MANAGERIAL COGNITIONS IN TECHNOLOGICAL INNOVATION PROCESSES

The study of interpretative processes

JOSE BERNARDO BICUDO DE AZEREDO KEATING

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THE UNIVERSITY OF ASTON IN BIRMINGHAM

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NAME: José Bernardo Bicudo de Azeredo Keating
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SUMMARY

In this research, conceptualizations of the links between technological innovation and organizational change are explored and recommendations in the literature concerning such changes are reviewed and criticized. Such recommendations do not usually address the details of social interactions by which organizational changes take place. As a consequence, the issue of how these recommendations become relevant for the actors who would carry them out is not addressed.

The complexity of organizational change processes highlights the role of actors' interpretations of organizational reality. Interpretations take place through the use of language in the interaction between actors. Theoretical contributions and recommendations concerning organizational changes should be seen therefore as discourses which contribute to these interpretations. They will influence the process of change only if they become relevant for organizational actors'.

A method for analysing discourse in organizations is presented. It is used to identify the variety of discourses which are put forward in organizations, and to describe the structure of their distribution among actors.

The structures of discourses in three companies suggest that knowledge about technological innovation processes becomes relevant to the extent that it contributes to political/discursive processes maintained by actors attempting to secure or change their role definitions. It follows that recommendations concerning planned organizational change should take into account these processes explicitly. It is therefore suggested that the analysis of discourse can be a valuable instrument for monitoring change processes. Suggestions for further research are made, concerning (i) the development of the method itself and its use in real situations (ii) the study of how discourse structures evolve over time and episodes of change.

Key words: TECHNOLOGICAL INNOVATION; MANAGERIAL COGNITION; STRATEGIC PROCESS; DISCOURSE ANALYSIS;

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Introduction.

During the last decade, successive insights into the organizational processes involved in technological innovation were developed, with a special emphasis on applications of micro-electronics.

There is at present a growing awareness that the adequate use of these technologies requires radical changes in the way firms operate. Initially, the introduction of micro-electronics in production processes was seen as a matter of doing "more of the same", possibly better and faster. One contribution from studies of technological change is the recognition that micro-electronics uses in production may correspond to the needs created by changes in critical dimensions of the strategic context of firms. In particular, rapid changes in market requirements have been identified as critical challenges. Such changes make relevant the adoption of practices deemed inappropriate in more stable contexts but which enable the adaptation to the turbulence of present contexts. In consequence, there is a strong emphasis across the literature on recommendations concerning the changes firms should go through in order to adapt to those contexts.

At the same time, there is a parallel recognition that these changes can be very problematic to implement. These problems arise from the fact that recommendations for organizational change are fed into existing organizational processes whose nature is not clearly understood. The outcomes are therefore unpredictable.

This does not mean that the reasonings behind such recommendations are not valid. But the relevance of recommendations concerning organizational changes would benefit from a better understanding of the organizational processes they are fed into. Only through becoming relevant in specific situations to concrete actors the knowledge generated by research will be used to change reality.

Part of the problems found in efforts to influence how organizations operate have to do with the fact that knowledge generated by research simply is not felt as relevant by the actors who actually have to transform that knowledge into action. Although such issues as knowledge formation and utilization do not provide a focus for this research, the question of how knowledge becomes relevant in organizations can be recognized (in retrospect, of course) as a powerful guiding line.

Chapter 1 reviews the literature on technological innovation, with a special emphasis on the recommendations concerning organizational change and the insights into the nature of technological innovation processes which were generated. Recommendations are criticized for not taking into account the process by which planned organizational change may take place. In essence, the view taken is that a viable approach to organizational change processes should take into account how actors re-define their roles in a very active way.

Chapter 2 shifts the focus to contributions coming from the study of strategic processes. The limits of rational approaches to strategy and alternative approaches which stress the active role of actors in the interpretation of "organizational reality" are explored. The view taken in this chapter is that the processes by which organizational actors interpret reality are essential to understand how planned organizational changes may take place. These interpretations are based on the use of language and the creation of a variety of discourses. This creation however, is not a planned, rational activity. Rather, it results from the involvement of actors in political processes concerning the definition of their roles in a changed situation. The variety of organizational discourses is seen as a trace of these processes. This leads to the definition of the study of discourse as a viable approach to processes of interpretation.

