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Concerns and Orientations of Mathematical Applications in the Scientific Organization of Labour and Production*

Men's constant effort to deepen the knowledge of nature and society, to use its laws for the benefit of a multifarious progress, has led to an impressive proportion of a largely diversified material production.

The upsurge of economy and other branches of social life could not have been possible, had science not brought its efficient share in the transformation of nature and society.

Society development requires that scientific research should outrun production, thus accelerating technical progress in all fields. Owing to this peculiarity of our times, scientific research becomes one of the dynamic, essential factors to the permanent modernization of technics and production.

The general picture of contemporary science is extremely complex. It points out periodically the various trends of development affecting society evolution and strengthening the confidence in the possibilities of science to contribute to the creation of a better and more prosperous world. Under the impulse of the ever growing requirements of practice and, at the same time, following out its natural tendency of extending the limits of knowledge, science has registered during the last decades a continuous progress. Having considerably enlarged its application field, it has also enriched its arsenal of investigation methods. Nowadays, scientific research is carried on at an increasing rate, its material basis having reached industrial proportions. The number of research workers can be compared now to that of people engaged in other fields of activity. And practical application of the results obtained by scientific work becomes increasingly prompt too.

Science represents a huge material force, and this accounts for the particular care shown by the Romanian Communist Party to scientific research; for it plays a prominent part in the socialist construction process. The measures adopted last year, according to the resolutions of the IX-th Congress of the R.C.P., speak for themselves. They are meant to ensure a permanent improvement of the research organization and management, as well as to develop its material basis, increase the number of research

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workers and achieve their training; with a view to extend the share of our scientific research in the solution of a great number of problems raised by the progress of national economy, they tend to enlarge the contribution of our science to the world treasury of civilization.

Within the frame of the general progress of science, a remarkable advance — which is bound to keep going forward — was made by mathematics. Science history proves that, all along the development of civilization, mathematics has been a major concern of human thinking, being permanently connected to the unceasing progress of society. In all ages, from ancient till modern times, mathematics has served men's creative labour, has helped to enrich the material and spiritual patrimony of society.

The development of mathematical research, its great variety of fields, which have appeared this last century — is due, no doubt, to the fact that mathematical methods and mathematical results have been successfully used in almost every department of human activity. We are attending at present to a complex and intense process of mathematization of all branches of science. It would be difficult to find, nowadays, a scientific discipline where the means offered by mathematics to research workers were not employed, on a larger or more restricted scale. Mathematics has proved to be a highly efficient means, and the use of its methods has contributed to obtain resounding successes in the most varied branches of science.

But the sphere where mathematics, its methods and achievements are to be employed is much larger than that, overstepping by far the bounds of scientific research. Mathematics is today an instrument of great practical value, its applications being multifarious. This fact reflects an essential peculiarity of contemporary mathematics; from a science which for a long time had been considered as "pure" or, anyway, all too slightly connected to the objective reality, it has turned into a science with very wide practical implications, powerfully linked — by its themes and applications — to the process of men's material activity. Although marked as a most abstract science with a high degree of generalization, today mathematics cannot be conceived beyond its relations to life. Even its more abstract branches may offer some practical applications, quite unexpected sometimes. The great performances of human genius, such as the displacement of cosmic space rockets with men on board, the launching of artificial satellites of the Earth, the utilization of nuclear and solar energy, all these could not have been possible but for the aid of up-to-date mathematical and cybernetical methods, of cumputers of the highest precision.

What, in contemporary society, renders mathematics applicable to such a large extent is the fact that it substantially contributes to the solution of some very complex problems and the adoption of decision concerning material production — this determining field of social life. Together with the other branches of science, mathematics, by solving some current problems and by the methods it forwards, shares the general advance of economy, holding a central position in the carrying out of the present technical and scientific revolution. And the coming progress of technical and industrial activity will include, as one of its most important elements, the intensive utilization of mathematical methods.

