Productivity and Technologies in the 12th to the 17th Centuries

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The third study week organized by the « Francesco Datini » International Institute of Economic History of Prato and held there on April 23-29, 1971 was devoted to « productivity and technologies in the 12th to the 17th centuries ». What particularly distinguished this conference from those organized previously was the absolute novelty of the subject. A novelty, it must be recognized, that was truly daring since the binomial productivity-technology, legitimate enough in the analysis of modern industrial economies, becomes very difficult to interpret when applied to pre-industrial economies owing to the uncertainty, elusiveness and incommensurability of the first of the two terms. The conference was further distinguished by the large number and wide range of the contributions made by the historians taking part in it. Contributions which, though they were all indubitably of a very high level and most valuable, suffered somewhat from their excessive dispersion. But if it was possible at times to complain of a lack of connection among the subjects dealt with, of their being contained in almost watertight compartments and above all of the absence of a clear and coherent description of the research methods and points of view which had inspired the various contributions, it was the very nature of the problems examined that was principally responsible since, as far at least as the history of productivity is concerned, their topicalness is of very recent date. It is in fact only in the last few years that studies on productivity in the centuries preceding the development of industrial capitalism have begun to be made. The interest aroused by these studies, which are the outcome of a decided effort to apply the methods for the economic and historical analysis of modern industrial growth processes to past economies, must be encouraged and developed. The conference therefore undertook an important action of promotion, the fruits of which we shall see in the years to come.

Carlo M. Cipolla opened the conference with a report on productivity in the centuries of the Middles Ages and the Renaissance. He first of all defined the notion of productivity and immediately after sketched a brief outline of productive and technological developments in the West from the fall of the Roman Empire to the Renaissance. Having thus set his subject in focus historically, Cipolla then examined more closely two important methodological questions.

The first of these questions referred to the measurement of productivity. He pointed out that if productivity is the ratio between output and recources employed, it is necessary — in measuring its variations — always to take into account the changes that have occurred in all the factors of production. Otherwise, if the variations are attributed to only one factor of production and productivity is measured on the basis not of a total but only of a partial ratio between output and resources, the conclusions reached will be of little value. A method of this kind has been used, for example, to measure agricultural productivity, taking the seed/output ratio as index, but for the reasons given above it must be rejected. Nevertheless Cipolla recognized that it is far from easy to allocate the shares of productivity increases accurately to the various factors of production. Statistics, when they exist, are very seldom perfect and, what is more, it is not always easy to isolate the factors of production from one another and reduce them to accurate quantitative measures.

The second question raised by Cipolla, besides being a matter of method, is also a matter of substance. There appears to be sufficient evidence that, both in the 11th and 12th centuries and from the Renaissance up to our days, technological progress has been the mainspring of increases in productivity. But what was it in turn that provided the incentive the use and diffusion of machines in production? Marc Bloch gave a by now classical reply to this question: the population movement conditioned technical progress or, more simply, the creation and adoption of machinery served to fill the gap left by human labour. Cipolla made no effort to prove the contrary — although the necessary elements would not have been lacking in view of the expansion of the population in the 11th to the 13th centuries — but he made a preliminary point which shifted the problem from the economic to the cultural and human ground. « Western Europe's reaction in the field of machinery », he said, « can only be understood and explained by seeking to grasp a particular mental and cultural attitude », It would consequently be necessary to inquire how a culture oriented towards machinery and the development of production came into being in Europe and why. In other words, what Cipolla wishes to point out is that men came first and machinery later.

Cipolla's report was followed by an important communication by H. van der Wee on the appliance of the notion of productivity to the history of preindustrial economies. After analyzing the theoretical content of the notion

of productivity, the Belgian historian stressed the necessity of making a distinction between micro-economies and macro-economies in the old economies. In the former productivity grew slowly and laboriously. He pointed out that the two principal factors of production, labour and natural resources, were certainly not lacking in the preindustrial economies, but were largely under-exploited. Productivity in physical terms was therefore able, under the stimulus of demand, to increase without requiring large-scale capital investments or raw material imports. And, in fact, in the first great cycle of European expansion, productivity increased chiefly as a result of the exploitation of natural resources, whereas in the second cycle (16th-18th centuries) it was the absorption of manpower that promoted expansion. Under the macro-economic profile capital already played a determining role in those centuries, but the greatest momentum was given to the expansion of production, and therefore to the increase in productivity both in physical and in economic terms, by the development of the commercial and urban infrastructure responsible for the enlargement of the market. Van der Wee therefore suggested the formulation of a growth model linked to the development of the infrastructure.

