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**The effects of technical change
on skill requirements:
an empirical analysis**

di

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*Introduction **

This essay offers an empirical analysis of the effects of technical change on skill ¹. Firstly, with the increasing diffusion of more and more mechanization and, in this decade, with the advent of microelectronics, this theme has been widely debated both in theory and in empirical analyses ². These latter are usually based on a measurement of skill in terms of the parameters adopted in the job evaluation. My critique to that approach is both on the job evaluation criteria adopted, and on the unclear distinction between quantitative and qualitative effects of technical change on labour requirements. The following analysis will show the importance of that distinction in interpreting data.

The case study is the production of ceramic tiles in Italy. The analysis is articulated in three parts. The first discusses an indicator of technical level of ceramic tile production. This indicator refers to the 'scale of mechanization' proposed by Bright in 1958. The oldest and the most up-to-date techniques in use in the early 1980's are compared with regard both to the level of mechanization and to the number of workers required at each task at factory level. This analysis is the premiss for the distinction between quantitative and qualitative effects of technical change. This - together with the discussion of a measurement of skill based on job content - is examined in the second part. The conclusion of the case study and a critical analysis of the main contributions on this topic are in the third part.

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¹The present study is part of a wider research on the nature and the effects of technical change. An outline of the results of that research has been published in 1983 in the papers of the Istituto Economico of the Facoltà of Economia and Commercio, University of Modena. M.Russo (1985) contains the part related to technical change, economies of scale and level of vertical integration in the ceramic tile industrial district in Italy.

²See references footnote 22.

I TECHNICAL CHANGE, PROFILE OF MECHANIZATION AND LABOUR REQUIREMENTS AT FACTORY LEVEL

§ 1. Level of mechanization and human intervention in the production process

In order to estimate how far the adoption of new techniques affects the number of workers required in the production process, I will compare, for each task, the number of workers with the oldest and the most up-to-date techniques in use in the early 1980's³. Since the number of workers is not proportionate to the scale of production, the comparison of data for each of the techniques will refer to the minimum efficient size⁴.

The analysis of the data will take into account the case where the techniques under study feature a different division of tasks among the workers. These differences will be evidenced, and the aggregations of tasks that enable comparison between the two techniques will also be noted.

In this part of the study I shall employ the classification of techniques proposed by J.R. Bright, according to which the flow of techniques in time can be characterized by a growing automation of operations performed in the production process.

Bright (1958) firstly defines the term "level of automation"⁵. Concluding a brief review of the various definitions of the term automation, Bright stresses that it is clearer to refer to automation by comparison with pre-existing state of things, so as to provide a definition of a relative rather than absolute kind⁶: the expression automation itself implies the idea of greater automation and has as its opposite the expression manual. Bright notes a range of intermediate stages between the operation performed solely by the worker and the operation

³The data on which the analysis is based have been collected according to the engineering method as given in M. Russo (1985).

⁴An alternative method consists in comparing data of labour productivity with the minimum efficient size of the two techniques in question. This method is advisable in cases where the number of workers needed to produce quantities of the product greater than the minimum efficient size increases disproportionately to the increase of the scale, or in cases where, besides the minimum efficient size, the distribution of workers among the various tasks is substantially modified.

⁵Several studies - in particular those of Scortecchi (1961), Crossmann (1960 e 1966), National Commission of Technology (1966) and Bell (1973) - employ Bright's analysis for the classification of production techniques, with the aim of estimating the effects of technical change on the labour force. Crossmann (1966), in particular, proposes a classification of automation on the lines set out by Bright, evidentiating, however, the role of automation as a process of substituting information provided by man with information provided by the machine.

⁶"Automation" is a value word, not a content word" (Bright, 1958, p.6).

in which the worker does not intervene in the production process. He classifies the degree of level of automation in 17 levels, on the basis of three variables. The first of these variables is the source of energy, which may be supplied by man or by a machine. The second is the type of response from the machine to the actions it is required to perform. This response may be variable: that is to say, either man may define the action to be performed with the use of the machine, or the machine may respond with certain pre-established signals, thus summoning certain interventions on the part of man; or the machine may respond by acting within a limited or very wide range of alternatives, thus requiring human intervention that will be more and more restricted as the level of mechanization rises. The last variable, used by Bright in classifying the level of automation, is the source whereby the operation is activated. This source may be the worker himself (who starts the machine, or inserts the items to be worked); or it may be a control mechanism that directs a series of predetermined operations; or the variable may belong to the environment.

Figure 1 is taken from a study by Scortecchi ⁷; for each level of automation (of mechanization as Bright calls it) it evidences the type of human intervention in the production process ⁸. It is this very aspect that characterizes the classification of each operation: "The concept of levels of mechanization is based on the assumption that there are different degrees of mechanical accomplishment in machinery. In what way does machinery supplement man's muscles, his senses, his mental processes and his judgements? ⁹ Bright's theory thus identifies technique with its level of mechanization and relates the machine's evolution to the worker's intervention. And with respect to the role it assigns to man this theory strikes one as analogous to Marx's treatment of technical evolution ¹⁰. Bright's analysis does not make allowance for variables such as the productive capacity of machines, the organization of labour (division of tasks among workers, shifts), or the cost of production. Nonetheless, it constitutes an essential point of reference in describing techniques of production.

⁷Scortecchi (1961) p. 312.

⁸The original figure (in Bright, 1958, p. 45) contains the same information but relates the 17 levels of mechanization to the source of energy and the type of control; this schematic representation is used later in our study (see fig.2).

⁹Bright (1958) p. 41.

¹⁰See Marx (1966) ch.12.

§ 2. *The profile of mechanization*

The level of mechanization is assigned in relation to each of the operations that make up the production process, rather than to the production process as a whole: this is because the performance of each operation may be the result of a different line of technological evolution ¹¹.

Once the level of mechanization has been assigned to each operation for each of the techniques investigated, it is possible to show the diffusion of automation among the various operations in the production process. To this end, Bright draws a graph that he calls profile of mechanization ¹², I suggest adopting Bright's profile of mechanization not so much to study the span of automation as to study the effects of technical change on labour requirements.

Figure 2 represents the 'profile of mechanization' in the oldest and the most up-to-date techniques in use in the early 1980's to produce two-firing ceramic tiles in Italy. Engineering data refer to the minimum efficient size of a vertically integrated factory. The various tasks are represented on the horizontal axis of the graph ¹³; on the vertical axis the 17 levels of mechanization are ranked from the lesser to the more mechanized. The area of the circles is proportional to the number of workers required for each task, for each technique.

Data shown in the profile of mechanization, figure 2, will be examined by grouping the various tasks in 4 groups ¹⁴. The first refers to tasks carried out during the process of transformation, the process which changes the state of the material to be worked; the second includes the tasks of transporting the material between the various stages of transformation; the third comprises the

¹¹It may, however, be postulated that technical evolution tends to reduce the technological imbalances between the phases of process. In this connexion see Rosenberg (1976).

¹²Bright suggests that this profile can serve as a tool for evaluating possible differences with respect to the technical level adopted by local units producing the same product (see Bright, 1958, chap. 5). This is the use of the profile made for example in the studies by Gallino (1961) and Scortecci (1961).