The development of every economy branch and, mostly, of industry, in close connection with science, has led to a high technical level of pro-

duction. The ever greater requirements regarding the production volume growth, the increase of labour productivity, the constant improvement of the product quality, all of these constitute a series of complex problems for science to deal with. In order to solve them, science has evolved too, improving its methods and diversifying itself.

Some new scientific disciplines, which have appeared during the last decades, have made fast progresses, bringing about a revolution in engineering and, at the same time, changing altogether the very means of scientific research. Automatics, for instance. Using its results on a large scale has led to a complex automation of the production processes and a higher technical level, thus facilitating men's labour and becoming one of the main branches of science. It is rather difficult to have a proper quantitative estimate of the positive effects of automation; however, experts all over the world unanimously share the opinion that it would have taken much longer for industry to reach its actual level, had it not been for the substantial help of automatics means. Nowadays, electronics is a scientific discipline with almost universal applications. Being an essential factor in automation, its applications are particularly efficient where material production is concerned. In its turn, electronics has generated the apparition of other branches in science and engineering, such as the electronic computation technique. At present, electronic computation cannot be absent from the great automatized industrial production, of which it has become a component part. Electronic computers are now deeply involved in the production processes management, and there is no substitute for them. On the other hand, the radiotechnical methods for measurement, control and adjustment as well as the latest achievements in physics (such as the laser technique etc.) are being largely employed by modern industry.

Practical utilization of the results achieved by these new branches of science entails profound implications in the structural modification of industrial activity; it has already conditioned the rapid growth of labour productivity and the increasing volume of material goods. Contemporary production is marked by a high scientific level, the possibility to achieve—by applying scientific methods — the optimization of industrial processes.

One cannot overlook the fact that the successful results obtained in these various fields of science — either classic or newly appeared — as well as their intensive use in technics and economy, could not have been possible without the massive contribution of mathematics which, in the process of its larger and larger application, has developed itself. The multiple practical and theoretical problems raised by an extended automation have caused the apparition of mathematical methods for the analysis and synthesis of linear and non-linear automatic systems. In order to obtain the best parameters of complex automatized plants, in will be necessary to resort to the mathematical optimization methods. In reaching its present high level, the radioelectronic technique has been substantially helped by some specific mathematical means, such as: linear algebra, the topological theory of electric and electronic circuits, the electromagnetic field theory a.s.o. At the basis of the rapid successes scored by the electronic computation technique lays — besides the development of technology in the field of electronic devices — the utilization on a large scale of numerical analysis. In obtaining more complex electronic systems of automation and computation, under the most

favourable working conditions, the safety in operation theory is a most helpful means.

Thanks to mathematics, engineers and research workers have at their disposal the efficient method of mathematical model-making. This method opens new paths to the technological processes, to the analysis of the behaviour of certain products under different conditions, to the designing technique. Of course these few examples can hardly give a complete picture of the part played by mathematics in the development of modern engineering. This picture is particularly complex in the process of practical utilization of mathematics. A close interdependence is registered between mathematics and engineering, leading both to the enrichment of the arsenal of mathematical methods and to the progress of technical disciplines.

The tasks of socialist construction exact a permanent development of the economic science, its transformation into a means capable of expressing, quantitatively and qualitatively, and as accurately as possible, the characteristic features of economic phenomena and of the social production laws.

The qualitative side of socialist production must not be disregarded, but what life demands of economic science is a deeper concern for the quantitative side of the economic phenomena; a higher level in economic calculation and substantiation; the utilization, for this purpose, of mathematical methods and the computation technique. The quantitative relations of the economic phenomena and their degree of precision play an important part in social life. For that reason the economic management at all levels — the economic decisions — constitute a most important field of application of mathematical achievement.

Therefore, specialists in the utilization of mathematics in economics have focused their attention on the elaboration of certain mathematical methods for the drawing up of plans. Working out the balance of relations between branches, with its two models — static and dynamic — and their optimization by means of mathematical programming is one important concern of specialists and research workers.