The general themes having been exhausted, attention shifted to the various sectors of production (agriculture, fuel and power, the textile industry, mining and metallurgy, business techniques). The calendar of the works allotted to each of these sectors a whole day, opening with a general report and followed by communications concerning particular points, addresses and discussions.

Agricultural yields were spoken of on the first day. It was only natural to begin with agriculture, both because up to the beginning of the nineteenth century, at least, it was the most important sector of European economic life and because agricultural productivity is the subject that has been most widely and deeply studied so far. The general report had been written by G. Duby. As the author was absent, the text was distributed to the members of the conference. Duby dealt with the problem of agricultural yields in the Middle Ages only. He drew a synthetic and exhaustive picture of the principal causes of agricultural productivity — climate, manuring and cultivation systems, tools and technical equipment, population pressure, distribution of economic power and influence of the towns — and then analyzed the sources of various kinds at the disposal of the historian. Among all the data available, the only ones he was ready to consider fairly reliable were the management accounts of the big landed properties, such as those of the British Church magnates in the 13th century. He made no secret of his scepticism concerning the possibility of being able to establish the trend of agricultural yields all over the continent throughout the Middle Ages. On the basis of the existing data he does however give a sketchy description of the variations in agricultural productivity in Europe from the 11th to the 16th century, emphasizing its growth

up to the beginning of the 13th century, the subsequent weakening due mainly to climatic difficulties and the redundant population which caused inferior land to be cultivated and the land already farmed to be impoverished by too intense cultivation and, finally, the recovery starting from the 15th century and favoured by the ebb in the population growth. Communications were then made, which can only be briefly mentioned here.

R. Fossier spoke of agricultural yields in North-West Europe, laying stress on the changes which took place in the 14th century, wrongly judged a century of crisis, which — through a general readjustment of crops — paved the way for the recovery of the following century. J. Goy examined grain yields in the Arles region between the 16th and 17th century, taking his figures from the account books of three big estates and providing an accurate analytic and graphic description of the parallel development of yields and overall production in this region. I. Imberciadori dwelt upon the causes that have been responsible until the present for cereal unproductiveness. L. A. Kotelnikova described types of crops and the techniques and systems of cultivation in use in Tuscany between the 12th and 15th century and then examined grain yields in the Lucca area, reaching the conclusion, from a comparison of his results with those of Luzzatto, Jones and Cherubini, that the progress made in those centuries with respect to the high Middle Ages was due more to an intensification of production than to an increase in yields. E. Le Roy Ladurie than spoke of grain yields in France from the Middle Ages to the 18th century, and never more than on this occasion was the absence of Slicher van Bath felt for it would have been most interesting to hear his reply to the flood of criticism unleashed against him by the French historian. In fact Le Roy Ladurie spent a considerable part of the time at his disposal refuting, with a wealth of data, the calculations on agricultural productivity in France made by Slicher van Bath in his *Yield Ratios*. In his opinion these calculations seriously distorted reality because, by placing the index of productivity at an arbitrarily high level, a growth or expansion, actually completely lacking, was represented. « Le fait capital », he said, « c'est que le monde des paysans de France et de Belgique apparaît, du XV^{e} siècle à 1840, comme un univers de productivité stabilisé ». After Le Roy Ladurie came the Pole Topolski who, in his communication, set in focus the fundamental question of the historical value that can be attributed to data on grain yields, that is the use that can be made of them as indices of growth, stagnation or regression. He stated that he was sceptical concerning the possibility of considering the data on yields obtained from the seed/output ratio as significant indices of the dynamics of agricultural productivity and claimed, as justification for this attitude, that the picture drawn thus would show a disconcerting stability despite all chronological distances and substantial differences. He further expressed the opinion that grain yields are in any case not reliables statistical indices as they completely ignore the size of the areas

sown. For all these reasons and for others still, such as the influence of soil fertility and of agrarian techniques on agricultural yields, Topolski suggested that the estimation of soil productivity, based on the production per surface unit should substitute the estimation of grain yields. In his address on grain yields in Sicily M. Aymard indirectly confirmed Topolski's remarks. He pointed out that in the 17th and 18th centuries grain yields were higher in Sicily than in Northern Italy. It was only in the middle of the nineteenth century that the roles were reversed and northern agriculture became more important than southern agriculture. The conclusion to be drawn from this is that grain yields are able to tell us very little about the causes that influenced agricultural productivity in the long rum. According to Aymard the progress made in Northern Italy between the 16th and 19th century was chiefly due to a more intense exploitation of productive forces.