Chapter 3 reviews studies based on cognitive mapping as a possible approach to interpretation processes. The fact that cognitive maps tend to ignore the political processes involved in interpretations suggests that different methods may complement the insights brought by cognitive mapping. The view taken here is that the description of language use in organizations, namely the distribution of different discourses along a social network, can give useful descriptions of interpretative processes. A method to carry out such a description is described and its validity problems are explored.

In Chapters 4, 5 and 6 the procedure is applied to analyze the discourse structures of three companies and the resulting descriptions are discussed. In Chapter 7, finally, the contribution of these three descriptions to understand organizational change processes is discussed. These descriptions suggest in essence that recommendations concerning technological innovation processes become relevant knowledge in organizations through political processes which can be approached usefully through the analysis of discourse.

CHAPTER 1:
TECHNOLOGICAL INNOVATION

1.1. Introduction

The use of micro-electronics in industry became a matter of public concern and research in the late 70's. This happened concurrently with an increased awareness that British industry was lagging behind their foreign counterparts and that technologies based on micro-electronics meant a whole new set of opportunities and threats which were already changing the existing pattern of international competition.

The situation in Britain was characterized by low industrial performance, as compared with their international competitors, and a decline in preference for British made goods, both internally and externally, for reasons of poor quality and untimely delivery. These problems were compounded by the world recession and the re-valuation of sterling, brought about by the North Sea oil and governmental monetary policies, which contributed to the worsening of the competitive position of British industry (Francis, 1989).

The recognition that something had to be done in relation to the crisis in British industry and the understanding that new technologies were a part of the solution created a context where technological innovation became an object of study extremely relevant for managements, academics, professional associations and trade unions, governmental organizations, etc. The question of revitalizing British industry, both internally and externally, became intimately associated with the question of technological innovation. Kenneth Baker's dictum "The choice for UK firms is stark -

automate or liquidate" (quoted in Bessant and Grunt, 1985) was a concise summary of this programme.

In the following sections, some of the insights into the relationships between technological innovation and industry effectiveness brought about by research in this context will be described.

1.2. Technological determinism.

Technological innovation helped to structure several theoretical debates. One of these debates concerned the processes by which organizations adopted specific configurations and the role of technology in these processes (Child, 1986).

The study of the relationships between technology and organization concerning the introduction of computer based technologies was influenced from the start by what Scarbrough and Corbett (1992) label "static" models. Contingency perspectives (e.g. Woodward, 1965) and organizational choice perspectives (e.g. Trist et al. 1963) both of which look for stable patterns of relationships between variables, are examples of this type of models.

Woodward (1965) described relationships between technological, organizational and performance variables, suggesting that for each type of production technology there would be one organizational configuration which was more efficient and hence more viable. This perspective resulted from the statistical analysis of extensive surveys which showed that the more effective companies were the ones which adopted the modal form of organization for each category of process technology (Woodward, 1958).

Although Woodward's study was based on samples of impressive size, very few of the relationships she found were confirmed in replications of her studies (Donaldson, 1976). Attempts to refine the methodology used in order to obtain more clear and stable relationships, failed to produce encouraging results (Lowstedt, 1985).

> "The advocates of the contingency approach to technology became more and more bogged down in intrascientific squabbles within their research tradition. The theoretical development does not appear to be in proportion to the frequently extensive empirical work" (Lowstedt, 1985:217).

Lowstedt's criticism of contingency perspectives focused particularly on its central assumption that it is possible to formulate general propositions concerning what actions to take given the technological and market circumstances. Some of Lowstedt's criticisms of contingency perspectives are summarized in the following points:

- contingency theories assume mechanical, stimulus-response relationships to explain phenomena as complex as organizations;

- the importance given to formal aspects of the organization is incompatible with the observation that organizational structures are increasingly fluid and established on an ad hoc basis;

- the assumption that the best organization form is that which survives, supposes perfect competition and efficient markets;

- contingency theories assume that the factors which explain organizational variety can be determined unambiguously. However, the difficulties in their operationalization and measure have been considerable, to the point that further efforts in the same direction can hardly be justified.

1.3. Organizational choice.

At a different level, contingency theory can be criticized as a mechanistic view of the organization which ignores the action of human subjects, their ability to use their judgement and to act creatively on the basis of their values or other subjective dimensions. Organizational choice perspectives, which have also long standing roots in the theory of organizations, addressed more clearly this issue. They were formulated explicitly for example in the socio-technical tradition (e.g. Trist et al. 1963), which concerned mainly the practical and theoretical problems of bringing together in the design of jobs what is known about the technical-physical problems of production and the social-psychological processes which take place between people in social interaction. In this process, a wide range of possibilities in the design of work organizations is assumed.

