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New Production Concepts in the Machine Tool Industry

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Abstract

In this contribution, we comment on some results of the Belgian Trend Study. The intention of this study was to examine the prevalence of new production concepts within the widest possible range of companies in the automobile, the machine-tool, the chemical and the clothing industries. The Trend Study aimed to answer the question whether the Taylorist division of labour is a thing of the past and whether shifts in the division of labour are accompanied by another type of personnel policy. The methodological concept used had to guarantee that the findings at the level of each industry could be generalized. Although a brief comparison with the evolutions in the three other branches is built in, we restrict ourselves mainly to an examination of the penetration of new production concepts in the main processing fields of the machine-tool industry.

Introduction

For about a decade, differing analyses of the labour process have been put forward, all of which share one common viewpoint: that the principles of scientific management and its concomitant deskilling are not an immutable expression of the logic of capitalist development, but rather a response to historically specific circumstances. Whether due to the introduction of new technology, changes in the product market or changes in the labour market, the emergence of a new organizing principle is being suggested that entails not more, but less division of labour. Predictions about the re-emergence of craft work through flexible specialization (Piore and Sabel 1984), the spread of new production concepts in core industries (Kern and Schumann 1984) or the triumph of lean production (Womack, Jones and

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Roos 1990) are all imbued with an optimistic vision of more fulfilling and skilled production work in industry.

By consequence, concepts such as 'post-Taylorism' and 'post-Fordism' have been flourishing in sociology of work. It is in this climate that we have attempted to tackle the basic question as expressed in Kern and Schumann's (1984) *Das Ende der Arbeitsteilung?* Their observations in the chemical, automobile and machine tool industries led them to report a development which would threaten the dominant position of Taylorism as a production concept. They observed the rise of *new production concepts* and portrayed these as rationalisation processes which the companies in question were being forced to accept in order to keep their heads above water in the competitive international arena. At the same time, however, these concepts also offered workers new opportunities. According to Kern and Schumann, capital had after all arrived at a point where a further rise in labour productivity could only be achieved by utilizing what remained of 'living labour' in an entirely different fashion (Bader 1988). Labour could no longer be considered a risk factor, something to be kept in line by means of a maximum division of labour.

1. The extent of the change : evidence from the Trend Study

The debate on the rise of new production concepts has dominated European sociology of work, as much as the flexible specialization debate has dominated Anglo-American discussion (Campbell 1989; Lane 1995). The conclusions put forward by Kern and Schumann were strongly disputed in numerous other studies. Researchers who attempted to test the general validity of their widely discussed thesis concluded that the 'new production concept' distinguishes itself by its conceptual vagueness. But *Das Ende der Arbeitsteilung?* was criticized primarily because of the restricted empirical basis for its conclusions. The fact that these conclusions were based only on a limited number of in-depth case studies meant that the need for more representative data was acknowledged on all sides. Schumann's SOFI research team bowed to this criticism (Schumann et al. 1989; Schumann et al. 1991). In the *Trendreport Rationalisierung in der Industrie*, the SOFI team developed a methodology which they considered suitable for collecting representative data at periodic intervals on the production concepts applied in trade and industry (Schumann et al. 1994).

The gauntlet was taken up in Belgium as well. The *Trend Study* was launched in 1991, developing from a similar ambition regarding methodology and substance

(Huys, Sels & Van Hootegem 1995). With a view to achieving maximum comparability with the results of Schumann's research team, the Trend Study also focused on the automobile, the machine tool and the chemical industry. In addition, developments in the clothing industry were studied. The Trend Study aimed to answer the following questions: Is the Taylorist division of labour a thing of the past ? Are shifts in the division of labour being accompanied by another type of personnel policy, and do traditional industrial relations have to make way for this new approach ? The methodological concept would have to guarantee that the findings at the level of each industry could be generalized.

For the Trend Study team, the initial task was to tackle the two basic problems of *Das Ende der Arbeitsteilung?*, namely its conceptual vagueness and its restricted empirical basis. The main challenge was to describe the term 'production concept' in such a way that it would be possible to distinguish traditional from new production concepts. A second task was to develop a methodology, suitable for collecting representative data at periodic intervals on the production concepts applied in industry. This section is structured in the following way: first is a brief summary of the multidimensional analytical framework used to distinguish traditional from new production concepts; the second part comments on the methodology of the Trend Study.

1.1 Conceptual fine-tuning

The ultimate aim of an industrial company is to produce products. This is its *executive* function. Production, however, unavoidably depends on a number of contiguous functions. It must be *prepared* (e.g. planning, work distribution), *supported* (e.g. quality control, maintenance) and *organized*. Complex organizations rarely divide, group and link these functions in a disorderly or serendipitous fashion. As a rule, there is a recognizable configuration - the *structure of the division of labour* - which can vary over three dimensions: production organization, work organization and production technology (De Sitter 1994).

Production organization

Depending on how the functions of execution, preparation, support and organization are divided over various divisions, a variety of production organizations emerge, each with its own consequences for the quality of the organization and for the work itself. The following configurations exist.

As far as the *supportive* and *preparative* functions are concerned, firms can choose between concentration and deconcentration. These functions can be concentrated into separate staff departments, giving rise to such classic divisions as production planning, product development, maintenance, quality assurance, equipment management, training and so on. These departments offer support or prepare the work of all production divisions. Another option is to allow these functions to be merged with production. In that case we speak of deconcentration. Each production division is responsible for its own maintenance, quality assurance, and so on. The transition from traditional to new production concepts implies such a deconcentration process. The new element is to be found in the integration of supportive and preparative departments on the one hand and production facilities on the other (Schumann 1988).