The researches performed so far by economists, mathematicians and engineers show that the balance of the relations between branches may have multiple uses in social production management. On its basis, the development proportions of production in different economic branches may be precisely determined — starting from the objectives of increase and distribution of the social product.

Modern computers, ensuring rapid solution of economic models, covering a great number of equations, allow the elaboration, in different variants, of the plans regarding national economy and its branches, thus offering the possibilities to choose the more efficient ones.

Mathematical methods and up-to-date computation technique are substantially contributing, nowadays, to a thorough understanding of the social production phenomena and laws, as well as to the economic theory development. Allowing the concretization — numerical or by mathematical functions — of some important aspects of the economic phenomena, functionnally establishing the numerous interdependencies occurring in their development, model-making and computation technique enable us to know and forecast in due time the analyzed phenomenon evolution.

The mathematical methods for working out the plan by means of the balance of relations between branches thus prove to have a considerable theoretical importance in discovering the mechanism of the formation process of the socially necessary labour-time consumption and hence, of the value and price formation process. Although the economic and mathematical model of formation and quantitative expression of the socially necessary labour expenses in not entirely elaborated as yet, in the main, the interdependencies and relations between the labour expenses — expressed with the help of the mathematic model of the balance of relations between branches — nevertheless offer a rich material for a thorough understanding of the value law action mechanism, under socialist conditions.

If application of the mathematical and cybernetical methods, at the national economy level is so far still under investigation, at the level of enterprises economy and organization, a large variety of up-to-date mathematical methods are in use at present, most of them based on linear and dynamic programming. Thus, the mathematical linear programming models for optimum distribution of the production tasks at the labour places are fairly well-known in enterprises of very different types : the application of the mathematical programming method for establishing the optimum assortment of goods to be produced within different periods of time, a.s.o. The methods of the waiting-queues theory in the organization of equipment repairs, of the machine-tools adjustment and of the service at the labour place are widespread methods. Probabilistical and statistic methods are being used for determining both the safety stocks and the duration of certain operations for which technical time-quotas have not been established yet (as for instance is the case in certain stages of technical preparations for the assimilation of new products).

Enterprises have been employing for a long time mathematical statistics in order to check the production quality and the carrying out of the technological process, obtaining remarkable results both in reducing the amount of rejects and in ensuring preventive technical control.

If mechanization and automation of the technological processes have caused the production technique of our enterprises to advance, they have failed to prove equally successful as far as economic computation works and economic management are concerned. The creation, in enterprises, of a rational informative flow, and the utilization of mathematical methods meant to regulate the quantitative relations contained in that informative date, will permit the use of modern technique of working out and transmitting primary and resulting informative data (the taking of decisions included), thus ensuring the automation of management activity and correlating its level to that of the technological processes.

The setting up of this economic informative system, providing a complete and rational flow of information — at enterprise level as well as at higher levels — will allow the management of the entire economy now in progress according to the dynamic modifications; it will supply as well the necessary forecasting data for the elaboration of increasingly complex economic models, susceptible of being optimized by means of the electronic computation technique. These models will have to reflect the modifications undergone by primary data, the actual level of the achievements, their deviation from the production programme. Having such a feed-back channel,

from output to input, these models will be marked by a cybernetical characteristic.

The practical results obtained by applying mathematical methods in countries with a high economic level, show that the production programmes worked out with the aid of special mathematical methods are able to assure a 15% discount of production expense, which proves that the application of mathematical methods considerably increases the efficiency of economic activity.