In socio-technical theory the possibility of organizational choice is based on systems theory, particularly the notion that open systems like biological organisms and social organizations can reach states of dynamic equilibrium from different starting points and following different paths. This gives legitimacy to the claim that organizations are not determined in an absolute way by specific configurations of situational variables (e.g. environments or technology, or size) and that the choices of human beings have a place in the process of achieving equilibrium.

To be fair in this critique of contingency theories, it should be noted that both contingency and choice perspectives were developed very much as critiques of the Taylorist tradition in job design and the classical management theory, which assumed that there would be "one best way" of organizing people efficiently and which left little to be done but following their prescriptions (Buchanan, 1979). They both share, however, the assumption that the source of agency in the changes recommended is to be found within the management group. This is a limiting assumption, in the sense that it excludes other sources of agency as irrelevant and underestimates differences in managerial perspectives.

1.4. Strategic choice

Child (1972) argues forcefully in favour of the notion of choice by groups in power in organizations. His critique of contingency theory hinges on the notion of "strategic choices" made by dominant coalitions in organizations. The three situational factors more clearly identified as determinants of organizational structure (the environment, the technology and the size of organizations) are seen as the result of strategic choices.

These choices determine (i) the environments in which the organization has to operate and the actions organizations may take in order to change these environments, (ii) the technology used by the organization, which is seen as the result of decisions on the tasks to be carried out in relation to the resources available to perform them, and (iii) the size of the organization, which can be directly changed, for example through the decision to break down large units in smaller, independent units or whose influence on organizational structure through the increased need of coordination structures can be counteracted, for example by using computer based technologies.

The point Child makes is that contingency theories exclude from their picture of organizations the processes by which situational variables are related to organizational dimensions. A process approach, as opposed to a variance approach (Mohr, 1982) is defined, which constitutes in reality not a rejection but a re-interpretation of the relationships established in the contingency tradition.

Spender (1989), in a similar vein, articulates a critique of dominant management theories around this question of determination and the control of uncertainties. He suggests that the "programme" of organization and management theories is essentially to try and explain all the uncertainties inherent to organizational structuring and functioning and to be able to give directions in all kinds of situations. By pursuing this aim they tend to reduce the role of managers and entrepreneurs to the identification of situations and to the application of the prescribed solutions for each situation. He suggests, also based on a process view of the organization, that this objective is impossible to accomplish. In his perspective, organizational theory has to come to terms with notions such as creativity, or more generally the non-rational, unexpected inputs managers can bring into this process, as the logical solution to uncertainty.

Both Spender and Child can be seen as dealing with the organizational processes of creating new facts from the perceived "reality". Situational factors are data, not necessarily determinants, in the process of creating the organization. They become information relevant to decisions through the evaluation people make of them. Another point in common is that they isolate powerful organizational actors as the source of changes in organizational structure, a point which is also shared by "organizational choice" perspectives. As we will see below this may not constitute a solid basis for the recommendations which are drawn from strategic choice perspectives.

1.5. The deskilling debate

In the context of technological innovation research, the assumption that it would be possible to find one optimal organizational solution for each situation also tended to exclude from consideration a number of other relevant actors, like workers, unions and other professional associations, whose interests are clearly at stake.

The relevance of Braverman's (1974) thesis to research on technological innovation comes, among other things, from his definition of the whole process of technological change as a political process. Capitalists aim essentially at increasing their control over the labour process by removing key assets, like knowledge and skill, from the control of workers by deskilling work.

Most of the research that concentrates on job and task changes associated with technological change deals in one way or the other with extensions of Braverman's hypothesis according to which programmable automation would be used to deskill jobs. Technological change was seen as an inevitable means of undermining workers and union power over the production process (e.g. Jones, 1982; Noble, 1979; Sorge et al. 1983).

This hypothesis has been repeatedly tested. Francis (1986) summarizes the debate on the deskilling hypothesis by suggesting that to keep looking for a general trend in the diversity of solutions managements have found to the problems of accommodating new technologies is a vain quest. To include all the dimensions that can be identified as having some bearing on the problem dynamics amounts not just to an enlargement of previously used models, but indeed to a radical departure from these (Francis, 1986:78).