The step from agricultural productivity, discussed eloquently and at some length, to industrial productivity was not immediate; in order better to introduce the subject the problems inherent in productivity and the exploitation of power sources were first of all set in focus. In his report L. Makkai spoke expertly of the evolution of the wind and the water mill, dwelling principally on the mechanisms designed to receive and transmit natural energy. The task of describing the equipment required for processing was left to other speakers. Makkai pointed out that the water mill in use in the Middle Ages was in those times the typical driving power, rudimentary, certainly, above all because of the rigid and inarticulate connection of the parts receiving and transmitting the power with those processing the material, but nevertheless a stage of capital importance in the technical evolution of mankind, intent from old times until today on creating the machine-man on the model of the man-machine. Makkai did not confine himself to telling the story of the water wheel only as applied to grind-stones, he also illustrated some connections between technical developments and productive and economic phenomena of a general nature. Almost all the following communications insisted on the history of the grain mill. U. Forti told how he had found in *Machinae Novae*, a work by the seventeenth-century writer Fausto Veranzio, evidence that the mechanical bolter was used in flour mills at least up to that time. A. Giuffrida illustrated the characteristics and history of the Sicilian water mill. G. Piccard recalled the principal developments in the Italian paper industry from the 13th to the 17th century and described in great detail the structure and working of the machines in use in a French paper mill towards the end of the 16th century. Lastly, W. von Stromer described the characteristics of the thread-drawing mill invented in 1415, probably at Nuremburg.

The examination of power sources having been completed, attention was turned to productivity and technology in textile manufacturing. The historians of industry were eagerly awaited. The conference members were

anxious to hear their contribution to the solution of the methodological problems that had so far been discussed, they wished to become acquainted with their specific problems and take part in a discussion at least as rich and animated as the one on agricultural yields, if not more so. On the contrary there was a good deal of talking and flitting from one subject to another, but general problems, common to all, were not discussed at all. The conclusion must be reached that either there are no general problems or that they were disregarded and passed over in silence. This is a pity, for if the second hypothesis is true, a good opportunity of mutually clarifying ideas and assisting the progress of research was wasted. The report on productivity and techniques in the textile industry was entrusted to W. Endrei. The Hungarian historian, who had already made a valuable contribution to a similar subject at the conference of the preceding year, remarked that it is customary to collect a number of most complex and heterogeneous processes and operations under the heading « textile industry ». This did not however prevent him from discerning the principal developments common to the whole sector. He pointed out that from the 13th to the 17th century progressive changes took placed in the working of all kinds of textile machinery, straight-line movements becoming circular and alternative movements continuous. Parallelly all branches of the textile industry began resorting to new and cheaper power sources and machines capable of driving several similar instruments at the same time were introduced. Side by side with these common forms of rationalization of the productive process, however, some more specific forms developed, namely technical innovations pertaining to the various stages of processing and destined to have a strong influence on the overall volume of production. These innovations are accurately reviewed by Endrei, who divides them into the four phases of spinning, weaving, knitting and finishing. On the whole Endrei's report, though short, was tightly packed and full of details and in any case most useful as an introduction to the following addresses. The series was opened by J. Pilisi who spoke of the incidence of technology on qualitative and quantitative product ivity, dwelling on the dressing of wool cloths and the evolution of shearing instruments. Next came I. Turnau, who spoke of the influence that textiles and leather-working on the one hand and European fashions on the other had on one another in the 16th and 17th centuries, showing how the different styles of dress depended on real production possibilities and above all on the development of techniques. The consumption and the production techniques of hosiery, ribbons and luxury skins were, in particular, the main themes of his communication. R. van Uytven devoted his attention to a by now classical subject: the cloth production of Ypres in the Middle Ages, seeking to establish the total amount of annual output in the basis of the number of weavers and their individual productivity. The conclusions he reaches are certainly interesting: they redimension the figures formerly sup-

plied by Laurent and van Werveke and relate the growth of drapery to the size of the population and to the socio-vocational structures of the Flemish towns. J. Wyrozumski outlined the technical evolution of weaving in Poland from the 11th to the 15th century. L. Braghina described the principal features of the policy of the Wool Guild in Florence in the second half of the 15th century, devoting particular attention to wool processing technology. Lastly, E. Carus-Wilson, in a lucid address, proved that the water-driven fulling mill and the horizontal pedal-loom were two contemporary innovations since they both made their first appearance in the north of France around the middle of the 11th century.