As far as the *executive* function is concerned, firms can choose between three basic structures, by which we mean alternative ways of organizing the flow of the production process; of splitting up, regrouping and linking executive operations:

- In an *operation-oriented* structure, identical operations are grouped into production divisions. Each division specializes in one or a few operations. When applied to metal cutting and shaping, for example, this means that operations involving turning, milling, drilling, etc. are each grouped into their own category. Orders of largely non-identical products pass through all or a few of these specialist production divisions in a series. The order of sequence is relatively open. The operation-oriented structure is more amenable to this type of flexible linking than are the flow-oriented and product-oriented structures. But this high level of flexibility comes at a price: a relatively low level of productivity. Operation-oriented structures are often plagued by long routing times and large intermediate stocks.
- As soon as the sequence of operations is more or less fixed, the operation-oriented structure loses much of its flexibility and tends to develop into the second variant, the *flow-oriented structure.* The products go through all of the necessary operations in a fixed and sequential order. The link is clear: there is one sequence, one route, the entire affair is highly structured but at the same time non-adjustable. The strength of the flow-oriented structure is said to be a relatively high potential productivity. Its weakness is the limited product mix and volume flexibility.
- In a *product-oriented* structure, one product is (largely) finished in a clearly demarcated processing phase. Each production division makes one type of product. The operations and machine tools required to perform that one

product are grouped together. The link between the processing steps is once again clear. The process moves in one direction, but takes multiple routes.

The trend towards product-oriented structures should entail a drastic simplification of planning, shorter routing times and reduced stocks. As such, these structures are more capable of meeting present-day market demands. Instead of the traditional concept's constant striving for specialization at work stations, this approach groups together non-similar operations which contribute to producing a product. Since it groups together non-similar tasks, it paves the way for job enlargement and, as such, is seen to be a prerequisite for a new concept in the division of labour.

Work organization

A far-reaching degree of concentration has its effects on the work organization. The work organization stipulates how the tasks *within* production divisions are grouped into jobs. If companies opt for a maximal concentration of supportive and preparative tasks, production divisions are supposed to direct all their efforts towards execution or production. *Segregated jobs*, consisting exclusively of executive tasks, are the result. Taylorism advocates such a removal of indirect tasks from production jobs.

Once preparatory or supportive functions are deconcentrated and integrated into production divisions, there is more room for *integrated production jobs* consisting not only of executive tasks, but also of preparatory (e.g. programming) and supportive (e.g. maintenance) tasks. While deconcentration is a necessary prerequisite for more integrated production jobs, it is by no means sufficient. A move towards deconcentration may well lead to more heterogeneous production groups, while leaving the profiles of most production jobs unaltered. For example, this is the case when the deconcentrated programming tasks are allocated to specialized programmers, who nevertheless work in the production division. Only when the separate job of programmer has been 'dismantled' can the path be cleared to creating integrated jobs for the production workers.

Choices have to be made not only concerning the integration of preparative and supportive tasks, but also concerning the number of executive tasks to be integrated into production jobs. Here, a company has basically two possibilities: very *narrow* jobs, i.e. those in which the employee specializes in a single task, or *broad* jobs, which consist of multiple executive tasks. Since in flow and operation-orien-

ted structures production divisions specialize in one or a limited number of operations, these are admirably suited to fulfilling the Taylorist ideal of narrow jobs (consisting of short-cycled, repetitive tasks).

Production technology

Any consideration of the division of labour cannot afford to ignore the division of labour between 'man and machine'. The number and nature of the tasks which remain in human hands hinge largely on the nature of the technical systems used, or, more precisely, on the way in which these systems are embedded in the organization. This requires us to make a distinction between *inflexible* technology, i.e. technology which is fixed by the mechanical structure of the machine itself, and *flexible* technology, which in the first instance refers to programmability.

Kern and Schumann (1984) were among those who identified flexible automation as the unmistakeable motor driving the trend towards new production concepts, since it facilitates the technical integration of various process segments. Moreover, the ease with which new technologies can be reprogrammed is said to allow volume producers to achieve a hitherto unheard level of product variation (Streeck 1989). The technological 'motor function' merits a closer look, however. It is important to note that the flexibility of freely programmable technology is no guarantee for the overall flexibility of the production system. Such flexibility can only be achieved in a production organization which allows the versatile use of such technology. Conversely, an inflexible organization will not necessarily become flexible by introducing flexible technology. The flexibility of such new technology would show up best in a product-oriented structure (De Sitter 1994).

Towards a multidimensional analytical framework

The various dimensions of the division of labour can be assembled to form a multidimensional analytical framework which enables us to describe both traditional and new production concepts.

Table 1. Traditional concept versus new concept

	Traditional concept	New concept
Production organization		
Structure of execution	Flow- or operation-oriented	Product-oriented
Support structure	Concentrated	Deconcentrated
Planning structure	Concentrated	Deconcentrated
Decision-making	Centralized	Decentralized
Production technology		
Nature of technology	Rigid mechanization	Flexible automation
Work organization		
Job scope	Small	Broad
Composition of jobs	Segregated	Integrated

The ingredients of the normative new production concept are: deconcentration, decentralisation, product-oriented production, flexible automation, broad and integrated jobs. It is important to note that, in the present BPR-debate, these ingredients are seen as central features of the re-engineered flexible production system too. According to Hammer and Champy (1993) such flexible production systems are brought about by changing work units from functional units to process teams (product-oriented production); jobs from simple tasks to multidimensional work (integrated jobs); organizational structures from hierarchical to flat (deconcentration) and executives from scorekeepers to leaders (decentralization) (Francis and Southern 1995: 115).