This departure has generated different approaches to the problem, but a common thread, in line with Child (1972), is the acceptance of the theoretical and practical possibility of strategic choices by managements concerning the structure and control of production systems which do not necessarily lead to tighter control and deskilling.

Nevertheless, Braverman's description of deskilling as an aspect of the general strategy of increased capitalist control over the labour process had the effect of putting the political actors back into the picture of technological innovation processes. Changes in work organization could thus be described as the result of, among other factors, the political conflict between workers and managements (e.g. Gill, 1984).

There is thus some complementarity between the deskilling thesis and the critiques to the contingency perspective reviewed in the previous sections. The nature of technological innovation processes can be seen not only as the result of choices made by actors in the organization but also as determined by ideological considerations which reflect the existence of actors with different interests in the organization. Ideological considerations can be presented in a rational form, but they are ideological all the same.

The ideological nature of organizational discourses, and by this is meant any kind of discourse one is exposed to when doing research on organizations, is not easy to deal with in organizational research. It basically entails that we have to interpret what is being said by an organizational actor by putting his or her discourse in relation to what other people are saying. Only then can an outsider interpret what is being said by an actor as part of the debate going on between several actors with different interests in the situation. This awareness of the ideological nature of organizational discourses will be a central feature of the method used in this research.

1.6. Changes in work organization: explanations and recommendations.

These debates encouraged an impressive amount of research on the processes of technological innovation and particularly on the impact of computer based technologies on work organization. A good deal of these works concentrated on the use of relatively simple implementations of this technology, like Computer Numerical Control (CNC) machine tools and Computer Aided Design (CAD). The deskilling hypothesis focused research mainly on the distribution of programming tasks and the degree to which these were removed from other tasks involved in the operation of the actual performing tool. As tasks which require a specific know-how they would be particularly sensitive to deskilling strategies.

Sorge et al. (1983; 1984) comparing work organization in Germany, France and the United Kingdom found much variety in the distribution of programming tasks. They found that the separation between programming and operation was positively correlated with two "classic" contingency variables: company size and batch size.

Similar results were found by Kelley (1989) in a sample of around 500 United States manufacturing companies. She found that non-Taylorist work organization was the rule: only in 24% of the companies was there a strict Taylorist separation between programming and operation, against 45% of companies where programming was shared in a variety of ways between blue and white collar workers and 31% of companies where only the operators did the programming. Non-Taylorist forms of organization were associated with smaller companies, batch sizes of up to 50 units and low unionization.

In these conclusions the influence of contingency modes of reasoning is evident, suggesting that prescriptions could be drawn from the associations found. Sorge et al. (1983) also found other factors associated with the separation between programming and operation: the complexity of the programme to be written and the time needed to programme were associated with greater separation between the two tasks; the sophistication of the machine, namely the possibility of programming on-line, i.e., while it was executing some other programme, and the existence of error control routines helped programming tasks being assigned to operators. However, they recognized that part of the variety found could be attributed as well to factors which were country-specific, and thus difficult to integrate in a contingency framework, namely work and management traditions and the skill-producing structures specific to each country.

The influence of national systems of work socialization and skilling was the object of a number of international comparisons of forms of work organization with new technologies. Their orientation is well represented by d'Iribarne and Lutz (1984) who argue that a successful move away from Taylorist forms of organization with new technologies although socially desirable is dependent upon (i) the efficiency of national education and professional structures in making available the necessary qualifications, (ii) national traditions concerning company organization, control mechanisms and salary and status stratification, (iii) the extent of users participation in the process of implementation of new technologies, and (iv) the investment in training which managements accept as reasonable in new technology implementation.

These and other works highlighted both (i) the importance of the macro social context in which new technologies are implemented to the understanding of the organizational forms which appear associated with new technologies and (ii) the existence of differentiated managerial strategies which do not always tend to greater control and deskilling. These are not necessarily put forward on a rational/scientific framework, as is apparent in the recognition of the role industry and work traditions appear to have in this differentiation.

These new strategies associated with the use of new technologies have nevertheless been explained on a more rational basis. Kern and Schumann (1984) for example, considered that the variability in work organization corresponded to a shift in the consideration of human inputs to the process of production. Traditionally, the rationalization of work had considered human inputs as a limiting factor to be overcome by automation. In practice, it becomes more and more clear that the reduction of human inputs to the production process is not necessarily an economic strategy. Human skills began therefore to be considered as an organizational asset to be protected and developed.