Showing the way for Romania to reach a higher level in the socialist construction process, the IXth Congress of the party was particularly interested in the research works to be performed in the field of the practical utilization of mathematics and cybernetics. The Congress documents, just as other party and state documents, strongly stress the part played by mathematics in the economy management; they assign important tasks to the economists and the engineering staff of the enterprises, and to all those involved in the economy management. "In order to obtain a larger and more complex economy" — Nicolae Ceaușescu was saying at the plenary session of the C.C. of the R.C.P. on June 27th-28th 1966 — "it is imperative to introduce strict economic accounts, improve the economic informative system and utilize on a large scale the electronic computation technique — in production programming, in transports and in other economic activities."

The institutions of scientific research and education of our country have accordingly put down in their plans, as a constant and most important concern, the study and application of up-to-date methods of management based on mathematical model-making of the processes, and the introduction of the economic computation technique and of economic cybernetics in the management, planning and organization of socialist enterprises.

The same concern was shown in the field of economic university education where new disciplines have been introduced, new classes set up, etc. At the University of Bucharest there is a special section for studying computers; in polytechnic education the engineers to come will have modern classes of organization, and all the education curricula in general will be constantly improved.

Taking the necessity of solving certain technical or economic problems as a starting point, the utilization of mathematical methods has known continuous progress in our country. Applications of mathematics in production are permanently enlarged at different levels (of enterprises, of the designing of new industrial objectives, of economy branches and national economy).

The scientific work carried on for some time in our country, the high level of the reports made, the practical and theoretical importance of the problems discussed, the lively debates displayed on this subject, all this eloquently proves that the idea of using mathematics in production has been penetrating deeper and deeper into the circles of specialists and that an actual opinion is being formed on that matter. It is our duty, henceforward, to reinforce and amplify it, to make unceasing efforts in order to intensify the scientific research activity in connection with the application of mathematical and cybernetical methods. It is our duty to stimulate the

utilization of electronic computation in economy and hasten the practical applications of the results obtained in this field by research work.

The attention of economists, engineers and mathematicians should concentrate in the future on problems which are of the greatest importance to national economy. The efficiency of the whole production activity depends on the solution of these problems. By applying the means offered by mathematics and modern technics, we shall ensure a more consistent scientific basis for the forecasting calculation of the gross output and the production of sold and cashed commodities. It is necessary as well to use on a larger scale mathematical methods both in the calculation — value calculation and in natural units — of the increase of labour productivity, and in the calculation of cost price reduction. Particular attention should be paid to the material expenses of production per 1 000 lei of goods, which represents the barometer of efficieny of the enterprises. The powerful instrument of the mathematical methods may find a field of utilization in the establishment of optimum variants of the efficiency of investments, thus ensuring a high economic efficiency of those variants. Another important field in which modern mathematical and cybernetical methods for study, analysis and forecast should be more actively applied is that of goods circulation; in order to ensure a scientific content to the study of the population's goods demand and that of the conjuncture of the world market with a view to exportation — in order then to supply scientific data to these studies, there is but one way : join the forces of mathematicians, economists and engineers in one common effort.

The present concerns of the scientifical organization of labour and production on the international scale, and particularly in the countries having a high industrial level, centre round the elaboration of production programmes and their detailing at the labour place.

The Five-Year plan has established the size and proportions of development for the next years of all the compartments of our society. In order to fulfill the provisions of the Five-Year plan concerning investments and constructions , industrial and agricultural production, the increase of labour productivity and the reduction of cost price, the highest efficiency of our economic activity, the party has assigned to all workers the task of finding the ways and methods to identify the economy reserves, mobilize them with the purpose of achieving and exceeding the general development plan of our country for the period 1966—1970.

In order to satisfy this desideratum, scientific analysis should be preeminently directed towards the enterprises, with their sections and workrooms, towards the labour places. In our field of vision must stand, more than ever, the section, the workroom and, most of all, the labour places; all of which are concretized by man and machine. For it is precisely there that material production is determined.

Intensive employment, in factories and plants, sections and workrooms of production spaces is of well-known importance. Utilization of mathematical methods with a view to improve both the organization of technological flow and the emplacement of machines and tools, correlated to the use of other methods — as for instance chain links, fictive ranges, models — may lead to a better organization of production spaces.