1.2 Survey research required

It was the Trend Study team's intention to make this conceptual framework sufficiently generic. It had to provide a superior basis for intersectoral comparison and hence to be applicable to a variety of organizational types. To ensure that the framework was in fact capable of performing this function, an operational instrument had to be derived from it for field research. The operational instrument finally had to undergo a translation for each industry before standardized questionnaires could be drafted for the respective industries. The search for new production concepts called for the formulation of fairly branch-specific questions. However, backing up each branch-specific translation with the same generic framework guaranteed comparability.

To acquire enough familiarity with the field, the researchers carried out extensive case studies (interviews and observations in several companies) prior to their survey research. The case studies were an indispensable step in translating the generic framework into a branch-specific questionnaire. Their purpose was to

show the research team how to map out the production processes involved using a standardized questionnaire. Research into organizational change becomes less nuanced when questionnaires are used, but thorough preparation by means of intensive case studies can perform miracles. What happened in the Trend Study is that the insights gained in the case studies were tested for their general applicability by using standardized questionnaires.

Two different questionnaires were used. The first, which focused on the employment relationship and company-level industrial relations, went to the personnel manager; the second, which focused on the production concept, to the production manager. The questions were restricted to an exploration of the facts as they stood at the time. There were no questions dealing with expectations for the future. It seemed to us that it would be more accurate to repeat a reliable series of snapshots periodically - this is why the project is named a *Trend* Study - and determine the shifts ourselves in the future.

Table 2. Number of observations.

	Chemical industry	Automobile industry	Machine-tool industry	Clothing industry
Number of companies	77	5	47	54
Number of divisions	154	15	104	123
Number of employees	11.373	32.420	5.975	5.467
Response ratio	75%	100%	33%	90%

An intensive interviewing approach was worked out. Before distributing the questionnaires, a number of assistants were 'hired in'. Their job was to insist on personal appointments with possible respondents. During these appointments, they provided the respondents with additional information on the questionnaire. It should be noted that the questionnaires were not filled in during the appointment. A strictly defined follow-up procedure was rewarded by a considerably high rate of response. Various details are presented in Table 2.

2. New production concepts in the machine tool industry

In this contribution, we focus on the results of the survey organized in the main processing fields of the machine tool industry : mechanical production (metal cutting and shaping) and assembly. Three hypotheses will be tested, covering the main features of the new production concept as presented in Table 1:

- *H1*: Machine tool companies are increasingly making use of the opportunities for flexible automation, allowing not only the small batch producers but also the volume producers to achieve a hitherto unheard level of product variation.
- *H2*: In order to meet present-day market demands, machine tool companies break with highly operation-oriented structures and introduce product-oriented production.
- *H3*: Supportive and preparative departments on the one hand and production facilities on the other are becoming integrated to a large extent. Within the production facilities, this trend is resulting in integrated production jobs.

If we manage to find evidence of a high degree of flexible automation (*H1*), a substantial penetration of product-oriented production (*H2*), deconcentration and job integration (*H3*), we can actually say that the new production concepts have effected a breakthrough.

2.1 H1: Flexible automation, diversified quality production

Since CNC machine tools have been introduced in the machine tool industry, there has been much discussion of their influence on flexibility and quality[2]. CNC machines are thought to be particularly well-equipped to meet the *flexibility* demand without conceding the traditional trump cards of automation: 'cheaper' and 'faster'. CNCs are relatively easy to reprogram, making it possible to set the machine tool in a variety of ways and for a variety of products. Introduction of CNC tools makes it also possible to satisfy the strict demand of consistent *quality*. If conventional machine tools are used, the accuracy, quality and time required depend to a great extent on the capacity of the machine operator, meaning that these factors may vary from day to day, worker to worker, and workpiece to workpiece. In CNC systems on the other hand, it is the quality of the program that largely determines the quality of the result.

According to Streeck, such flexible technologies make it possible for companies to manufacture large volumes of customized products of competitive quality. The ease with which these technologies can be reprogrammed allows volume producers to achieve a hitherto unheard level of product variation. The result, according

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[2] In this contribution operations centres as well as flexible manufacturing modules, cells and systems are all referred to as CNC machines. In the companies investigated, the CNC machines are good for 37%, the operations centres for 54% and the flexible manufacturing modules for 8% of the total number of machine tools.

to Streeck (1992: 6), is "a restructuring of mass production in the mould of customized quality production, with central features of the latter being blended into the former and with small batch production of highly specific goods becoming enveloped in large batch production of basic components or models". Thanks to flexible automation, it is becoming possible to satisfy the new market demands within the context of large-scale production (Appelbaum and Batt 1995). In addition, the new technology is giving small-batch producers the opportunity to engage in cost-price management. The traditional contrast between productivity and flexibility can be bridged in this fashion (Sorge and Streeck 1988). This model was christened *diversified quality production.*

To verify Streeck's prediction - as to whether a rise of flexible automation is leading to diversified quality production -, we first have to explore if there is a considerable rise in flexible automation. According to the Trend Study data, it is clear that machine tool companies are increasingly making use of the opportunities for automation presented by CNC technology when replacing old machinery. However, this has not yet led to a radical, almost complete automation of the metal cutting and shaping process. In the 47 companies investigated, NC and CNC machine tools are good for 29 per cent of the machinery. The principal part of the machinery is still composed of conventional technology. New and conventional technology complement one another to a certain extent. (C)NC machine tools are more likely to be used to process large batches and complex pieces or when working within narrow tolerances. Conventional machinery is preferred for one-time or simple pieces. It is striking to note that (C)NC technology has penetrated smaller companies (i.e. less than 60 employees in production jobs) just as deeply as larger ones. When it was first on the rise, it was frequently considered unattainable for small companies. They seemed afraid of taking on the social reorganization which accompanies the introduction of this technology. The inherent difficulty of programming the machine tools and the high cost of hardware had a similar effect (Noble 1983).

Despite the increasing use of the opportunities for automation presented by CNC technology, we can call Streeck's proposition into question in two fashions. Firstly, the combination of a high level of customization and a large volume of production still is more of an exception than the rule. The indicator 'volume of production' (the quantity of goods produced) is in the case of machine tooling very misleading owing to the large variety of goods produced. In the Trend Study, we looked at company size as an approximate indicator. With respect to the second element of Streeck's typology (level of customization), we have applied

a composite 'flexibility performance index'. To complete this index we looked at several parameters: the number of different end products that a company produces, the percentage of end products which can be considered customized and the percentage of production which can be considered on order. If a company scored high on these requirements, then it was categorized as a 'flexible' one. According to the Trend Study data, Streeck's proposal must be tempered somewhat for the machine tool industry. The 'flexible' companies are concentrated among the smaller ones, while the majority of the larger companies score relatively poorly on the flexibility index. The combination of a high level of flexibility and large-volume production still seems more of an exception than the rule. The same holds for diversified quality production, hence. The data collected show that this strategic turnaround has not gained very much momentum. Although there are undoubtedly signs that some large-scale mass producers have succeeded in offering more product variety, the wall between small volume customized production and standardized mass production has not displayed many chinks.

Secondly, Streeck's proposition takes no account of the fact that not every industrial process is equally accessible to (flexible) automation. Metal cutting and shaping is, for example, but assembly is not. Automation is fairly rare in the assembly shops of the machine tool industry. Table 3 compares the type of work performed in the machine shops to the type of work performed in assembly.

Table 3. Type of work performed in metal cutting and shaping versus type of work performed in assembly (percentage of production workers in 47 machine tool companies) [3]

	Metal cutting and shaping	Assembly
Performing manual labour	10%	80%
Working with conventional machines	46%	17%
Working with numerically controlled machines	44%	3%

Forty-four per cent of the machine shop employees operate one or more (C)NC machine tools. This figure was entirely in keeping with expectations (Schumann et al. 1989). Assembly presents an entirely different picture. Manual labour is the rule here, and working with numerically controlled machines the exception. Even

[3] In order to construct this Table, production managers were asked to count the number of employees in the respective production area's and to qualify them as 'manual labourers', 'operators working with conventional machines' or 'operators working with numerically controlled machines'. Table 5 was constructed in the same way.

at companies where the high-tech era has dawned in the machine shops, the assembly shops continue to be low-tech area's. The conclusion is that flexible automation can scarcely be the 'bridge' that Streeck thought it was, linking the entire process. Does that mean that flexibility and productivity are incompatible goals? Not necessarily. It does mean that the rationalisation concepts which are supposed to have bridged the gap between the two will not be technologically driven in assembly. The solutions there will have to be organizational ones.

2.2 H2: Product oriented structures of production

Kern and Schumann (1984) identify flexible automation as the unmistakeable motor driving the trend towards new production concepts. Authors like Sorge and Streeck (1988) add to this proposition that, thanks to flexible automation, it is becoming possible to satisfy the demand for more custom-made product varieties within the context of large scale production. However, in elaborating our conceptual framework, we have warned of the pitfalls of technological reductionism. The flexibility of the new technology is very much determined by the flexibility of the structure of the production process. We stated that there are alternative designs for this structure. In an operation-oriented structure, identical operations are grouped into production divisions. In the flow-oriented variant, the products go through all of the necessary operations in a fixed and sequential order. In a product-oriented structure, each product is (largely) finished in a clearly demarcated processing phase.

These alternatives do indeed have different effects on productivity, flexibility, routing times, and so on (Rommel et al. 1995). In general, the product-oriented structure is more capable of meeting present-day market demands (De Sitter and Den Hertog 1990). Since it groups together non-similar tasks which contribute to producing a product, it paves the way for job enlargement. It is, therefore, often seen as a prerequisite for the new production concepts (Christis 1988). Table 4 explains how machine tool companies do structure their machining and assembly operations.

Table 4. Percentage of companies opting for a flow oriented, an operation oriented and a product oriented structuring of the machining (n= 29) and the assembly process (n=35)

	Metal cutting and shaping	Assembly
Product-oriented structure	23%	48%
Operation-oriented structure	34%	35%
Flow-oriented structure	43%	17%

Table 4 confirms that in machine shops the operation-oriented structure still is the most common one. In 43 per cent of the companies with multiple metal cutting and shaping divisions, these divisions are specialised in specific operations. Only in 23 per cent of these companies, each product order is assigned totally to one fully equiped division. The product-oriented structure has made deeper inroads in assembly. In one out of two companies with multiple assembly divisions, each product order is assigned totally to one fully equiped assembly division.