Melman (1984) suggests that, given the capital investment represented by new technologies, the stress on optimization shifts from increasing the predictability of human inputs to increasing the predictability of capital investment. This is achieved by a stable operation of the machines which requires that the "tacit qualifications" (Jones and Wood, 1984) of workers be considered in the design of work systems.

Underlying these changes in perceptions of human inputs to the production system is the awareness of environmental changes which alter the "rules of the game" and require different approaches to work organization. Sorge et al. (1983) suggest that the major change in the situation companies operate, which explains these changes in operating logic, is the need to diversify the products and the corresponding flexibility which production systems have to show.

The reasons presented by managements for new technology implementation confirm this notion. They have mostly to do with the competitive dimension of company operation in a changed market. These include improved productivity, cost reduction and a more effective response to market demands by improved flexibility (e.g Northcott and Walling, 1988; Lee 1987; 1988; 1989), improvements in international competitiveness (Kelley, 1989; Lee, 1987; 1988), better product quality (Northcott and Walling, 1988), and keeping abreast with technological developments which are available to the competition.

These justifications illustrate the awareness that the context where companies operate is undergoing fundamental changes and also that technological developments are recognized as relevant aspects of this change.

The need to adopt flexible production systems is stressed by Lee (1987) and Campbell and Warner (1989), among others. The research problem becomes more clearly not the "mechanical" determinants of organizational structure but the conditions which facilitate the adoption of flexible structures with the ability to respond to fast and frequent changes in the market where companies operate.

Lee (1987) suggests a logical framework of contrasting managerial strategies concerning both human resources and technical equipment utilization, in the management of changes at the skill, task and organizational levels.

1. **skills**: general reskilling versus selective reskilling; reduction of "tedious" skill elements (e.g. in drafting with CAD) versus the polarization of skills

2. **tasks**: job enrichment and enlargement versus the intensification of work; high utilization of new equipment versus new equipment used only by professional elites and

3. **organization**: operators involvement with project teams versus the marginalization of operators when implementing the new technology; functional flexibility (based on intensive training) versus numerical flexibility) (Lee, 1987).

Her general point is not just the possibility but also the desirability of a "responsible autonomy" approach by management to work organization. This is put forward not just on the basis of humanistic values or of socio-political commitment but, arguably, in a very definitely strategic framework, in the sense that this type of approach provides management with greater scope for gaining acceptance of structural changes related to technological innovations. It is clear, nonetheless, that the oppositions defined are based on a set of contrasting values, regarding the exercise of power and discretion by managers. The message is that a more democratic, participative approach yields better results. This orientation requires both substantial investments in training and a change in managements attitudes where long term considerations play an important role.

This line of reasoning receives support from Machjrzack and Cotton (1988) who found that workers satisfaction when changing from assembly line work to small batch production work using new technologies was positively correlated with (i) increases in variety of inputs and outputs of their jobs, (ii) increases in control over their work and possibilities of social discussion and (iii) decreases in workflow integration, with larger cycles and larger buffers.

The significance of this is that it points to managerial strategies concerning organizational design that enable a more positive adjustment to new technology, which in turn is likely to enable shorter delays in getting these technologies up and running. This is a desirable outcome for managements against which the costs of such strategies can be evaluated. These considerations also put back into the picture other relevant actors, which the managerialist bias in contingency perspectives tends to undervalue.

In summary, the works reviewed identify relationships between environmental, structural and performance variables from which recommendations concerning structure are drawn. They come together in the recommendation of flexibility as a desirable characteristic which organizations do or should present in order to attain the goals expressed as reasons for investing in new technologies. Flexibility, or the ability to respond quickly to environmental changes, becomes thus focus of research and recommendations for technological innovation processes. In what concerns the implementation of flexibility these recommendations adopt an "organizational choice" approach, in that they assume that these changes are possible without much trouble, as long as a reasonable approach is taken by managements in their relationships with other organizational actors.

1.7. Flexibility and organizational integration

Most of the research reviewed so far has considered stand alone applications of information technology on production process equipment. The integrative potential of technologies which relate simultaneously to various phases of design, production and control processes has also been discussed by some authors (e.g. Voss, 1989). The integration of traditionally separated processes is seen as an important condition for the successful implementation of new technologies in that it enables greater flexibility in the productive structures.

Beatty and Gordon (1988) identify organizational fragmentation as an obstacle to the understanding of what computer based technologies can really do for a company, a blindness which can lead to underestimating the return on investments in that area and to limit the learning opportunities which these technologies can open. Some degree of integration across different functions is therefore recommended as an asset in the implementation process.