There are great possibilities of successful results in the intensive use of machines, tools, aggregates and equipments, and particularly of machine-tools.

The practice of some industrially advanced countries shows that the coefficient of calendar-time-utilization for machine-tools, in machine building industry, may amount to 70% or even more. The methods of operative programming of production, to which co-operate the whole mathematical programming, mathematical statistics and others — have a particularly important share in the increase of the utilization index of tools. And this is one of the most concrete fields where mathematical methods can be applied. The development of these methods, the organization of their application constitute a vast field of scientific activity for specialists in production as well as mathematicians, economists and engineers doing research work.

In connection with the best ways to improve the utilization index of machines and equipments, special care is to be paid to labour-time utilization and particularly to the problem of shifts organization.

It is a well-known fact that our economy is equipped, every year, with an increasing number of machines and tools of high productivity. Aggregate works, plants, factories with a high level of technicality, automation of old equipments as well as of newly created ones — do not always have a scientific basis, they sometimes fail to keep pace with the new technical conditions. For this reason, some enterprises are registering important, yet unjustified, work-quotas excesses. In the field of rate-setting, we find great possibilities of increasing labour productivity and reducing the cost price. We have to mobilize these reserves and render them profitable. A particular contribution, in the setting of scientific work-quotas and in the problem of shifts organization, may be given by statistical and mathematical methods, the graphs theory a.s.o.

There are also great reserves available in the field of production expenses. Analyses have proved that material expenses (for raw materials, fuel, electric energy) as well as those regarding manual labour, are still high. Application, in designing, of electronic computation and mathematical simulation, has obtained remarkable results in many advanced countries. Our enterprises should follow the example and put it into practice too.

On the other hand, mathematical methods for studying the reliability in operation, for determining the stocks, for checking the production quality, for mathematical programming of the transports, may enable us to avoid certain unproductive expenses, like those connected to locations, interests, penalties etc.

Our party leaders pay unrelenting attention to the scientific organization of production at the labour place, to its equipment with modern, highly productive technical means. Such labour places, ever more numerous in our industry, constitute a vast field for mathematical application, with a view to ensure the highest efficiency of machines, the constant increase of production volume and labour productivity, the reduction of material expenses for each product. All these important objectives are just as many problems; in order to solve them it is imperative to apply on the largest possible scale both mathematical and modern computation technique methods, soliciting for a larger and more efficient contribution from engineers and other specialists in production, for scientists and research workers.

PRÉOCCUPATIONS ET ORIENTATIONS DES APPLICATIONS MATHÉMATIQUES DANS L'ORGANISATION SCIENTIFIQUE DE LA PRODUCTION ET DU TRAVAIL

Les demandes du développement de la société imposent que la recherche scientifique devance la production, en déterminant les chemins vers lesquels la production matérielle se dirigera. Dans ce contexte, le tableau général des sciences contemporaines est extrêmement complexe, mettant en évidence, périodiquement, les diverses tendances de développement qui influencent l'évolution de la société et qui affermissent de plus en plus la confiance dans la possibilité de la science, de contribuer à la création d'un monde plus prospère, plus juste.

En partant de ces idées, l'auteur démontre avec une particulière force de conviction la valeur pratique offerte par l'introduction des mathématiques dans la méthodologie de recherche des diverses branches de la science. Le développement de l'économie et surtout celui de l'industrie, étroitement lié à la science, a eu comme résultat, l'accroissement à rythme rapide du niveau technique de l'activité de production.

Les demandes toujours grandissantes, concernant l'accroissement du volume de production, l'accroissement de la productivité du travail, ainsi que l'amélioration perpétuelle de la qualité des produits sont des problèmes de plus en plus complexes, auxquels la science doit faire face. L'utilisation de l'électronique, surtout dans l'automatisation du processus de production, est soutenue par des méthodes mathématiques modernes. La réalisation des paramètres optimes des installations automatisées complexes n'est possible qu'avec la contribution des méthodes mathématiques d'optimisation.

Les méthodes mathématiques et la technique moderne de calcul ont aujourd'hui une contribution tout à fait spéciale à la compréhension des phénomènes et des lois de la production sociale, ainsi qu'au développement de la théorie économique.

En utilisant la concrétisation numérique ou les fonctions mathématiques de certains aspects importants des phénomènes économiques, en établissant fonctionnellement les nombreuses interdépendances qui surgissent pendant leur déroulement, le modelage et la technique de calcul permettent la connaissance et la prévision en temps utile, de l'évolution du phénomène analysé.

Les modèles qui en résultent doivent illustrer les modifications des dates primaires, leur niveau de réalisation et leur déviation du programme de production, fixé par le plan. En disposant d'un tel canal de connexion inverse, de l'output à l'input, ces modèles auront un caractère cybernétique.

La tâche qui revient à la cybernétique économique est justement celle de créer le support théorique et le cadre d'organisation qui permettront la direction optime de l'économie, dans les conditions complexes d'aujourd'hui.

L'application des méthodes mathématiques dans la planification et dans l'organisation de la production, au niveau de l'économie et de ses branches, ainsi qu'au niveau des industries, a comme but la meilleure réalisation des activités des hommes. En ce sens, l'appareil mathématique utilisé dans l'organisation, contribue à l'accomplissement demandé par la loi de l'économie de travail social ou du temps de travail.

ВОПРОСЫ И НАПРАВЛЕНИЯ ПРИМЕНЕНИЯ МАТЕМАТИКИ В НАУЧНОЙ ОРГАНИЗАЦИИ ПРОИЗВОДСТВА И ТРУДА

Потребности развития общества требуют, чтобы научные исследования опережали производство, ускоряя введение технического прогресса во все области, определяя движение вперед материального производства. В этом контексте, общая картина современной науки показана очень сложной и выявляются различные тенденции развития, которые влияют на ход истории и все больше укрепляют уверенность в возможности науки способствовать расцвету и прогрессу мира.

Опираясь на эти главные идеи, автор показывает с особенной силой убеждения практическую ценность, которую представляет введение математики в методологию исследования различных отраслей науки. Развитие экономики и, особенно, промышленности, в тесном контакте с наукой, обеспечило подъём очень быстрыми темпами технического уровня производственной деятельности. Все больше потребности роста объёма производства, увеличение производительности труда, постоянное улучшение качества продуктов, поставили перед наукой всё более сложные проблемы. Применение электроники особенно в автоматизации процессов производства, опирается на современные математические методы. Осуществление оптимальных параметров сложных автоматических установок невозможно без вклада математических методов оптиматизации.

Математические методы и современная техника вычислений в настоящее время вносят особый вклад в углубление понимания явлений и закономерностей общественного производства, в развитие экономической теории.

Допуская числовую конкретизацию при помощи математических функций некоторых важных сторон экономических явлений функционально устанавливая многочисленные взаимозависимости, которые имеют место и в их развитии, вычислительная техника и моделирование позволяют познать и предвидеть заранее эволюцию анализируемых явлений. Полученные модели должны отражать изменения во времени первичных данных, уровень достижений и их отклонения от производственной программы, намеченной в плане. Обладая таким каналам обратных соединений, от выхода до входа, эти модели будут иметь кибернетический характер. Задачей экономической кибернетики является создание теоретической основы и организационного ансамбля. обеспечивающих наилучшее руководство экономикой в исключительно сложных современных условиях.

Применение математических методов в планировании и организации производства как и на уровне экономики и отраслей, так и на уровне предприятий, предполагает оптимальный аппарат, используемый в организации, способствует выполнению требований закона экономии общественного труда или трудового времени.