¹³Certain tasks cannot be immediately classified in one of the levels proposed by Bright. Sometimes the task needs to be broken down into its elementary units so that an appropriate level of mechanization can be assigned to each of these; or it may be necessary to determine which of the elementary units are more important (in terms of time, of performance, effect on the product, etc.) so that the level of mechanization of this unit can be considered as the level of mechanization of the task as a whole. It should be noted that a profile of mechanization can be correctly built up only on the basis of a profound knowledge of the production process in question.

¹⁴Taken as a point of reference, the set of tasks excludes experts in the installation of plant, heads of department, technicians supervising production control. Nevertheless, the following analysis will stress the growing importance of this group of workers in the production process.

tasks of controlling the operation of transformation and transport (it is often indicated as a task of 'overseeing'). The fourth type includes all tasks of maintenance, comprising the operations of checking, repairing and modifying the machines ¹⁵.

§ 3. Technical change and labour requirements at factory level: the analysis of engineering data

The comparison of the two profiles shows, firstly, that the most up-to-date technique uses almost half the number of labourers required by the oldest technique ¹⁶. This difference would have been even greater if the oldest technique in the comparison were that in use in the late 1950's: in the last 20 years labour has in fact increased four times. Secondly, for many tasks the two techniques require the same number of workers, and thirdly they have the same level of mechanization for many tasks. The last two observations indicate that labour productivity and the level of mechanization are only two of the many characteristics of a technique of production ¹⁷. Nonetheless, since the level of mechanization is defined as the degree of worker intervention in the production process, the profile of mechanization still offers a useful key to elucidating other aspects of technical change, among them, the improvement of the technical characteristics of machinery, the reduction of physical effort, the division of labour, and the role of auxiliary operations and maintenance.

All these aspects can be examined in discussing the relationship between the level of mechanization and the number of workers for the two techniques represented in Figure 2. The following 5 cases throw some light on this relationship.

a) For almost every task associated with moving materials through the various processes (including loading and unloading machinery), for the selection of glazed tiles and for an auxiliary operation (cleaning the serigraphic screen) the most up-to-date technique is classified at a level of mechanization higher than the oldest technique in use and this determines a reduction in the number of workers of almost 3/4.

¹⁵This classification is based on Bell (1973, p. 67). He studies the technology of a production process as a complex of three functions or systems: transformation, transport and checking. In our study this classification has been characterized in terms of tasks, and the group of maintenance tasks has been added.

¹⁶The data for tasks are reported in table 1.

¹⁷The comparison of cost data of the two techniques here examined is presented in M. Russo (1985).

The group of tasks in question employs 170 workers with the oldest technique but only 46 are required for the most up-to-date technique. The extent of this reduction accounts for the bulk of the difference between the two techniques in question. In particular, the greatest reduction relates to the moving of materials. With the most up-to-date technique the task of moving materials consists in overseeing the working of the equipment used to load, unload and move the trucks. In practice, with the most up-to-date technique, there is no longer the enormous physical effort typical of the oldest technique, where materials are shifted by hand ¹⁸. It is worth mentioning that women began to be employed at these tasks only when they became automated.

In the case of the task of glazed tile selection, the increased level of mechanization has been made possible by an increased division of labour. With the oldest technique in use, the workers (only women are employed for this task) rank the tiles and put them in different boxes according to the quality of the glazed surface and the shades of the decoration; with the most up-to-date technique women need only rank the tiles, the boxes being filled by machine. But the automation of box-filling is matched by a complete change of the selection operation itself; the worker no longer takes the tiles (from a table or conveyor) and places them in boxes. Instead, the tiles run over a conveyor and the worker expresses her judgement on the quality and shades of the glazed surface, not by putting the tiles into different boxes, but by touching each tile in a particular position with a magnetic codifier. The code-fixing (which allows for a narrower range of alternatives than the previous process) is then the basic element that makes it possible to fill the boxes automatically. Now that the old operation has been split into three - moving, codifying, box-filling - and has been automated, the productivity of the selectors has quadrupled ¹⁹.

Finally, the increased level of automation has decreased the number of workers needed to clean the screen of the serigraphic machine from six to two.

b) In some tasks, for example, pallet filling and biscuit selection, increasing mechanization has brought no change in the numbers employed, but it has completely eliminated the physical effort they formerly required. In the case of biscuit selection, this has been possible by splitting the operation into two: selection for the soundness and integrity of the biscuit, and selection for its surface. With the oldest technique in use, the workers (in this case, too, only

¹⁸The automation of the stages in transport of material is a classic case in the literature on the effects of technical change on the organization of work. Relevant in this connexion is the role played by the introduction of conveyor belts at Ford in the opening decades of the XX century. This has received much attention from scholars.

¹⁹It is worth noting that the most up-to-date technique is in some factories worked by men, mainly as a result of the fact that this department works at night. Nonetheless, the prejudice that the selection operation was a woman's job is still so deep that it is difficult to persuade men to perform it.

women) perform both tasks manually; with the most up-to-date technique the quality of the biscuit is controlled automatically by means of a small mechanized hammer that strikes the tiles, and the worker intervenes only to deflect from the conveyor, by means of a magnetic codifier, those tiles with defective surfaces.

c) For the task of cleaning the press die the two techniques have the same level of mechanization but the most up-to-date technique requires fewer workers than the oldest one. Though this case is not a very significant one (using only 4 workers as against the 6 required by the oldest technique), it serves to introduce a particular aspect of technical development which I wish to discuss next: the increasing productive capacity of the machinery. For some operations, the number of workers may be proportional to the number of machines they are assigned to and not to the quantity of output of these machines, and, as a result, an increase of productive capacity determines an increase in labour productivity, without any change in the level of mechanization.

d) The two techniques both have the same level of mechanization and the same number of workers in half the operations. This set of operations consists of quite different cases, which can be divided into four main groups. First of all, there is one auxiliary operation (box forming) and various other operations (including the minimum requirement of an in-factory chemical laboratory for glazes, the preparation of final product samples, and the work of drivers and porters). None of these operations have been touched by technical change²⁰. Secondly, there are the operations in the final products store and in the spare parts store. The introduction of a mini-computer could rationalize the working of these departments. Though at present no factory has automatic systems in either store, it is plausible that computers could be used in future in the final product store, in particular for administrative purposes. In the case of the spare parts store, there is no need for a similar development. In fact, the level of such stocks is in general very low because of the quick service supplied by the machine producers, who are largely located within the ceramic tile industrial district. Thirdly, there are three moving and loading tasks that have already long been mechanized (the loading of hoppers for the grinding machine, the moving of pallets and the removal of the sherds).