Voss (1986) describes the integrative effects of the introduction of computer aided design and computer aided manufacturing (CAD/CAM) at the organizational and at the individual job levels, on the basis of seven case studies. His general conclusion is that successful implementation of CAD/CAM was associated with some kind of integration process.

At the job level, he found integrative processes which blurred the traditional demarcations between engineering, design, and manufacturing jobs, with positive effects on the way occupants began to perceive the interdependencies between these functions, enabling shorter leading times from receipt of customer orders to production and to improved quality design.

At the organizational level integration took the form of establishing project teams, on a temporary or stable basis, and forms of organization close to the matrix form, all with positive effects on the companies ability to respond quickly to market demands. This point is also made by Lee (1988), who furthermore suggested that the matrix type of organization could be more relevant in large organizations, who face more complex problems of change.

Voss (1989) argues in favour of an enlargement of the notion of integration. Integration should occur at several levels: strategic integration, by a widespread awareness of what the company strategy is at every moment and the relevance of each function or job to it; material flow integration by adopting forms of control which enable, at all points of the process, an understanding of what is happening at other points, eventually leading to solutions like just-in-time supplying; technical integration, for example in the engineering/design/production cycle; information integration by the use for example of compatible data bases; and organizational integration, as described above. Each of these levels of integration is recognized to constitute several managerial challenges, which are not all clearly mapped. But the framework is put forward as a potentially valid orientation in organizational design to implement integrative technologies.

The role of managements in these recommendations is crucial. Campbell and Warner (1989) suggest that managers have a key role in creating a culture of "permanent implementation", which can only be brought about by highly adaptive organizational structures. This requires significant investments in training, particularly management training.

The main theme underlying these recommendations is that of organizational change. Planned organizational change is recognizably a complex problem and this leads to the analysis of the process of implementation by which the desirable changes can be brought about.

The notions of integration and flexibility can be quite valid dimensions of structural arrangements which might improve company effectiveness. The recommendations made take managements as the sole initiators of organizational changes towards greater integration and flexibility. If we think about the process by which changes can be brought about, the question which remains is what is the relevance of these recommendations to actors in a particular organization? How can flexibility and integration become relevant concepts for at least some of the actors working in an organization?. Unless this happens it is unlikely that the research and recommendations reviewed become useful knowledge.

1.8. The process of implementation

A common theme running through the observations and recommendations reviewed above is that the implementation of new technology has to be considered (at least) on the technical and the organizational plans (also Leonard-Barton, 1987; Loveridge and Pitt, 1990). Loveridge and Pitt (1990) suggest that the success of Japanese competition was due largely to

> "their recognition of the strategic need to define and appropriate the benefits of technology in terms of <u>both the social and technical requirements of organization</u>" (Loveridge and Pitt, 1990:2, emphasis added).

In practice, the introduction of new technologies, can become a difficult problem to manage and the expected gains in productivity through flexibility and integration may be lost in the effort to manage processes of organizational change with unforeseen levels of complexity.

Most unexpected problems in the implementation of new technology in organizations have been attributed to lack of planning and organization prior to the introduction (Tranfield and Smith, 1987, 1988). Lowstedt (1988) observing the introduction of Computer Aided Design (CAD) in Swedish companies, notes that the time and effort required before CAD could be used was vastly underestimated because important organizational factors and regulatory mechanisms were overlooked in the implementation process.

Winch (1989) suggested a three stage model of the process by which new technologies are introduced in organizations: an evaluation phase, where performance gaps are identified, an installation and commissioning phase, where organizations evaluate technologies on their technological dimensions, and a consolidation phase, where the benefits in terms of the business as a whole are evaluated.

The author himself recognizes that this is too simplistic an image of the implementation process, although it defines useful anchors for descriptions of an essentially fluid and dynamic process.

Voss (1986) criticized the dominant "narrow" descriptions of new technology implementation processes as something which takes place between the moment of purchase and the moment it is used successfully. The success of implementation is determined by actions which can take place before the new technology is purchased or even considered. Voss suggests that different contexts, different structures of skill, existing technologies, managerial attitudes, etc. are significant influences on the success or failure of processes of technological innovation. These elements certainly give a richer picture of the process of implementation. However, Voss does not attempt to describe the details of the process by which these elements become important.