It should come as no surprise that the product-oriented structure occurs less frequently in the machine shops. It is difficult to achieve maximum utilization of machine capacity in a product-oriented structure, and that is an obstacle to its being implemented in relatively highly automated machining processes. The problem machine tool companies are facing in this context can be explained with the assistance of a highly typical story of a Belgian machine tool company. At the time that it introduced numerically controlled machines, the company attempted to break with the highly operation-oriented structure and introduce a product-oriented structure, which was seen as an excellent means of reducing the complexity of the process. Thirteen product units were set up. At the same time, the company also found itself facing the difficult task of turning its conventional machinists into CNC operators. There was no guarantee that the conventional machinists would be capable of handling the digital, abstract information required when working with numerically controlled machines. This lack of confidence was translated into a model calling for a maximum division of labour. The setting of the equipment, the programming of the machine tools and the quality control responsibilities were concentrated in specialized staff functions or departments.

The combination of product-oriented production and a far-reaching division of labour turned out to have negative effects, however. Management was especially concerned about the product-oriented structure. It just didn't seem possible to supply enough manpower and machines to keep each product unit running under its own power. As a consequence, the units were constantly borrowing from one another, exchanging employees and machines in order to meet pressing capacity demands. What had been intended as an uncomplicated, extremely manageable

product-oriented structure took on more of the 'cris-cross' nature of operation-oriented structures. Product-oriented production failed. Operation-oriented production was restored to its former glory. But also for the concentration of quality control tasks, a heavy price had to be paid. The quality inspectors checked the first piece of a batch. If the quality was up to standard, batch production continued. If something went wrong during batch production, not only the passive operator missed it, but frequently the quality inspector as well. That had repercussions. The company had to learn to live with an extremely low yield, as quite a few workpieces were rejected after quality inspection because they did not meet the specifications.

With a view to effecting a dramatic increase in the yield, the company decided to reassign the quality control and setting tasks to the CNC operators. One thing led to another. Once the operators were allowed to perform quality inspections, then it seemed logical to allow them to optimize programs, in other words adjust quality, as well. And what happened then, probably to the great merriment of the promotors of product-oriented production ? The company decided to risk introducing a product-oriented structure again. The rediscovery of the integrated operator job was a major factor in this decision. It is, after all, much easier to balance parallel product units in a situation where 'everyone can do (almost) everything'. Product-oriented production no longer had to be linked with crippling capacity problems. This brings us to the third hypothesis, the one concerning the penetration of integrated jobs in machining and assembly.

2.3 H3: Integrated, broad jobs

Upon the introduction of CNC machine tools, a number of tasks disappear. New tasks are added to what remains of the old ones. The package of tasks which emerges consists of: operating and monitoring the machine tool, setting the equipment, programming, testing and correcting programs and monitoring quality. Research appears to be particularly interested in whether the operators perform the programming tasks themselves. There are many arguments in favour of this interest. Programming is, after all, the most complex task and whether or not an operator is allowed to do the programming himself determines the complexity of his other tasks to a large extent. If the operator does not program himself, then he will have to clamp the workpiece and choose and set the equipment according to detailed instructions supplied to him by the programmer. The integration of programming tasks is consequently a highly relevant object of research, especially

if the purpose of the study is to be able to draw conclusions about the 'enrichment' or 'impoverishment' of the operator's job.

Companies working with (C)NC processes may opt for complete concentration, whereby the programs for all machine shops are written by the staff of one specialized programming office. A first move towards deconcentration implies that this programming department is split up and that each of the machine shops is allocated its own 'customized' programming office. A second step is that the division between programming and production is eliminated, with the programming work falling entirely within the control of the machine shops (workshop programming). But even in the event that companies introduce a system of workshop programming, the operators not necessarily do the programming themselves. The task of programming may be allocated to specialized programmers, who nevertheless work for the production division. Only after the separate function of programmer is dismantled, the path has been cleared to job enrichment through the integration of programming tasks into the operator jobs.

The Trend Study survey allowed us to estimate the relative scope of workshop programming. Sixty-four per cent of the companies investigated has opted for a system of workshop programming. Most striking is the fact that all the smaller companies have done so, whereas the companies which maximize concentration tend to be larger ones (i.e. more than 60 employees in production jobs).

Table 5. Integration of setting and programming tasks in the operator's job (percentage of operator jobs, counted over 47 companies)

	Smaller companies	Larger companies
Operating/monitoring	7%	5%
Operating/monitoring and setting	40%	77%
Operating/monitoring, setting and programming	53%	18%

The result of this difference in production organization between smaller and larger companies is that the share of operators who do their own programming is considerably higher in the smaller companies. Production managers of the companies investigated were asked to indicate what percentage of their CNC operators perform programming tasks or set the equipment. The result is presented in Table 5. In the smaller companies more than half of the operators are in charge of programming-related tasks. In the larger companies that is less than one in five. If we perform an abstraction on the difference between smaller and larger companies, the integration of setting tasks appears to be the rule (73 per cent of the

operators). The rudimentary operating/monitoring job is the exception (6 per cent). Twenty-one per cent of the operators perform setting and programming tasks. Their jobs may be considered completely integrated. About one in four companies has opted for full integration. Comparable research in the Netherlands and in Germany has provided evidence of even less division of labour. Alders, Christis and Bilderbeek (1988) remark that about half of Dutch machine tool companies use the integrated option. According to Schultz-Wild (1988), the practice of permitting the programming of CNC machines by operating personnel is widely accepted in Germany too (in 70 per cent of machine-tool firms; quoted by Müller-Jentsch et al. 1992: 96).

In reality, programming consists of a cluster of operations of widely varied complexity and difficulty. They vary from communicating processing deviations to adjusting the targeted parameters and complex programming work. The following diagram therefore refines this concept somewhat by presenting a hierarchy of programming tasks: from 'almost always integrated into production jobs' to 'frequently removed through concentration'.

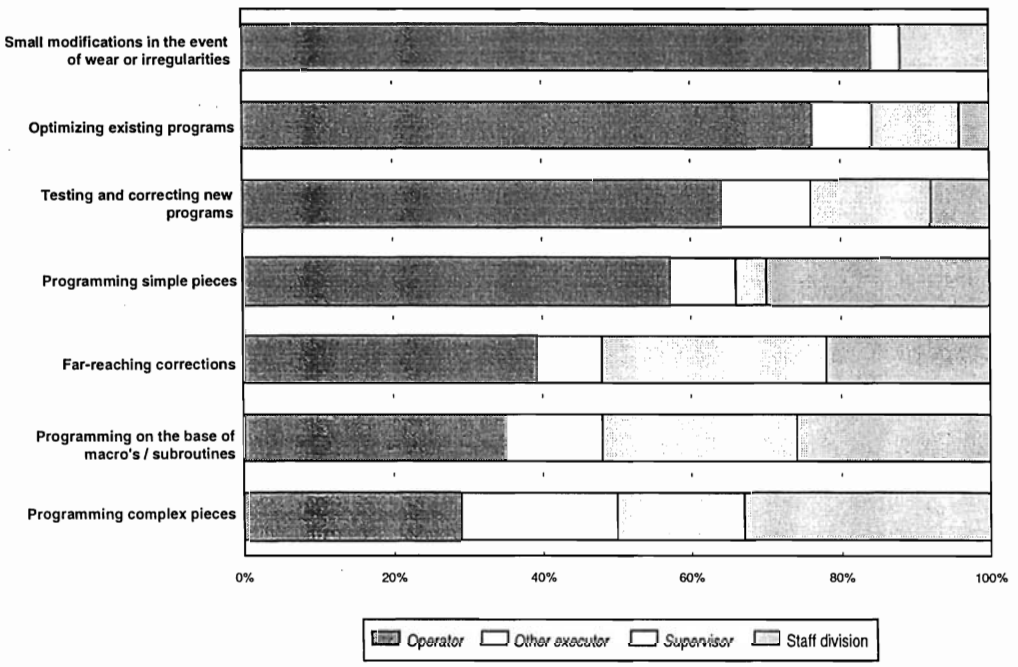

Figure 1. Options of companies with regard to programming tasks : who is responsible for the task ? (percentage of companies)

The figure makes one thing clear from the start. Dividing operators into 'those who may' and 'those who may not' program does not do justice to the complexity

of the real situation. This division takes on other forms depending on how the research defines the concept of 'programming'. If adding small changes in the event of wear and tear or irregularities, or working in and optimizing existing or new programs are included in the definition, then we can say without exaggeration that machine tool companies are tending towards integration of programming tasks in the operator jobs. Even programming simple pieces is as a rule left to the operators. Machine tool companies are, however, much more restrictive when it comes to adding far-reaching corrections, programming based on program macros or programming complex pieces. Conclusion: in the majority of companies, tasks related to programming are *partially* integrated.

Even if we acknowledge differentiation in the group of programming tasks, the differences between smaller and larger companies remain. It is, however, especially striking how the gap between 'small' and 'large' increases along with the complexity of the tasks. The task of programming complex pieces is left to the operator only in the smaller companies. Remarkably, however, about half of the large companies allow their operators to work in and test new programs and correct geometrical and technical parameters. Even the optimization by operators of existing programs is common practice. While the large companies have not introduced full integration, they frequently tend to choose a model of *flexible cooperation* between the operators on the one hand and the programming office on the other. The office drafts source programs which are geometrically or technically incomplete, and these are worked in by the machinist, who optimizes and even corrects them. The division of labour between the programming office and the workshop is retained, but the wall dividing the two is made permeable. The result is a planning process 'at two levels' (Hirsch-Kreinsen and Wolf 1987), whereby the operator assumes increasing responsibility for the process.

All things considered, the division of labour in the machine shops is far from extreme. In general, not only the programming tasks, but also the support tasks like machine maintenance and quality control are fairly well integrated. As far as the assembly shops are concerned, the claim put forward by Kern and Schumann (1984: 149) that assembly is a bastion of skilled craftsmanship cannot be contested on the basis of the Trend Study data either. Schumann's research team situated no less than 92 per cent of the assembly jobs at the skilled *Facharbeiter*-level (Schumann et al. 1989). Whether this conclusion applies without any modification to the Belgian machine tool industry is difficult to say on the basis of the Trend Study data. If we analyse the job content, however, we can say that the assembly work is mainly long cyclic, skilled work. Since product-oriented production is

dominant in assembly, this should not suprise. Moreover, most companies prefer fairly far-reaching forms of integration. Planning tasks have largely been integrated in the assembler's job. In the majority of the companies, it is the assembler himself who chooses and (albeit less frequently) sets the equipment he needs before beginning his work. It is generally also the assembler who inspects the equipment and adjusts and/or fine-tunes it accordingly. Even equipment maintenance is in the hands of the assembler in almost half the companies.

Numerous machine tool companies had tried in the second half of the eighties to break with this dependence on skilled assembly work. They conducted a variety of experiments with modules, computer-controlled monitoring instruments which were supposed to determine the performance of the machines produced, systems of product documentation which made it possible to establish quality standards and production specifications, improved production logistics by using PPS systems, etc. All these interventions led to some intensification of assembly work. The repercussions of these rationalisation attempts were, however, largely felt on the 'periphery' of the actual assembly process. The prevailing organizational concept, shored up by such terms as autonomy and job integration, did not really suffer, however. But the search continues.

3. New production concepts ...

In these concluding sections, we will focus on a general final assessment, in particular on the question whether and to what extent there is evidence of new production concepts in the machine tool industry. Firstly, we will do so by contrasting the data on the machine tool industry with the results of the surveys organized in the three other industries (§ 3); secondly, by confronting the current ways of organizing work and production with the typical features of the traditional production concepts in the machine tool industry (§ 4).

As far as the automobile, the chemical and the clothing industry are concerned, the transformation which companies are supposed to undergo to acquire the necessary flexibility is not quite as spectacular as the thesis on the new production concepts might leed us to believe. The *automobile industry* has taken important steps. Staff departments have been slimmed down and split up to separate production areas. Subsequent process parts such as welding, painting and assembly have become partly self-sustaining with regard to maintenance, quality control, engineering and even personnel policy. This is the often stated ambition to establish 'small plants within the plant'. This process of deconcentration does not

necessarily imply that production jobs have become more integrated and therefore involve quality control, maintenance and other indirect tasks. In fact, this is not the case at all. The continuing domination and further 'intensification' of the assembly line (flow oriented structure) makes such forms of task integration hard to accomplish. Through reduction in stocks, if possible without any buffer, workers in other subassemblies are tied equally directly to the main process flow. The pacing effect of the main assembly belt is increasingly spreading to all areas and corners of the plant. More workers than ever before are finding themselves confronted with short-cycled and tightly paced work.

There is even much less evidence in the *chemical industry* that any process of deconcentration, decentralization or job integration is taking place. The trend towards deconcentration, mentioned in the automobile industry, is currently no concern for the chemical industry. Preparation and support for production are located in separate staff departments. Splitting up support and planning vis-à-vis 'bits of the production line' is not always feasible in the integrated processes of the chemical industry. Moreover, chemical plants have a particularly heavy hierarchy, with a limited span of control. Important decisions on the running of the process are taken by supervisors who are present round the clock. This tight surveillance on decision-making is motivated by the great safety risks related to the operator's job. The absence of deconcentration and decentralization processes means that there is also little evidence of integrated jobs. The involvement of production workers in the field of mechanical maintenance is restricted. A similar picture emerges with regard to quality analysis of products, the maintenance and programming of the measurement and control equipment, etc.

As far as the *clothing industry* is concerned, a mix has been established between the manufacturing of standard products in low wage countries and upmarket specific products tailored to individual customer needs, as well as quick deliveries in Western countries close to the market. Quick response market demands are indeed a reality for most of the Belgian clothing factories. To achieve the necessary flexibility one would expect changes in the division of labour. Surprisingly, steps in this direction can hardly be detected. The production lay-out remains basically operation-oriented. The emphasis is on maximizing machine-utilization in tying seamstresses to their sewing machine. For the invested capital to yield, full capacity utilization through repetitive and short-cycled work seems an absolute necessity. The concept of 'standing work', as advocated by the Toyota Sewing System, which enables workers to switch swiftly between machines, is utilized by a mere seven out of the 123 sewing sections investigated. The general picture

remains one of restricted interdependance between workplaces and limited possibilities for seamstresses to coordinate work. By consequence, the concept of self-sustaining teams with discretionary power to plan, distribute and control their own work is still a far away vision in most factories.

Both scholarly literature and the media make reference to a fundamental transformation which has come over our labour system, conjuring up terms like post-Taylorism and post-Fordism. The 'new employee' and the 'factory 2000' are being hailed with great enthusiasm. These supposed developments are being linked to other fundamental changes in our society. The critical observer who hopes to find the empirical observations that support these pronouncements is generally disappointed, however. From the very beginning, the Trend Study team had the ambition of entering that debate with arguments based on empirical evidence on the depth and speed of the predicted transformations. The empirical evidence on the production concepts in the automobile, the chemical and the clothing industry make it possible merely to suggest a 'neo' rather than a 'post'-Taylorist concept. It is beginning to look more and more like improvements in flexibility and quality of production can in fact be achieved without departing from the structuring principles of the Taylorist concept.

At first sight, the new production concepts only have effected a breakthrough in the machine tool industry. Table 6 summarizes the scores which are essential for a final assessment on the machine tool industry, incorporating the basic dimensions of the 'new production concept' as explained in Table 1. The categorization is generalized. The description relates to a majority of the plants researched.

Table 6. Summary of the results on the machine tool industry.

	Metal cutting and shaping	Assembly
Production organization		
Product-oriented production	-	+
Deconcentration of support	+	+
Deconcentration of planning	+	+
Decentralisation of decision-making	+	+
Production technology		
Flexible automation	+	-
Work organization		
Broad jobs	-	+
Integrated jobs	+	+

The image of assembly seems to be the diametrical opposite of that of metal cutting and shaping when it comes to both production technology and the structuring of the production process: a low level of automation versus highly auto-

mated, and largely product-oriented versus largely operation oriented. What's more important is that the picture of forms of production and work organization shows a consistent move in the direction of (partially) integrated jobs, deconcentration and decentralization. These are the crucial features of Schumann's 'new production concept'. According to Schumann (1988), the new elements are to be found, above all, in the integration of support, work planning and programming departments on the one hand and production facilities on the other (deconcentration) and in the integration of planning, programming, maintenance and/or quality control tasks into production jobs on the shop floor (integrated jobs). Of the four branches investigated, the machine tool industry has the widest distribution of integrated jobs. The crucial question, however, is whether this is all that new.

4. ... or timeless craftsmanship ?

In the debate which followed the publication of Kern and Schumann's book, one of the questions which received too little attention was whether the industries investigated (automotive, chemical and machine tool) could be lumped into the same category. We don't think so. Kern and Schumann were wrong to assume that Taylorism, in the form of a maximum division of labour, constituted the 'old' production concept in each of the three branches, and that the new concepts in each branch could only really flourish after confronting their common Taylorist past. This past is actually not so common as one may think (Lutz 1988). The production concept which aims to achieve a maximum division of labour has played only a subsidiary role in the machine tool industry. Machining, for example, has a tradition of skilled craftsmanship which long resisted any encroachment by Taylorism. Taylor, who attempted to crush the machinist's skills monopoly, did not succeed in his efforts. He came to the conclusion that there was no 'one best way' when it came to small-batch processes, and that one could only formulate 'slide rules' (Braverman 1974). Process technicians and labour analysts who came after him never succeeded in crushing the power of the conventional machinist. Conventional machining has hence always served as a model for work organization based on craftsmanship, a limited division of labour and few hierarchical levels - precisely the characteristics that Kern and Schumann ascribe to the *new* production concepts.

It is precisely the introduction of NC and CNC technology which has breathed new life into the Taylorist dream. The opportunities for a more far-reaching divi-

sion of labour are considerably greater when numerically controlled machine tools are used. Numerical control does indeed allow one to organize shop floor activities in such a manner that management gains greater control over both production and the workers. It is, then, precisely numerical control which is labelled as management's umpteenth attempt to take the workers' power over the production process away from them (Noble 1983).

There is nothing inherent in CNC technology, however, that makes it *necessary* to assign the tasks of programming, setting, operating, monitoring, resetting, and so on to different jobs or departments. Numerically controlled technology only makes such a division of labour *possible*. In that sense, there is an essential difference between CNC and NC machine tools. With NC machine tools, the strong division of labour is in fact the unavoidable result of the time-consuming programming method associated with numerical control and the quasi-impossibility of making any major alterations to the machine tool. In that respect, the CNC machine tool is much less coercive. It too can be controlled by using a maximum division of labour. However, if full advantage is taken of the opportunities for workshop programming, then it is possible that, with the transition from NC to CNC, the pendulum is swinging back again: from a minor division of labour for conventional machine tools to a major division of labour for NC machine tools to the gradual reduction of the division of labour for CNC machine tools.

On the basis of the data presented in this contribution, one can conclude that machine-tool companies do not take 'advantage' of the new possibilities of implementing a maximum division of labour. Although certain programming tasks are concentrated in specialist bureaus, the division of labour is far from the maximum that can be achieved. That is true for the large companies as well. They are more likely to introduce what we could call partially integrated operator jobs. The operators are frequently given the authority to optimize technological parameters. Maintenance and quality control tasks are also frequently integrated. We can draw the same conclusion from Schumann's Trendreport. It suggests that recent years have only seen an expansion in the technical opportunities for a maximum concentration of production planning tasks. In particular the producers of relatively stable product types have attempted to liberate themselves from their dependence on CNC-style *Facharbeit* as much as possible by introducing a maximum division of labour (Schumann et al. 1994: 425). Today their belief in the unlimited opportunities for central control of CNC machining is waning. A maximum level of concentration, it seems, does not solve the existing instabilities (variations in quality and measurements of the material, wear-and-tear on instru-

ments and tools). On the contrary, as a consequence of rising product complexity and diversity, these instabilities are more likely to increase than decrease. Most of these enterprises have therefore returned to an organizational concept in which system regulation is the task of the operator (deconcentration).

We can conclude that the machine tool industry has a wide distribution of integrated jobs. That is, however, no indication of a breakthrough of new production concepts. Since Taylorist principles have always been less readily accepted in the machine tool industry, the question as to the 'end of the division of labour' seems misplaced here. So it is more correct to refer to *timeless craftsmanship* than to new production concepts. The same conclusion holds for the assembly work. These days the assembly shop is the province of skilled craftsmanship. Whether it is also timeless is another story. Management is increasingly keen to rationalise assembly. There is frequent experimentation with the concept of modules (stretching out assembly by means of pre-assembly of separate modules). Attempts are being made to separate mechanical and electronic assembly completely. And the mechanical assembly shows the first inklings of an emergent assembly line. This could be the machine tool sector's first acquaintance with short-cycle repetitive labour.

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