The last group of operations includes all those production operations for which recent technical developments have improved the machinery without affecting the labour force required, since this was already at its very minimum. Here, technical innovation has increased the productive capacity of the

²⁰ Quite a different conclusion would have been reached if the profile of mechanization had included operations not directly connected with production, such as office work (administrative tasks, pay packets, accounting, etc.) or work connected with production control. All the related aspects are examined - with reference to the division of labour between firms - in M. Russo (1985).

machinery both by increasing the speed at which it works, and by reducing the time lost in auxiliary operations (such as loading, unloading and maintenance)²¹. The increased productive capacity of these machines will not, however, in general lead to a proportional increase in the number of workers employed on them. When the tasks associated with the transforming operations are exclusively, or mainly, those of controlling the working of the machinery, then the increased productive capacity is likely to affect not the number of control workers ('overseers') but the number of maintenance workers. This introduces the last case in question.

e) The two techniques have the same level of mechanization but the most up-to-date one requires a higher number of workers. This is the case in the glazed tile selection department, which with the oldest technique in use does not require specific maintenance workers, whereas two workers are indispensable when the most up-to-date technique is adopted. The other case is that of the electricians employed for factory maintenance. Technical change seems to influence maintenance according to three trends. The first confirms what we said above. In particular, with the most recent technique, even though a larger amount of equipment is employed (for the mechanization of secondary operations and movement), the number of maintenance personnel does not vary: this because part of the maintenance has been mechanized, because the possibilities of breakdown have been reduced, and because the substitution of parts is quicker. However - and this is the second trend - the most recent technique provides for the use of machines to carry out operations that were done manually in the oldest technique: thus a certain number of maintenance workers were necessary to install these machines, to intervene in case of breakdowns, to adapt the machines to produce different formats. Lastly, the third trend: technical change has altered the role of the maintenance workers, not only in terms of numbers (with the most recent technique the maintenance workers represent a larger proportion of total workers), but also in qualitative terms (see, for instance, the use of electronics and the specialisation of tasks). The last aspect will be studied in detail in the second part of this paper.

²¹ A. Touraine (1955) stresses that: "Under the heading of "factor k" work study experts include time lost for reasons concerning the material, for lubrication of the machine, for starting and stopping it, for changing and substituting the tool, performing small modifications (...) time lost for reasons concerning the personnel" (1974 It.ed., p.119).

II TECHNICAL CHANGE AND LABOUR SKILL

§ 1. How to measure "skill"?

A study of the effect of the technical change on labour skill is essential if we wish to have a picture of the type of work force necessary as increasingly mechanized techniques are adopted. In particular, we shall need to evaluate whether the new techniques, as compared to the previous ones, require a work force with a different skill and, if so, how this skill can be acquired.

Since the Second World War this theme has been the object of several studies²². It is important to bear in mind that the term "skill" has been used to define a set of quite disparate variables. For example, Bright (1958, p. 187) states "that 'skill' (...) is an indefinite blending of several things - manual dexterity, knowledge of the art, knowledge of the theory, and the comprehension and decision-making ability based upon experience". In defining skill, apart from these elements certain variables would seem to be necessary, such as physical and mental fatigue, the conditions of the working environment, the risk involved in a particular task, the ability to sustain a working rate considered to be high. "Skill" thus appears to be something much less definite than Bright sees it. A confusion often arises between the elements making up the definition of skill and those employed for characterising - through the contribution, or sacrifice, made by the worker in the production process - the wage to be assigned to each worker. That is to say, the attributes of job evaluation are frequently used for estimating the skill of the job (and Bright's study is an example of this).

The analysis that follows advances two critiques of such a way of analysing skill. Firstly, the criteria adopted in defining a "job evaluation" are highly ambiguous and subjective. Bright, while using a job evaluation approach, does not discuss the measurement he adopts for estimating the level

²²Between the 1950s and 1960s several countries organized studies on the effects of automation on work skill. By way of example we may cite such studies as those performed by Crossmann (1956, 1960) and Woodward (1958) on behalf of the Department of Scientific and Industrial Research (UK), by the Consiglio Nazionale delle Ricerche in Italy (1961), by the National Commission on Technology (USA, 1966) and again by Crossmann for the OECD (1966). These studies pursue a common line of investigation, focusing on the quantitative aspects (specially those concerning the increase in work output following the adoption of new techniques), the effects on the type of labour force the new techniques require, the implications in terms of professional training and wages. Moreover, these studies have in common not only their analytical structure, but also the kind of results that emerge from examination of production processes. A different perspective is provided by G.Friedmann (1959, 1960), A.Touraine (1955). These authors mainly discuss the "qualitative" effects of technical change on labour requirements.

of skill. He confines himself merely to marking the increase or decrease of skill (deduced from impressions gathered by examining various cases) as the level of mechanization rises ²³.

The second critique is closely related to the aim of this study. In my opinion, if we are to investigate the effects of technical change on skill, rather than on wages or working conditions, we must give a definition of the term "skill" in such a way as to isolate the study of this aspect from the others. This can be done - as in the case of the scale of mechanization - having regard to the contribution of the worker in the production process. I suggest measuring the level of skill required on the basis of the time necessary for learning the tasks that have been assigned to the worker.

§ 2. Time of learning: specifications on the measurement adopted

Three main specifications regarding the "time of learning" must be mentioned.

Firstly, the time of learning must be evaluated with regard to a worker who has completed the compulsory school course, who has had no previous experience of work, and who is available to perform only the tasks that have been assigned to him. The time of learning consists of a period in which the worker receives instruction from technicians and experts, and a further period in which he carries out his work with the possibility of observing how that same work is performed by another worker ²⁴.

Secondly, the tasks to be performed are defined by a set of operations to be carried out in a fixed unit of time. Furthermore, the tasks assigned to each worker must be characterized not only with respect to a series of movements or interventions, but also as regards the skill required in performing these, the responsibility towards equipment, towards the quality of the product and the safety of the persons working in the factory: all these elements represent special skills demanded of the worker ²⁵.

Lastly, we must specify that the time of learning is defined in a given moment of time, and it is further necessary to measure the time of effective learning, i.e. the time after which the technicians judge it possible to entrust the task to the worker without further supervision beyond that which is normally carried out.

²³ See Bright, 1958, chaps. 4, 5, 13.

²⁴ In the case of maintenance staff and electricians, we consider the time of learning as including the period of study in technical school.

²⁵ As regards responsibility, we shall offer a more detailed discussion later on of the role of this attribute which characterizes the kind of work force in the analysis of skill.

In conclusion, the time of learning, as above specified, is greatly affected by cultural and social conditions that are crucial in forming people's theoretical and practical knowledge.

§ 3. *Technical change and the qualitative and quantitative effects on labour work*

A simple comparison of the average skill level needed for the oldest and most up-to-date techniques seems to confirm the thesis that technical change increases skill requirement. In fact, with the most up-to-date technique the average level of skill (measured in terms of the time of learning) is 18 weeks, whereas with the oldest technique presently in use it is about 10 weeks. Nonetheless, it is my conviction that this result is not in itself too significant; indeed a more detailed analysis discloses quite different conclusions.

First of all, the level of individual workers does not have a normal distribution (see Fig. 3). In particular, with the most up-to-date technique 80% of the labour force has a skill inferior to the average, while less than 6% of the labour force has a skill four times greater than the average level. With the oldest technique 85 per cent of the labour force has a skill level below the average. From this, it emerges that technical change has not substantially altered the concentration of the level of skill at two ends of the labour force: one where the level of skill is very low, the other where it is very high. Given this conclusion it is clear that average skill data do not provide an adequate basis for interpreting the effects of technical change on skill requirement.

To this end it is more useful to analyse skill in a way that, for each individual task, sheds light on the relationship between the effect of technical change on skill and the effects of technical change on the quantity of workers required at factory level in the production process (data are shown in table 1). If we take this approach the following 5 observations emerge.

a) None of the individual tasks requires a higher time of learning with the most up-to-date technique.

b) The time of learning drops considerably in many tasks in which the most up-to-date technique is characterized by a higher level of mechanization and by the least number of workers. This is the case in the moving and loading tasks, in some auxiliary tasks and in the selection both of biscuit and glazed tiles.

c) Some tasks have the same level of skill with the two techniques but the most up-to-date requires a lesser number of workers because of the increased level of mechanization. Three of these tasks (loading the glazing line, filling and emptying saggars) have a very low skill requirement needing less than 4 weeks training. By contrast, where a worker is employed to move trucks in the firing departments the level of skill required of him is higher (8 weeks), but this is determined not so much by this task itself as by the need to learn how

to control the firing equipment. These two tasks are performed by the same worker and for this reason I have assigned the same learning time to both, but it is the increased mechanization of moving operations that has reduced the number of workers required. (It is for this reason that I have split the global task into two in Figure 2).

d) For all the transforming operations, for almost all the maintenance, for the stores and for the tasks included in the group 'services', the two techniques are identical in every respect.

e) Finally, though the level of skill required of the individual workers remains the same (three and a half years), the most up-to-date technique needs one more electrician's assistant than the oldest one. Similarly maintenance workers in the glazed selection department are required only for the most up-to-date technique.

To conclude: the two techniques differ more in their labour force requirements than in their skill requirements. In particular, the level of employment in the most up-to-date technique is less for levels of low and very low skill, while there is an increase in the numbers employed - even if by only a few units - for the very high skill.

To complete the comparison between the two techniques, it should be noted that the flow of new techniques is accompanied by the design of prototypes of machines, by the verification of processes, by the study of equipment layout, by the installation and perfecting of new plant, by the study of the division of tasks between the workers. All these activities - which have not been considered in comparing the two techniques - require very high levels of skill.

In the case of ceramic tile production it emerges that these levels of skill are seldom present within the factory that adopts new techniques. Generally speaking, the necessary skills must be sought within the industrial district. An investigation into the level of skill must therefore focus on the research laboratories, the engineering firms that design the prototypes and produce the machinery, and the technical consultancy firms. The relation between these firms may sometimes be a very close one and an increase in skill among the labour force may be brought about through professional careers among the firms in the district as a whole.

The analysis that follows will not take account of these tasks but will confine itself instead to studying tasks performed within the ceramic tile production unit.

§ 4. A change in the notion of skill

If we interpret the oldest technique now in use as that prevailing at the end of the 1960's, the above conclusions may be construed with reference to the technical evolution of the last 15 years. In this period the techniques

introduced have not changed in any substantial way the level of skill of the individual tasks. Nonetheless, in the past decade a higher wage rate has been assigned to many tasks for which the level of mechanization has increased and, accordingly, the skill requirement for that task has come to be seen as higher. Moreover, particularly due to EEC funding, formal training courses have been organized in the ceramic tile industrial district to provide greater numbers of skilled workers because of this supposed increase in skill requirements.

These developments stand in contradiction to the conclusions drawn above. Nonetheless, they are not simply the result of wrong opinions. Rather they refer to a concept of skill which is different from the one I am referring to; in particular, to a concept of skill for which the time of learning is absolutely irrelevant in measuring skill requirements. The following analysis will show how technical change has affected the very notion of skill requirements.

Only by the study of the evolution of job content is it possible to understand how the elements that go to make up the notion of skill change with the changes in techniques and labour organization. The analytical framework of this analysis refers to the studies of Touraine (1955), Friedmann (1956), Bright (1956) and Braverman (1975). What these studies have in common, which makes them very important for the following discussion, is the idea that the evolution of job content can be interpreted in a more complete way by reading it together with the evolution of the technical characteristics of the machinery and of changes in the product.

§ 5. The evolution of job content in ceramic tile production

From World War II to the end of the 1950's the only machines used in tile production were the grinding machine, the press and the kiln. At that time, only a small portion of the workers employed in the ceramic tile factory were hodmen assigned to moving tiles and trucks between the various operations. The largest part of the labour force performed transforming operations. These are the typical "making-workers", referred to by Touraine, who determine the use of the machine. The making-worker's ability defines his skill. Such ability may be measured not only in terms of the time required to learn it, but also in terms of the quality and quantity of the outcome of his work: the product. In this period, in fact, the piecework wage is largely used to encourage increased output: the more the worker knows 'his' machine, the higher the number of units of output he is able to produce, and the higher, then, his wage. Hence the skill of the making worker - his ability and experience - determines a large part of his wage.

As an example of the evolution of job content, I shall now describe the task of pressing.

The presser had to know 'his' machine in order to give, with his strength, the right movement to the pressing mass. This was the crucial task the presser had to devote all his attention to, the performance of which depended solely on his experience, itself achieved only after years as a assistant presser. It was the presser's ability that guaranteed the good quality and the uniformity of the product. But the presser had other tasks too: he knew when to replace the die or the worn-out parts of the press, and, moreover, it was he who filled the die with the clay and then drew the pressed tile out of the die to be piled on the trucks; finally he took the empty trucks and moved the filled ones away from the press. In performing all these operations the presser might be helped by an assistant, who learned in the meantime how to 'govern' a press in order to become, in a couple of years, a presser himself. To conclude: the work of the presser, as for the grinder and the fireman, brought together very skilled tasks and very heavy tasks which required no skill, and for which an assistant was employed as a form of on-the-job training.

Until the end of the 1950's output was not very high and only very small sizes of tiles were produced; in fact, given the limit of the muscular strength of the worker, the manual presses in use at that time could not produce sizes larger than 7.5 x 15 cm. The 1960's, by contrast, were characterized by precisely the increase and diversification of output, particularly as a consequence of the production of glazed tiles.

Increasing output encouraged a greater division of labour within the factory. In practice, the skilled work of the grinder, the presser, the fireman, became more and more separated from the heavy, completely unskilled tasks, typical of the previous period. This 'liberation' set apart those who controlled the grinding machinery from those who loaded the hoppers; the man who pressed from the man who cleaned the die, piled the tiles and moved the trucks; the man who regulated the firing equipment from the one who moved the trucks in the department. Sometimes the heritage of the previous period still confused this distinction, but already from the middle of the 1960's onwards the group of workers specially assigned to moving and loading operations came to have an increasing importance. These workers, who in the 1950's had the opportunity of becoming making-workers, are now completely deprived of the opportunity of any "professional career" within the factory. Their tasks are heavy and the learning time for them is, in practice, the time required to be able to stand the pace of work. Instead of an apprenticeship of several years with the prospect of a higher wage and a better job, there is just a couple of days spent in on-the-job training. These workers do not determine the use of the machinery; on the contrary it is the machine that determines their pace of work. For these tasks the piecework wage is no longer determined in the terms discussed above. Instead, it is the physical strength alone and not the skill of labour that determines how many units of output are produced and, as a result, the wage.

Other groups of tasks came to have an increasing role during the 1960's. These were the glazing operations: from glaze preparation (then produced in the ceramic tile factories) to the decoration of the tiles. The central task in this group was that of the glazer who decided the amount of glaze to be applied to the tiles, and tested the working of the various devices used for glazing and decorating the tiles. Tile selection constituted the other group of tasks with an important role in the process. This is because the uniformity of the various batches is guaranteed only by classifying the tiles with care. Indeed, uniformity could not yet be guaranteed by the characteristics of the transforming operations. Though both the tasks of glazing and selecting require a long time to learn, only for the first group of operations is skill considered as a basis for negotiating the wage rate. Since the tasks of selection are exclusively performed by women, this fact induces the payment of lower wages without considering any skill involved in performing them.

It was during the 1960's that the whole gamut of existing manual/craft skills started to be eliminated²⁶. The improvement of the grinding machine, of the press, of the firing equipment, and later of the glazing equipment, transformed the making-worker of the 1950's into two figures that the organization of production now tends to split up even further; on the one hand the hodman and on the other hand the

It is worth discussing in detail the role of this group of workers which in the 1960's was associated only with the various transforming operations but that in the next decade - as a consequence of the automation of moving and loading and auxiliary operations - came to involve a considerable share of the blue-collar work in the ceramic.

In the 1960's the overseer controlled the working of the machinery, performed some loading and moving tasks and some auxiliary operations. But what is more important, he intervened when the machine broke down. As a result, he had to have technical knowledge that would have been useless to the making-worker of the 1950's. The overseer did not determine the use of the machinery, as the making-worker did; his job was to intervene to modify the machine's performance. In the 1950's the worker's ability determined the quantity and the quality of output and thus his wage; in the 1960's the overseer guaranteed only the regularity of the flow of production, and in this period only an irrelevant part of the wage rate was determined by skill. Large parts of the piece work rates were absorbed into the basic rates as fixed amounts, very often differentiated within the individual task. When the negotiation of wages for groups with similar tasks began towards the end of 1960's, the level of skill was no longer the critical element characterizing each task. Instead, exposure to dust, noise, temperature, and harmful substances were the elements used to rank the various tasks. In the late 1960's the tasks

²⁶There is no case for 'deskilling', see Braverman.

assigned to the overseer started to change: he assumed the role of mere controller which became typical in the 1970's. Instead of intervening in the event of breakdowns, his job was to alert the maintenance worker of the department - as quickly as possible. What then came to constitute the skill of the overseer was partly his attentiveness, but mainly the responsibility he carried.

With regard to the technical developments of the second half of the 1970's, three blue-collar figures may be singled out - the overseer, the maintenance man and the hodman - who are no longer associated with particular tasks as they were in the 1950's (that was the case of transforming operations). In a previous section, it was explained that the number of hodmen whose tasks involve mere physical effort, becomes smaller and smaller as the loading and moving operations come to be automated. To complete the analysis of the evolution of job content it now remains to discuss the role of the overseer, on the one hand, and the maintenance worker on the other hand. Such analysis starts from the notion of responsibility, which becomes a crucial element in defining the overseer's skill, but also, as discussed later, that of the maintenance man.

§ 6. *Overseer vs. maintenance man: observations on the notion of responsibility*

A recent paper on skill - prepared by the Association of Ceramic Technicians ²⁷ - pointed out how the most up-to-date techniques require a higher degree of responsibility from employees for the quantity and quality of output ²⁸. Consider, for instance, the worker whose task is to oversee the press and the machine for the automatic piling and loading of the pressed tiles on the trucks. He must get rid of the broken or cracked tiles and must signal to the maintenance worker all the possible imperfections in the working of the machinery that might cause the production of ill-shaped tiles. If the worker's attention wavers, broken tiles may be piled on the trucks and this causes damage in the firing phase, or a higher percentage of sherds after firing. Does the worker's attention waver? Will he control the machine and call the mechanic for help as quickly as possible?

²⁷ See Assiceram (1979).

²⁸ In the words of the paper: "Since the same output is now produced by means of a smaller number of workers and more costly equipment than in the past, investment per worker is considerably increased. This is why the parameter 'sense of responsibility to the value of the equipment' assumes so high a value, and, as a consequence, why workers must be able to manage and preserve the equipment entrusted to them" (my italics).

Consider two different situations: if a worker must load a machine by hand, any break in the performance of this task has an almost immediate effect on the next operation, and the worker is of course scolded by his foreman; on the other hand, if the worker's task is to oversee machinery and he fails to do it, then all manner of problems occur in the next operation but with a considerable delay. And moreover, it is impossible to trace which worker has been negligent.

What I am describing here is an extreme case and it would be important to know how the overseers usually behave; to find out we should ask them directly ²⁹. The impression drawn from interviewing the technicians - that constitutes, in any case, a very partial view - is that overseers are less and less reliable. The technicians point out three possible solutions to this situation. The first consists in involving the overseer in tasks, like ordinary maintenance, that would give him an opportunity to use his judgement and intervene - albeit a small one. The other solutions suggest a system of wage incentives: an up-to-date version of the piecework wage. The third solution can be defined as more radical: the improvement of the technical characteristics of the machinery and the drastic reduction in the time of the process (that implies a quicker intervention in case of non-signalled breakdowns) offer justification for complete elimination of the overseer. Possible breakdowns would then be considered directly by maintenance men. The factory in which the only type of worker is the maintenance man is not implausible, and I believe that the current trend in technical developments in ceramic tile production makes it possible. But the point is, once again: what will be the reaction of the maintenance men to this situation in which all responsibility is entrusted to them? The mechanic, a typical figure of a highly skilled worker, enters the stage as the "responsible man". And in the case of this group of workers, too, the symptoms of "irresponsibility" start to appear.

As an example, let us consider the ordinary work of maintenance that consists, essentially, of preventive interventions. This work may be organised in two ways. Either one relies on the fact that the mechanic knows the wear-and-tear time of the various parts of the machinery, and then relies on his arbitrary intervention; or such times are defined and the mechanic has a very detailed list of interventions to do and given deadlines to meet ³⁰. Only in this latter way can ordinary maintenance have foreseeable consequences for production. At one time the low cost of machinery made possible the purchase of spare machines to be used while the machines normally in use were being repaired. Today, the quite considerable investment cost of many machines makes the use of spare machines very limited, and any stop in production due

²⁹With regard to responsibility, Brecher and Costello (1979) provide a very interesting account of workers' behaviour based on interviews to American blue-collar workers.

³⁰Footnote on wear-and-tear time and on learning by using. See Rosenberg 1979.

to maintenance either is programmed (in terms of frequency and length) or determines irregularities in the flow of production with very damaging results for all the subsequent operations. But if the technicians have suggested a very radical solution for the overseers, for the maintenance men only a very bounded autonomy of judgement can be predicted. A factory without workers is a utopia which it is probably not worthwhile discussing. A factory in which the human beings allow for flexibility is still arguable and an analysis of this would extend beyond the limits of the factory.

III CONCLUSIONS

The conclusions which emerge from the case study partly contradict those that may be drawn from such studies as those by Crossmann (1960, 1966), OECD (1966), Woodward (1958); these latter would suggest two fundamental theses.

The first is that the level of mechanization reduces the contribution of the worker directly engaged in the production process in terms of theoretical knowledge and experience. This occurs, however, not by the simple passage of these attributes from worker to machine, but rather by profound modifications in the production process and in the product itself³¹. Which is what broadly emerges also from the case under investigation.

The other thesis emerging from the studies cited is that the workers directly engaged in production are occupied exclusively with the control of machines and their task consists in signalling eventual breakdowns to the foremen, or to the production technicians, or to the maintenance. This thesis sets the overseer of machines against the other figures mentioned above. In this contrast between these two groups of tasks there is, on the one hand, a set of workers who are effectively required to be "responsible" (that is to say, they must promptly report breakdowns and faults), while on the other hand there workers who are presumed to be in possession of theoretical and practical know-how which will enable them to intervene to correct any faults occurring in the production process.

However, as has emerged from the foregoing case study, there are certain misleading elements in interpreting this antithesis.

Firstly, there is a "quantitative effect": a comparison between increasingly mechanized techniques may indicate that, all other conditions being equal, the number of workers engaged in maintenance remains almost constant, or rises slightly, whereas the number engaged in other tasks shows a considerable drop. On the basis of this result we have a percentage increase in work that can be defined as skilled and a percentage decrease in unskilled work (and here, in defining skill, we are entirely neglecting responsibility). It would seem very important to emphasize this effect because if it does occur, then, all other conditions being equal, it will not be necessary to deal with the problems concerning the training of new workers.

³¹ On this point see M.Russo (1985) with reference to the case studied here.

The second element to highlight is the new technical know-how the maintainers must possess following a radical change in the technical characteristics of the machines: these will need, for example, more electrical and electronic servicing and less purely mechanical servicing. But in this case it is still doubtful whether real retraining is necessary. For example, the employment of electronic equipment in the manufacturing sector has shown how the intervention of the maintainer can be reduced to merely replacing one circuit board with another. Of course this is to simplify grossly, but we can say that, in order to carry out this operation, it will be enough for the maintainer to know where the appropriate circuit boards are stored and how they should be inserted into the machine. Even in this case, therefore, it is very doubtful whether the workers require "retraining".

The last element we must evidenciate in interpreting the antithesis between unskilled and skilled work bears on the notion of responsibility. Much support has been given to the thesis according to which, however valid the arguments dealt with above on the skill of the maintenance workers, there is still a need for the "overseers" to be skilled. In defining the figure of the overseer as "skilled", we confirm that he is central to the production process. And with more mechanized techniques the overseer actually remains the sole worker directly engaged in the production process ³². He has nothing in common with the making-worker of "phase A" described by Touraine (1958). Indeed, the overseer has nothing to which he can apply his intelligence, his creativity, his manual ability. He is required only to have prompt reflexes which he will use as the occasion requires. Those who claim that the overseer is a skilled worker seem to be aware that there is very little motivation inherent in his tasks. In an age in which the idea that work is central to the life of the worker is disappearing, a fair number of entrepreneurs claim that overseers are skilled workers and thus deserve higher wages ³³. And this may be a good incentive to staying alert and reporting breakdowns ³⁴!

³²It is worth noting that technical evolution changes the line of demarcation between work "directly" and "indirectly" involved in the production process.

³³In his study of 1958 Bright already emphasizes that the entrepreneur must be warned against the conviction that he should pay higher wages to workers dealing with more automated machines. However, what Bright is unable to take account of are the effects on the behaviour of workers after several decades of development in automation.

³⁴Brecher and Costello (1976) and Blackburn and Mann (1979) take different paths to reach very similar considerations. The former report the reactions of workers to this situation. The latter offer a detailed discussion of how management pretends to see the overseer's task as skilled, and argue at length the thesis of "divide and rule" which lies at the basis of wage increases aimed at "motivating" the workers.

What should be noted is that the importance of the overseers in the production process is characteristic of a stage in technical evolution. Referring to Bright's scale of mechanization, we see that already at level 9 the figure of the overseer has disappeared. As the level of mechanization increases the functions of control, measurement, modification and correction are progressively incorporated in the machine and the overseer is replaced by the maintainer or the production technician. In the investigation of the job content of the maintainer it has emerged that one of the characteristics inherent in the flow of increasingly mechanized techniques is the diminishing need for maintenance: several maintenance functions are in fact performed automatically (e.g. the lubrication and check on the oil pressure in oil-powered equipment). The intervention of the maintainer consists essentially in equipping the machine to modify its speed in performing the process, or changing the characteristics of the process. But, as in the comparison between the overseer and the making-worker, the maintainer has tasks somewhat different from those allotted to the tool setter indicated by Touraine. Indeed, the interventions to be performed by the maintainer are generally classified according to fairly rigid hierarchies of competence, so that each worker is assigned only a circumscribed part of the maintenance.

One conclusion we may draw from this study is that the responsibility of the worker assumes considerable importance as the increase in level of mechanization enables the machine to perform all the other functions in the production process³⁵. At the time the worker was assigned the tasks in the performing of which he had to use his intelligence, his skill, his experience and theoretical know-how, he showed a taste for the work which created no problems for responsibility: it was inherent in the way he related towards his work. Hence his sense of identification with his job, his factory. But all this have been vanishing from the end of nineteenth century on. Mass production, the organization of production in large factories, the adoption of Taylorism as

³⁵It was especially in the nineteen-fifties that a debate arose on the topic of responsibility. And indeed, studies on job satisfaction are aimed at establishing how to get the worker to commit himself to work that is unanimously admitted to be alienated. In this type of study it seems to us that the work of Davis (1966, 1971) and Emery and Trist (1960) represents the most interesting line of research. They deal, on the one hand, with the connection between work and job design, and on the other, with the problem of the relation between work and environment. In recent years attention has been drawn to responsibility in defining skill shortage. On this respect see J.M.Oliver and J.R.Turton (1982).

a tool in the expropriation of skills, the increasing mechanization of production process, - all these lie at the root of disappearance of what, by definition, made the worker responsible and reliable ³⁶.

³⁶The process of alteration in the relationship between the worker and his work is suggestively described in two studies: the first by Braverman (1975), the second by Accornero (1980). There is a substantial difference between the two authors. The degradation of work in the XX century is the object of Braverman's book, and underlying his thesis is the idea that it would be good to reunite what capitalism has dismembered in its 150 years of pell-mell growth. But Braverman offers no precise indication of what direction that reunification should take; his is merely the statement of principle of one who confines himself to indicating socialism as the real alternative for which it is worth fighting to alter the current state of things. Instead Accornero discusses, on the one hand, the historical roots of the idea of work as a central element in the life of man; on the other side, he studies the changes in the relation between work and capital that have come about since the end of the last century. Accornero goes far beyond Braverman's statement of principle, throwing doubt on the entire Marxist-renaissance ideology that sees homo faber as the "reunified man of the socialist future", and proposing an investigation of the implications that this change has in class relations.

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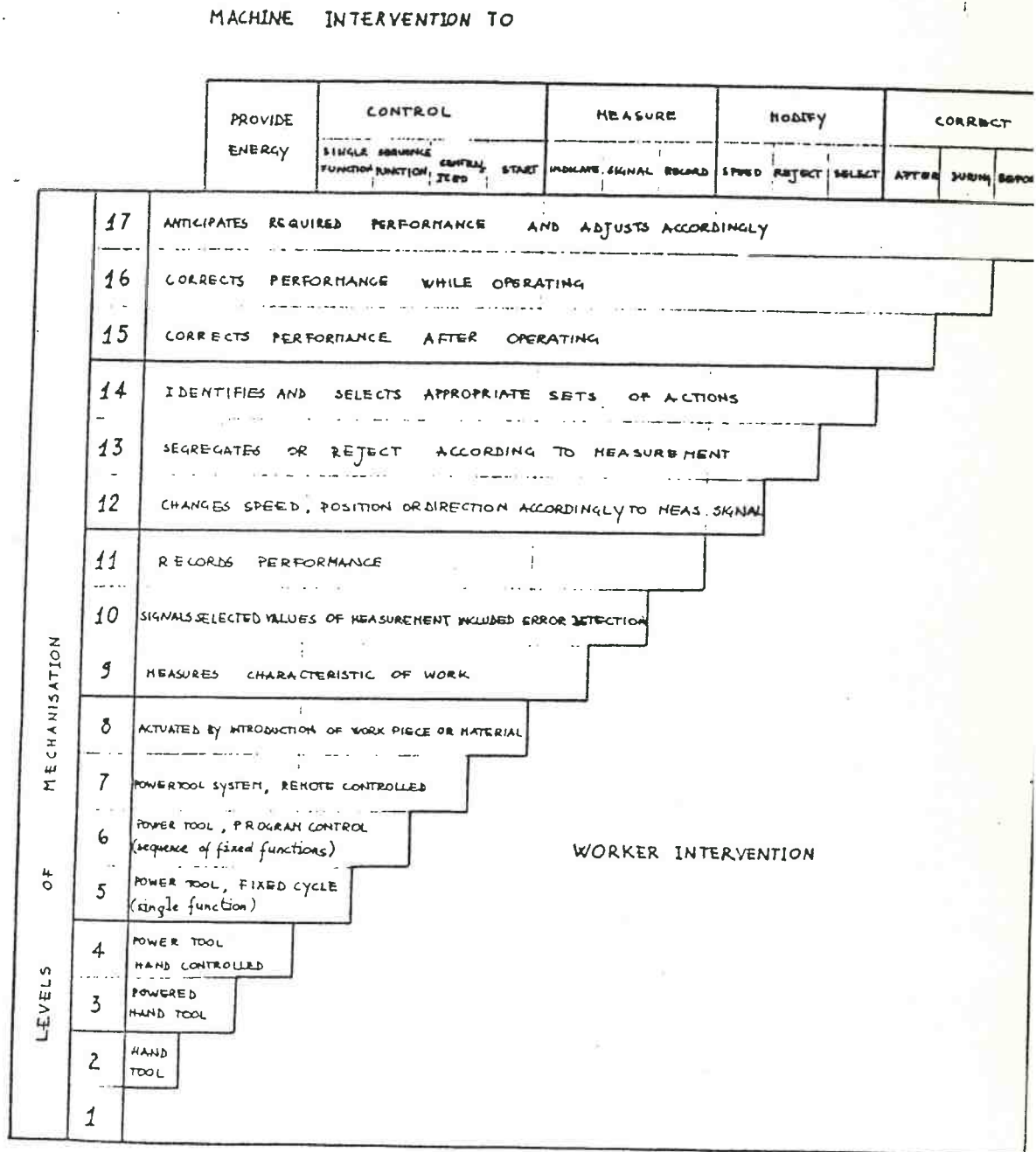
Table 1. Level of mechanization, number of workers required to produce ceramic tiles of size 200x200x10 mm at the minimum efficient size of a vertically integrated factory (7680 sqm of final product), time of learning* by task for the oldest and the most up-to-date technique

Department	Tasks	OLDEST TECHNIQUE			MOST UP-TO-DATE TECHNIQUE			
		Level of mechanization	Number of workers	Time of learning (No. of working weeks)	Level of mechanization	Number of workers	Time of learning (No. of working weeks)	
I CLAY GRINDING	1. Hopper loading	4	1	4	4	1	4	
	2. Grinding	5	1	24	5	1	24	
	3. Clay deviation	4	2	2	5	M	-	
	4. Pressing/forming	6	M	-	6	M	-	
II PRESSING	5. Die cleaning and press controlling	1	5	6	1	4	4	
	6. Piling and loading of pressed tiles on trucks	1	15	6	8	4	4	
	7. Maintenance of the press department	2	4	48	2	4	48	
III DRYING & 1 st FIRING	8. Moving of trucks	3	6.5	8	5	2.5	8	
	9. Biscuit drying and first firing	11	2.5	8	11	2.5	8	
IV BISCUIT SELECTION & GLAZING	10. Loading the biscuit selection line	1	12	1	3	3	1	
	11. Biscuit selection	1	12	3	4(+M5)	12	1	
	12. Glazing on line	5	12	16	5	12	16	
	13. Serigraphy	8	M	-	8	M	-	
	14. Ser. screen cleaning and control of serigraphic machine	1	6	3	6	2	2	
	15. Filling the saggars	1	36	3	8	12	3	
V 2 nd FIRING	16. Maintenance of the glazing department	2	6	44	2	6	44	
	17. Moving of trucks	3	8.5	8	5	4.5	8	
VI GLAZED TILES SELECTION & PACKING	18. Glazed tile firing (2nd firing)	11	4.5	8	11	4.5	8	
	19. Emptying the saggars	2	16	4	8	6	4	
	20. Glazed tile selection	1	48	5	8	M	-	
	21. Box filling	1	6	1	1	6	1	
	22. Box forming or 'making'	1	8	2	3	8	2	
VII FACTORY MOVING	23. Pallet filling	4	1	3	4	1	3	
	24. Pallet moving	-	-	-	2	2	192	
	25. Maintenance of the glazed selection department	3	20	2	8	M	-	
	26. Moving of factory trucks	4	1	3	4	1	3	
VIII FACTORY MAINTENANCE	27. Removing of sherds	2	1	96	2	1	96	
	28. {	Mechanic	2	4	24	2	4	24
		Mechanic assistant	3	2	24	2	2	24
		Brick layer	2	1	56	2	1	56
		Plumber	2	1	16	2	1	16
		Plumber's assistant	2	1	48	2	1	48
		Carpenter	2	1	216	2	1	216
		Electrician	2	2	168	2	3	168
Electrician's assistant								
IX STORES	29. Final product store-keeper	4	7	6	4	7	6	
	30. Spare parts store-keeper	1	1	72	1	1	72	
X SERVICES	31. Preparing final product samples	1	2	4	1	2	4	
	32. {	Preparing glazes	4	4	12	4	4	12
		Laboratory chemist (glazes)	4	2	16	4	2	16
	33. {	Driver	4	1	8	4	1	8
Porter and night watchman		4	4	3	4	4	3	

* For the definition of 'time of learning' see

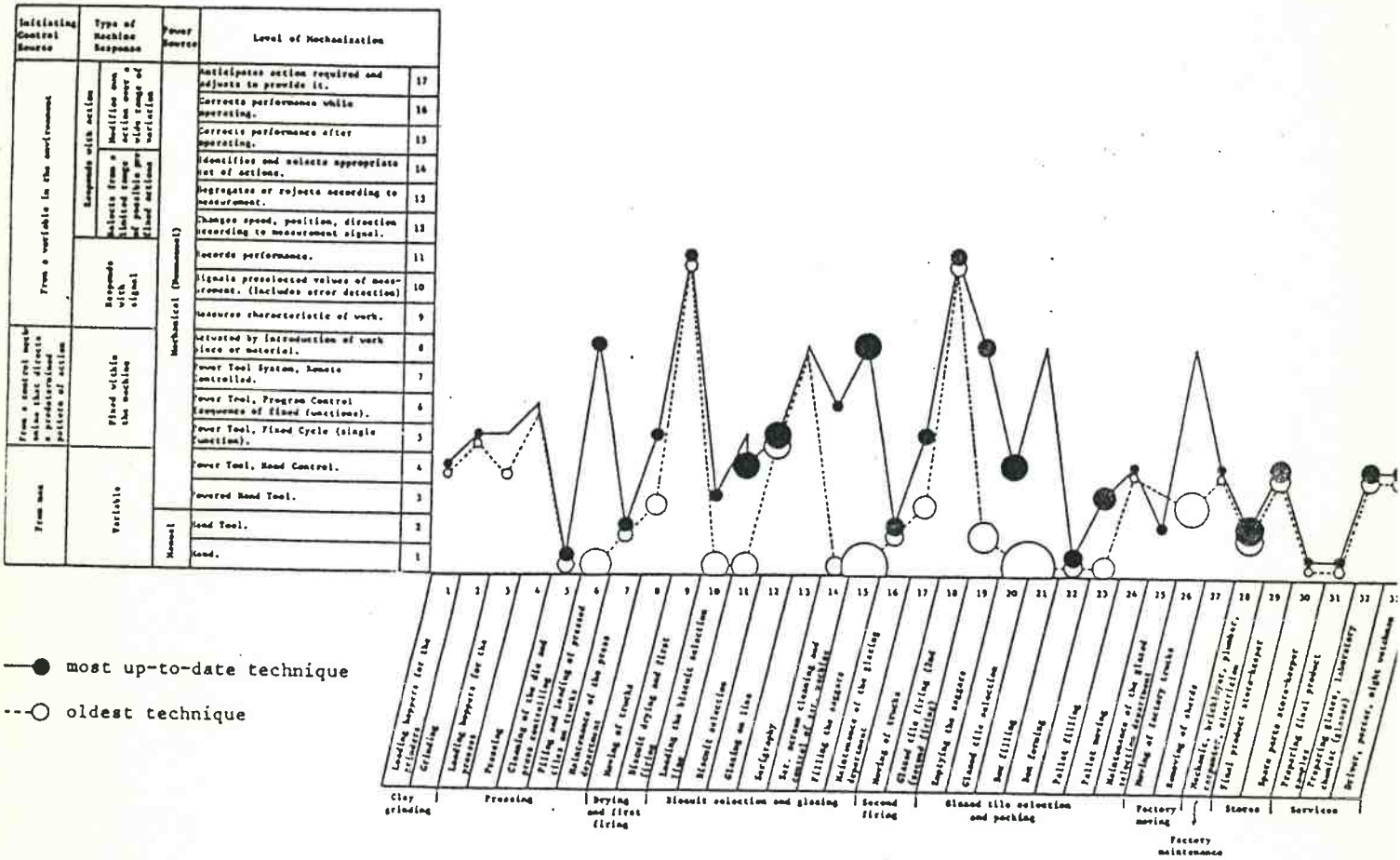
Source: Engineering data taken by interviewing technicians in the ceramic industry

Fig. 1 Levels of mechanization and their relationships to the worker intervention and the machine intervention in the production process



Source: Elaboration of Bright's figure (1958, p.46) made by Scortecchi (1961, p. 312)

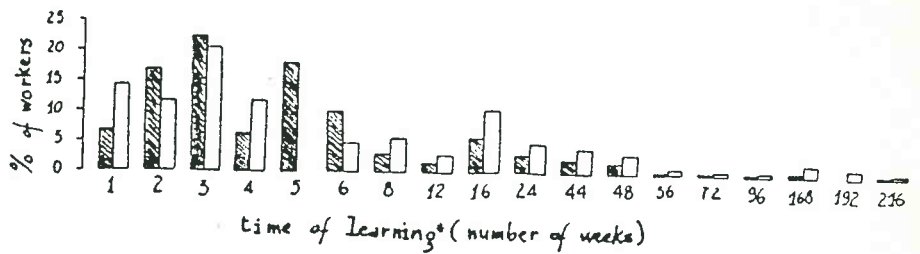
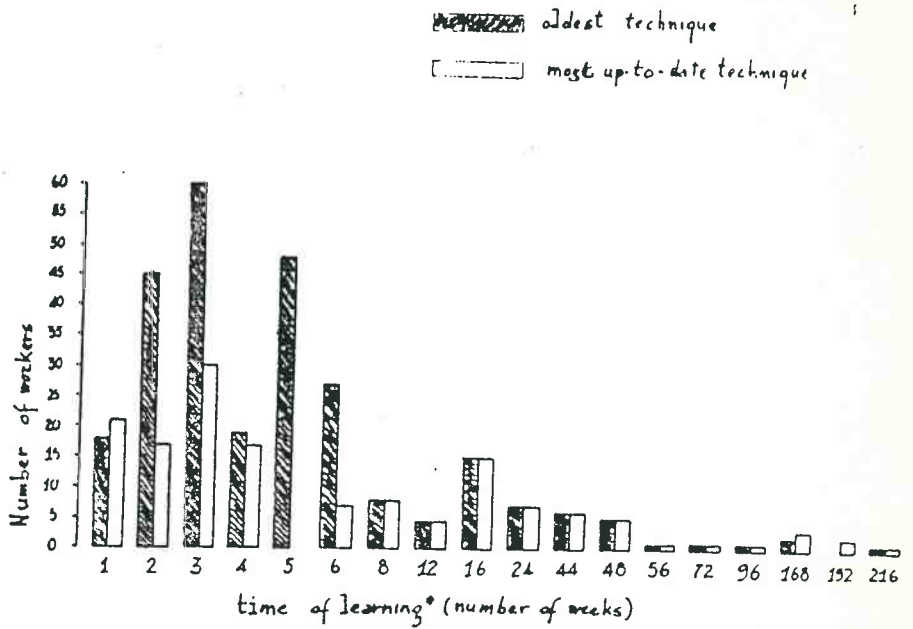
Figure 2 Profile of mechanization of the oldest and the most up-to-date techniques in use in the late 1970s to produce two-firing ceramic tiles



Source: Engineering data taken from my interviews with engineers in the ceramic and machine producer firms.
 Level of mechanization: see Bright, 1958, ch. 5.

Fig. 5

Time of learning* the individual tasks in the production of ceramic tiles. Comparison between the oldest and the more up-to-date techniques**



Source: Engineering data collected by interviewing technicians of ceramic tiles firms

* For the definition of "time of learning" see pp.
 ** The number of workers relates to an integrated plant of minimum efficient size

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