Lee (1987) identifies some of the elements in the process of implementation which include: (i) pressures to adopt include "top-down" aspects of corporate strategy, focusing on competitiveness and productivity issues, and "bottom-up" pressures from professional groups, like engineers, who may be aware of advances in technology relevant to their sphere of work; competitors can also be a significant influence in the sense that companies will not want to be seen as technologically backwards by their customers, actual or potential; (ii) the rationale of adoption, which can be strongly influenced by the operational considerations made explicit in the capital case presented to top management, stressing high utilization rates and improved productivity leading to enhanced competition through a more effective response to markets.

These elements can interact in a negative way where the rationale for adoption implicit in the capital case is the only explicit guideline for implementation: this may cause a prevalence of operational considerations, with the concomitant risks of short-termism, a tendency for direct control, deskilling and conflictual approaches to work-management relationships. These may hinder the high trust relationship recognized as a key factor for planned organizational change to take place. In this description, a more clear notion of process is given, in that one sees how these aspects of the process can be used by particular actors, in the pursuit of their interests.

The importance of managerial values, attitudes, and strategies to the implementation process has been recognized widely (e.g. Campbell and Warner, 1989; Lee, 1987; Lowstedt, 1988; Voss, 1986), even if their integration in a more process-oriented model of the process of change is not developed. Other factors, however, were found to influence the process of implementation. Leonard-Barton (1987) suggests two factors related to the processes where technology is introduced, which influence the time needed and the uncertainty in the process of introduction: (i) the "organizational span" of the technology, i.e., the number of people and functions affected by its introduction and (ii) the "process scope" of the technology, which is related to the degree of centrality of the productive process where the technology is introduced and to the degree to which this process depends on the coordination of a large number of people. The higher the technology is in these dimensions the more complex and the lengthier their implementation is, the more uncertainties are present and the more political interaction takes place between organizational actors.

A possible interpretation of this is that the more organizational roles are changed, the more the process will be uncertain. In fact, the notion of organizational span refers clearly to the number of roles changed, whilst the process scope of a technology may related to the changes in role inter-dependence. In both changes it is likely to exist, as Leonard-Barton writes, a great deal of political action as actors re-define their roles in the organization and their relationships with each other.

The dynamic nature of the process of implementation is described by Leonard-Barton (1987) in her discussion of technology transfers internal to the organization. The key notion in her work is that the introduction of a new technology causes a series of misalignments at the technical, structural and organizational levels. These misalignments induce iterative processes of "correction" which modify both the organization and the technology until alignment is achieved. These processes are described as taking place at several levels, thus providing a picture of wide ranging changes, which constitute an episode of innovation that eventually reaches a stable state.

These iterative processes are described in a fairly abstract way, but again they can be interpreted as having to do with the politics of organization in that they will certainly involve actors giving different definitions of what is happening and what should be done about it.

Winch (1989) discussing the implementation of CAD/CAM suggests a typology of technologies based on their complexity and integrative potential. His typology is summarized in figure 1.1.

It should be noted that this typology assumes too much influence coming from the characteristics of the technology itself. Newell et al. (1989) suggest that the changes technologies may bring to organizations depend very much on the way these technologies are implemented and used. Therefore, this typology can be seen more as a typology of actual uses of technology.

		INTEGRATIVE POTENTIAL	
		Inter sphere integration	Intra sphere integration
COMPLEXITY	Simple	INTEGRATING TECHNOLOGIES (CAD/CAM)	INCREMENTAL TECHNOLOGIES
	Complex	RADICAL TECHNOLOGIES	COMPLEX TECHNOLOGIES

Fig. 1.1. A typology of technologies (adapted from Winch, 1989:11).

Inter-sphere integration, i.e. the integration of spheres of activity which are usually clearly differentiated, is the kind of integration which raises new organizational problems. Winch describes the process by which these integrating technologies are implemented as a "continual process of incremental development of the system" (both on its technical and social levels) "sandwiched between periodic re-evaluations". The key point in his description is that he considers the whole process to be recursive, interactive and lagged, all characteristics which, contrary to Leonard-Barton's (1987) notion of alignment, suggest the process will not tend to equilibrium. Its nature is that of permanent change.

This is an interesting notion because it suggests a reorientation in the consideration of technological innovation. The works reviewed so far assume the implementation process is a finite process: the successful implementation of management defined strategy will eventually lead to a stable organizational structure, smoothly using the new technology. