social sides of production and tries to consider these two things in their interrelations as they exist in reality. Thus the approach of social sciences covers, among others, also the problems of work organization, which is not merely a technical, but also a social problem; it goes as far as the characteristics of wage construction, incentive systems, the methods of supervision and control in the workshop, and the like.

The social science research approach is concentrated on the system of production as a socio-technical system. The essence of this approach (which can be connected, among others, with the Tavistock Institute and the sociological school represented by Emery, Trist, Thorsrud and others) makes a distinction between the technical, technological and social sides of the production process; these two sides, however, are closely connected and interrelated; in industrial organization each problem can be interpreted, each target can be formulated and achieved only on the basis of a joint consideration of the technological and social aspects and their interrelations (joint optimization).[11] Such an approach means, from the point of view of our topic, the necessity of widening the narrow "man-machine relationship" and substituting for this narrow view the investigation of the "man—production system relationship". The narrow ergonomic approach contradicts the very nature of analysis by the social sciences.

It should be noticed that the technical and the social sciences apply two different ways of description to the same reality: one of them is more concrete and narrower, while the other is wider, but consequently less concrete. Because of their close connection, it is sometimes difficult even to draw a dividing line between them. The approach of the technical sciences, which since Taylor has become traditional in industrial engineering, endeavours to consider also the "human aspects" of the problems and thus to surmount its "narrow" technical limits. The approach by the social sciences, on the other hand, is based on knowledge supplied by the technical sciences. Because of the basically technical nature of the problem, no workable social scientific approach, classification, or scale of technological progress can be constructed without relying on the results of the technical sciences. This dependence at the same time explains the negative features of certain projects in the social sciences which, even in the investigation of basically social problems cannot rise above the concreteness and narrowness of the technical approach.

A wrong approach leads to contradictory results

Our paper attempts to prove that the transformation of the content of industrial work as a consequence of technological progress cannot be investigated and described entirely on the basis of a narrow approach to technology, because this will produce contradictory results. Most contradictions in scientific evaluations concerning the effects of technological progress are due to the choice of the wrong approach. Research workers in the social sciences should try to apply a wider approach, which is—as we have argued—that of the social sciences. For proof of this statement, we rely on the material of the research projects that we have carried out in the past few years in Hungary[12] and on problems that have occurred in the realization of the "Automation and the Industrial Worker" project in Hungary.[13]

The "Automation and the Industrial Worker" project, whose target is to describe the social consequences of the use of automated and non-automated units in the automotive and steel industries, originally applied a technological scale and classification which concentrated on the "man-machine relationship"; that is, one whose approach to technology was basically of a technical (and not a social) scientific nature. This technological scale, which in fact represented an adaptation of the approach by Bright, Auerhan and others for machine tools and automation in manufacturing industry, measured the level of mechanization of direct production activities. Firstly, it broke down the job (operating the machine tool) into part-activities like feeding, positioning, fastening the workpiece, selecting, setting tool, moving it into working position, starting the machining process, and so on. Secondly, each part-activity was qualified as to the level of its mechanization, i.e. whether it was done manually or by the machine with human assistance or by the machine without human assistance. With the help of such a scientifically grounded technological scale, a clear distinction could be made between automated, semi-automated and non-automated (traditional) machine tools and the jobs based on them in the automotive industry. In the case of automated machinery the majority of activities were obviously done "by the machine without human assistance", that is, the worker mostly fed in the material, removed the product and had a supervisory and control function over the process; in the case of a traditional machine tool, on the other hand, the majority of the activities would be done "manually". It is easy to demonstrate that work on an automated transfer line differs greatly from operating a traditional lathe, and probably the mental and physical requirements of the two jobs also show certain differences.

But what is work on a traditional machine tool like? As regards this question, our investigations have supplied contradictory information. But similar contradictions have been found in connection with the so-called automated jobs, too. In some cases, jobs on traditional machine tools could be characterized by high mental requirements, variety, responsibility, autonomy and independence. In other cases, jobs with the same machinery proved to be simple, semi-skilled routine tasks of a monotonous nature, lacking autonomy and independence.[14] Thus, in our own research project we were faced with the same type of contradictions and almost diametrically opposing facts, which frequently come up in discussions about the effects of technological progress on industrial work and which we cited in the introduction to the present paper. In this rather embarrassing situation, we decided to think over the theoretical and methodological bases of our project once again, and we found that such elements in the content of work as variety, responsibility, autonomy, independence, and the like cannot be investigated and interpreted by considering only the level of mechanization of direct production activities. In other words, the original approach of the project to technology, borrowed from the technical sciences, proved to be unsatisfactory: the level of mechanization was only one, and perhaps not even the most important, among the factors of technological progress influencing work content.

Let us look at an example. A multi-purpose, manually controlled turret lathe at all times and in all places represents the same level of technological development, if it is defined in terms of the mechanization of the production activities carried out on it. Yet, operator jobs on the same traditional turret lathe can be as different as chalk from cheese. The lathe-operator can be engaged in single-unit production; he does not manufacture even two identical pieces, his tasks change from product to product, he relies to a great extent on technical drawings, he has to change the setting of his machine several times a day. His work is consequently varied, interesting and autonomous. As his tasks cannot be standardized, he gets a daily rate of pay, he is not pressed by the speed of others, etc. But the operator *on an identical machine* can be engaged in short cycle, repeated work tasks that do not change for weeks or even months; he is deprived even of the duty of setting his machine, since this is done by a set-up-man, the piece to be machined comes to him directly from the machine doing the previous operation and is also taken directly to another machine doing the following operation. Consequently, the speed of his activities is to a great extent fixed, he is a semi-skilled worker, working in a piece-rate system, his job is of a routine, monotonous nature. Although the two examples quoted represent extreme types, they are not fictitious.

The differences in the content of work described above cannot be attributed to differences in the technological level of machinery; in the two cases the "man-machine relationship" is the same. There are very significant differences, however, in the "man—production system relationship". In the first case the machine and man are part of a workshop in single-unit production (e.g. a workshop producing prototypes, a maintenance or repair shop and the like), while in the second case they belong to a unit, where large batch production or perhaps even mass production takes place. It is a well-known fact in industry that traditional machines—because of both technological and economic considerations—are often used for large batch and mass production, too. The technological scales constructed for the purposes of the technical sciences are mostly unsuitable for describing such characteristics of the production system as the volume of production and the like. Traditional turret lathes, for example, in both the above cases can be included in the fourth degree of the Bright scale ("manually controlled machine") and in the third degree of the Auerhan scale ("one-purpose, multi-purpose and universal machines"). The approach by the social sciences, on the other hand, sharply underlines the differences in the production systems: on Woodward's technical complexity scale, single-unit or batch production is one of the extreme points, mass production is the middle point, while Perrow puts the two cases described on the two opposing extreme points of his scale, which is perfectly justified as he concentrates on the routineness of the job.[15]

In order to describe the transformation of definite industrial jobs (e.g. lathe operator, welder, etc.), we have to rely on the consideration of the features of the production system. This is, however, only one of the motivating factors of our insistance on the system of production. There is also a second reason for this. It is obvious that technological progress has its effects felt not only by changes in the content of definite jobs, but also by modifying the general pattern of industrial jobs: it increases the relative importance of some jobs, decreases that of others, and it often happens that some types of jobs even cease to exist, while others only come into existence as a result of technological progress. The substitution of traditional machine tools by automated transfer lines modifies not only the content of the operator jobs, but it also changes the relative importance and ratios of the operators, maintenance-men and set-up-men. In investigating the influence exerted by technological progress on industrial work, we cannot restrict ourselves to the analysis of changes in definite sets of jobs with identical names. The structure and composition of the totality of the whole of the jobs connected with the given system of production should be investigated. By concentrating on changes in the content of definite jobs, we once again run the risk of getting one-sided or contradictory results: it is general experience, for example, that skilled machine operators are replaced by semi-skilled labour as technology develops; thus, technological progress seems to impoverish these specific types of jobs. But it is also noticed—as, for example, Touraine[16] points out—that the importance of skilled maintenance people increases, while simultaneously that of unskilled assistants decreases. Thus the effects of technological progress are contradictory in themselves, some minuses on one side are usually counterbalanced by pluses on the other. To include both sides in our analysis makes it necessary, however, to use a wider approach. The practical solution for that is to cover all those jobs in our investigation which are connected with the manufacturing of the given type of product from start to finish.[17]

Work organization and the content of industrial work

In a scientific approach which concentrates on the system of production, work organization is given great emphasis: it has to be established again and again that the content, requirements and conditions of the workers' jobs are determined by the characteristics of work organization to such an extent that it often exceeds in importance even the level of development of the machinery and equipment, and of the mechanization or even automation of production activities. A major conclusion of the "Automation and the Industrial Worker" project has been that the nature of work organization has such a considerable influence (compared to that of automation) that it should certainly be taken into account, otherwise the separate measurement of the effects of automation will prove to be impossible.[18] It is probably not an exaggeration to say that the social consequences of contemporary technology cannot be investigated or described without paying proper attention to work organization.

A basic difference between the approaches and technological classifications by the technical and the social sciences is that the former integrate in themselves a consideration of work organization, while the latter do not. (This situation does not contradict the fact, however, that industrial engineering analyses work organization in detail for other purposes.)[19]

How can work organization be investigated? Without making any attempt to give a full description, two of its most important aspects should be emphasized. Consideration of great importance in work organization seems to be the *volume of production,* as is obvious from the approach and results of Woodward, Perrow, Touraine and other social scientists. In this respect, distinctions are usually made among single-unit, small-batch, large-batch and mass production. The most significant difference between the two extremes is that *single-unit production* is carried out at individual customers' demand, according to individual specifications, and consequently work tasks, at least in principle, are not repeated: *mass production,* on the other hand, embodies the manufacturing of standardized goods under standardized conditions for longer periods of time (in the automotive industry it mostly means several months), thus work tasks are constantly repeated. Mass production and standardization made it possible to work out types of work organization which are characterized by a high level of specialization, by the breaking down of work tasks into narrow parts, as is typical in the case of assembly lines in automotive industry, used for the first time some sixty years ago by Ford. It is probably unnecessary to underline the importance of the volume of production as compared to that of mechanization and automation, from the aspect of the content of industrial work. Let us add one more illustrative example to our arguments so far: as regards the level of the mechanization of the production activities, the ill-famed short-cycle, overspecialized jobs on the assembly line and the job (which one could also call art) of the goldsmith fall into the same category, as both are done "manually or by simple tools". The difference between them from the aspect of the volume of production is that the goldsmith is engaged in typical single-unit production, while the assembly line worker is engaged in mass production.

Another important aspect of work organization, at least in the engineering industry, is the pattern of the organization of the production process, i.e. its non-flow or flow character. In the case of *non-flow production,* the machining is carried out on a larger number of pieces, operation by operation; that is, the organization of the work process is concentrated on individual operations and machines. In a workshop organized according to this traditional pattern, the machine tools are located in homogeneous groups (that is, lathes are put in one group, boring machines in another group, etc.); thus the location of the machinery has nothing to do with the sequence of operations on a certain product. It often happens that pieces are subjected to operations by one machine only, or by a minority of the machines, and they always leave the workshop without having been touched by most of the machines. In the case of *flow production,* on the other hand, organization is focused on a set of operations and machines connected with the same product or with a small group of products. The location of the machinery follows, more or less strictly, the sequence of operations on the piece. The product goes through most or all machines in the course of manufacture. In this pattern of organization, and by its very nature, the individual machines are connected by transport equipment, as exemplified by the production lines in the automotive industry. Lines can be *flexible or rigid.* In the first case stocks (puffers) of pieces can be established between two machines in the line, or the sequence of operations can be changed to some extent. In the second case operations by the individual machines are closely linked: the second machine can start working only when the first machine has finished: no puffers can be established, no changes in the sequence of operations can be realized. A typical example of rigid flow production is an automated transfer line. It should be noted that assembly lines also represent flow production and they can be organized in both flexible and rigid ways.

As regards the content of work, the pattern of organization of the work process seems to influence many aspects of industrial work: it affects various constraints, the time pressure on the worker, his dependence on other people, the autonomy of his job, his freedom to take decisions, and the like. It does not require a lengthy discussion of this problem to enable one to point out that in the case of traditional non-flow production the worker has considerable autonomy and independence. He receives material in cases and pieces which are removed from him in the same way, he is practically isolated, in the work process from the rest of the people, he has control over his own speed of work, etc.; in flow production, especially in its rigid type, the independence and autonomy of the people seem to be considerably less, the worker and his job are part of a strictly regulated and coordinated system. It should be emphasized, moreover, that the pattern of work organization has direct social consequences, it is closely connected with such qualities of the work as its individual or collective nature, and it determines the manner of supervision and motivation as well. In non-flow production the rational system of motivation is based on the individual (traditionally it is an individual piece-rate system) and in flow production it is based on the group (in Hungary it is mostly a group piece-rate system).

Work organization—the volume of production, the pattern of organization of the work-process—are not independent from the level of development of mechanization and automation.[20] An automated transfer line in the machine industry is synonymous with mass production and flow production from the point of view of work organization. Nowadays it would seem to be nonsensical and hardly possible to use automated machinery in the machine industry for single-unit production. This relationship at other levels of mechanization and automation, however, is not as close and unambiguous. Traditional machine tools, as has been pointed out, can take part in single-unit, small-batch, large-batch or even mass production, and can be parts of either non-flow or flow production. Some limited variations can occur in the case of semi-automated and automated machinery as well: the rigidity of automated production lines, for example, is often loosened up to exclude some negative side-effects of rigid organization: they are made suitable for the storage of stocks, or puffers at some points.[21] While mechanization, automation and work organization are closely connected, there are many fields in which their relationship and their mutual dependence are far from strict and direct. As a result, machinery and equipment at the same level of development can function in very many types of work organization.

The various types of work organization enumerated above (and even slight variations within the framework of these rough categories) can have a considerable impact on the content of work. This fact provides the basis for the experiments carried out by a number of companies of international reputation whose aim is to reduce the monotony of the jobs by having their workers learn several jobs and by providing a possibility for systematic or occasional job-rotation. A similar experiment in the automotive industry involves the elimination of the traditional assembly line and its substitution by a new type of work organization which possesses some of the features of the traditional workshops and thereby gives more autonomous, less dependent, more interesting and wider jobs for the workers than the short-cycle, repeated, monotonous activities they had before.[22] The success of such experiments underlines work organization once again as a factor of primary importance in influencing work content. Among experiments directed at the transformation of work organization there are even some which concentrate on such problems of direct social relevance as wage systems.[23]

Conclusions

We hope that the present paper has succeeded in throwing light on some obscure aspects of this topic and will contribute to a better understanding of the relations between technological progress and the transformation of industrial work. If this is so we have come closer to a realistic evaluation of the often contradictory or diametrically opposite scientific results, political and ideological standpoints, which emerge daily in discussions about the social effects of the scientific-technological revolution. Our conclusions are strictly of a methodological character. They refer exclusively to the methods of scientific approach and do not try to provide answers to the questions discussed. Although we have cited some examples to illustrate our arguments from industrial reality, we have no intention of taking up any position on the question of whether the actual influence of technological progress on industrial work is "positive" or "negative" and its prospects are "bright" or "gloomy". Our methodological conclusions, which now seem to be self-evident, are as follows:

The development of machinery and equipment in manufacturing has been accompanied by other changes in the environment of work, primarily the transformation of work organization. The various levels of mechanization and automation are today in some cases closely connected with specific types of work organization, but in other cases this relationship is fairly loose. Work organization seems to influence work content to a considerable extent, even slight changes in it often bring about radical changes in the requirements of jobs. That is why changes with definite purposes (job enrichment, job enlargement) are possible and justified in work organization.

The character of technological progress, the way in which it makes its effects felt, makes all narrow concepts and approaches to technology unsatisfactory for the proper investigation of factors in the transformation of industrial work. Approaches related to one or two aspects of technological progress (to the level of mechanization of production activities, for example), if used for giving a general description of the phenomenon discussed, will lead to contradictory scientific results. These approaches can produce valuable results concerning one or two aspects of technological progress and a limited section of its effects (e.g. changes in the mental and physical requirements of jobs) but such results cannot be generalized. The narrow approach of the technical sciences, which neglect social aspects (work organization, wage systems, relations among workers, and between workers and supervisors) cannot be successful. But similarly the approach of the social sciences will also be a failure it if is not based on a proper description by the technical sciences of the stages of the development of technology. The approach by the social sciences cannot be an alternative to that of the technical sciences; rather it is a method of investigation of a different nature, the main quality of which is its concentration on social phenomena.

The various aspects of technological progress, including work organization, seem to influence differing aspects of work content and requirements: the process of the mechanization of production activities seems to have a connection with changes in the structure of mental and physical requirements; while moving from single-unit to mass production seems to modify routineness, and switching over from non-flow production seems to touch autonomy and independence, although these changes are naturally overlapping and interrelated. This emphasizes the necessity of investigating work content, as well as technological progress and the relations between them with an approach that is as wide and as differentiated as possible. The differentiation of our approach should reflect that of the object of investigation. One can never rely on the preliminary assumption that one's concept of technology or work is well founded; it is always necessary to check whether our approach and scales are correct and appropriate for the purpose of our enterprise; only in such a way, by the careful consideration of individual cases, can we loosen up the natural rigidity of our concepts.

It is not, perhaps, an exaggeration to say that the existence of most contradictory, opposing scientific views about changes in industrial work brought about by technological progress can be attributed to methodological insufficiences in social research. Of course social research can be blamed only for committing methodological mistakes. The long survival and prosperity of such insufficiencies and the illusions based on them stem from the emotions, interests and ideologies of certain social groups. Social research and researchers are also responsible for the over-generalization of their results, which is another methodological mistake. But if research results are basically sound, their seemingly existing contradictions are often of a superficial nature: if the limits of their generalizations are properly set, they may prove to be justified and of a complementary character. The present paper gives many examples illustrating that seemingly homogeneous technological levels are not homogeneous at all if investigated from other viewpoints. Thus the complexity and contradictions in research results reflect, after all, the complexity and contradictions of real life.

Although we have avoided making judgements about the way in which technological progress exercises an influence over work, it seems to be necessary to make some—still methodological—remarks as to the essence of this matter. In the light of our knowledge about the complexity of both technology and work, it seems to be a naive scientific attempt to try to force the impact of technology into the extremely narrow limits of the concepts "negative" and "positive". It is quite obvious that the problem of whether technological progress is a "benefaction or curse for mankind" is not only naive and superficial, but it also represented an undesirable over-simplification of the problem, and has nothing to do with scientific research. The duty of scientific analysis, in our opinion, is to give a differentiated picture concerning the changes, trying to find out what their advantages and disadvantages are and how the profits of this progess can be maximized at minimum costs. It is obvious that even if the long-range effects of technological progress on work are basically favourable, we also have to face serious costs and losses that must be compensated for as far as possible.

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[1] Because of the modest targets and narrow theoretical limits of the present paper we avoid the term "scientific-technological revolution" and restrict ourselves to discussing "technological progress in industry".

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[12] We have been carrying out research work for the Ministry of Technology, firstly in the machine industry and metallurgy, on the problem of workers' adaptation to up-to-date technology. See e. g.: Héthy, Lajos–Kulcsár, Kálmán–Makó, Csaba, *A munkaerő alkalmazkodása az új technikához* [The Adaptation of Labour Force to New Technology], OMFB. Budapest, 1974.

[13] This is a multinational comparative project which began and was coordinated by the Vienna Centre for Social Sciences.

[14] A part of our results have been published in: Héthy, L.–Makó, Cs., *Az automatizáció és a munkástudat* [Automation—What the Worker Thinks about It], studies of an international comparative research program entitled "Automation and the Industrial Worker", 2. Published by the Institute for Sociological Research of the Hungarian Academy of Science and the Centre for Scientific Research of the Central Council of Hungarian Trade Unions (SZOT).

[15] *Op. cit.*

[16] *Op. cit.*

[17] Because of the gradual development and manifold effects of technological progress in the automotive industry, the grounds of the statements above may not be so obvious for many people as they are in reality. The steel industry supplies us with more unambigous examples, of which let us take one: when traditional ingot casting is replaced by continuous casting (which represents a technologically more developed alternative to some extent), technological progress has its consequences felt not only in the transformation of definite jobs (such as that of casters), but also by the complete abolition of some very unpleasant, dirty and hard jobs, such as the preparation of chill-forms.

[18] Attention was first drawn to this question within the project by some of our research experiences: we found, as described in the present paper, considerable differences in the content of jobs on identical traditional machine tools in differing contexts of work organization. As a result, the theoretical and methodological framework of the project was modified.

[19] Page 24. The present paper relies on information by industrial engineering, too. See, e. g.: Héberger, Károly–Iliász, Dimitrisz–Kalászi, István–Rezek, Ödön–Tóth, István, *A gépgyártás technológiája. III. Tömeggyártás* [Machining Technologies. III. Mass Production]. Tankönyvkiadó, Budapest, 1967.

[20] Whether we consider work organization to be a component of technology (like the mechanization of production activities) or a separate thing remains a problem to be solved. Just as other social scientists like Woodward, Perrow, and others, we are in favour of the first solution.

[21] There are attempts at present to develop computer-controlled groups of machine tools which are suitable for either single-unit or batch production. Such experiments with so-called "computer integrated manufacturing systems" (CIMS) take place, for example, in the United States and in the GDR. (See Cook, Nathan H.: Computer-managed parts manufacture. *Scientific American*. February 1975.)

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