The cycle of discussions on industrial productivity and technology closed on the penultimate day with the session devoted to mining and metallurgy. H. Kellenbenz, who was the relator that day, started off with some important general considerations on the subject. He criticized the growth model proposed by Rostow because, based as it is on per capita production data, it underrates the economic dynamics of the centuries preceding the industrial revolution. Research in the field of productivity, and consequently of the technology that influenced it, should therefore serve chiefly to shed light on these dynamics. Kellenbenz then confined his survey to non-ferrous metals (copper, tin and so on): first he described the relevant manufacturing processes and innovations and then he classified the consequences of the innovations on productivity proper. Attention was therefore devoted to the effects of the improvements at the various stages of ore mining and dressing, the reduction and formation of the metal and hammering and melting processes. The survey then moved on to a broader plane, considering in turn rationalization, the merging of firms and labour specialization. Lastly the relation between productivity and market was estimated and then the alternation of growth and stagnation. What is particularly important is the fact that Kellenbenz dealt with the whole subject not only from the West European point of view, but from the much broader standpoint of the whole continent in order to show the diffusion of technical innovations and the stimulating effect that competition on a European scale had on the dynamic processes. The next speakers were: M. Abrate on the production of fire-arms in the second half of the 17th century; D. Molenda on the extraction of non-ferrous metals in Poland; R. Sprandel on productivity in medieval iron-working: O. Pickl on Tyrolese iron-working in the 16th century; B. Zientara on productivity and iron-working techniques in Poland in the 12th to 17th century; A. Svaridze on mining and metallurgy in Sweden in the 14th and 15th centuries and V. Vasquez de Prada on Spanish iron-working in the 16th century.

The most interesting communication was that made by Sprandel, the only one who endeavoured to put to profit the suggestions contained in Cipolla's introductory report. From a study of iron production in the late

Middle Ages he drew some conclusions concerning the economic and cultural prerequisites of technical progress which tally with the references made by Cipolla. After pointing out that throughout the last centuries of the Middle Ages there were two technical processes for iron production: the direct process, which was the older and less productive, and the indirect process, based on splitting up the different processing stages, which was the more productive. Sprandel sought to explain why the first of the two processes lasted so long and was not immediately replaced by the second. In his opinion there were two elements that prevented this: the mistaken mental attitude of the individuals concerned or better the fact that interest in the technical improvements of production and interest in larger profits were seldom to be found together in the same physical persons so that any conscious action in the more fruitful direction was unlikely to be taken. The second element was the larger consumption of wood required for the indirect process. It was only when ore and manpower grew more expensive that recourse was had to the second method. To begin with, the resistance to be overcome was strictly political as the more intense exploitation of wood from the forests was hindered by a number of legal constraints. Once the latter had been removed and the existing natural resources exhausted, the problem naturally assumed a technical aspect. Until then, Sprandel pointed out, innovations had stemmed from practice and it is here in fact that can be found the principal limit to further technical changes. Modern chemistry had first to be born, technical research on scientific bases had first to be organized before coke could take the place of wood and be used on a vast scale in the modern iron industry. Zientara's and Svaridze's communications also contained some interesting points. For example, Zientara particularly stressed the principal stages of Polish iron-working — the development of which was assisted by some German settlers — and the repercussions that social and political changes had on it. Svaridze insisted on the organizational short-comings of Swedish mining and metallurgy, controlled by an extremely composite social group which consequently often lacked any real entrepreneurial and industrial management capabilities.

The last day of the week was devoted to business systems and productivity in the usage and writings of the times. F. Melis was the relator and illustrated the general subject through the business papers and firms' handbooks compiled between the 13th and 16th century. He pointed how how, until well into the 13th century, the principal innovations in business techniques were due to the representatives of the maritime cities, who were later on replaced by those of the inland cities. Whereas for the former period there are plenty of studies, some of which are first-rate, no exhaustive reconstruction has as yet been made of the latter period. After making this point clear, Melis went to the heart of the matter, carefully passing in review both the innovations introduced by firms to increase their profits and those of a

purely technical operational nature designed to raise productivity. The reference to the principal forms of trading associations — from the *commenda* to the *societas*, the *company* and the union of several companies in a « group of firms » — serves as introduction to the subject of the determinant influence of « education » on firms' productivity, both in their correspondence and in their book-keeping. As his numerous studies in this connection have already examined these problems most thoroughly, Melis confined himself on this occasion to drawing particular attention to the degree of perfection and efficiency reached by the accounting instruments used by firms in the period considered. In the second part of his report Melis described the chief technical innovations that gained a hold at the general operational level, innovations which may be summed up as follows: the many advantages connected with the action of the big companies (*e. g.* long-range operations, transfer of business units to the most important centres of economic life, etc.), the differentiation of transport rates and the lowering of freights made possible by the large-scale development of merchant shipping, the expansion and improvement of credit techniques (« operating credit » developed at this time), and the development of maritime insurance. Marketing practices and commercial arithmetic handbooks were dealt with in the following communications. G. Arrighi spoke of the Tuscan abacus users; R. S. Lopez of the first handbooks on marketing practices and B. Dini on Ambrogio de' Rocchi's marketing practice.

The conference closed with a speech by Amintore Fanfani who, after expertly summing up the results of the historiographical Marathon which had ended on the seventh day and suggesting some interesting subjects for new research, turned his attention to the future prospects of history as they emerge from the development of past events.

The Tuscan historian started by saying that the week at Prato had closed satisfactorily as, thanks to it, knowledge concerning the progress of technology in the field of production and of its effects on productivity had been increased and strengthened. To Cipolla who, while recognizing the exaltation of the value of productivity in the late Middle Ages and in the Renaissance, had been unable to give a plausible explanation for it, he replied by referring to the central function of man the entrepreneur, the fearless promoter of the great movement of technological and productive progress of the modern era. And to Kellenbenz's remark concerning the independence of technology from science he replied that we must not forget that ever since the Renaissance the entrepreneur, the practical man, has often joined forces with the scientist, suggesting to the latter the techniques best suited to increase the productivity of human labour. The only fault Fanfani had to find with the conference was that it had only examined the changes which had occurred regarding the production of wealth, neglecting the no less important changes which had occurred in how wealth was distributed. He

mentioned in this connection the technological innovations that had taken place in the world of labour in general and in firms in particular, the connections between credit and productivity — so close, he said, as to suggest the transformation of the binomial technology-productivity into the trinomial credit-technology-productivity — the development of advertising and its technology, promoting or supporting an increase in productivity, agreements designed to limit competition, and management's relations with labour and with the government. In spite of these gaps, he once again praised the work done by the organizers and members of the conference and then went on to point out the targets at which future history should aim.

In Fanfani's opinion, the whole historical cycle which started far back in the 12th century, and has only now reached full completion, had as target an unlimited increase in productivity. The character and spirit of modern man was therefore moulded by the dogma of producing more and more. But today all this is no longer sufficient. It is not necessary to become involved in moral and philosophical reflections to recognize that technological progress, at the point reached, threatens the very conditions of human survival. The protection of these conditions may therefore become the new objective of the period opening out before us. Should this be the case, sweeping technological changes will take place also in the field of production. Both industrial technology strictly speaking and the technology of advertising, industrial agreements, management-labour relations and relations between the economic and the political power, among classes, trade unions and parties and even among nations, would have to take on a dimension more consistent with the respect of human life and of the equilibrium between man and his natural environment. « This », concluded Fanfani, « will give rise to a new impetus of solidarity, not only as an act of altruism, but as the necessary guarantee of life for each individual. The technological and productivist revolution... therefore seems likely to give birth in the second half of the 20th century to an inevitable psychological and ideological revolution, teeming with innovatory movements in the relations among the members of the several small communities and in the relations among the communities of the big human family. In this light inventiveness will continue to be appreciated and stimulated, but the whole of humanity will claim the control of its practical appliances. In the same light consumism in economy will be superseded, while in politics " participationism " will triumph ».

It was thus that the curtain dropped on the third study week of Prato in the expectation of the materialization of these attractive forecasts in the near future.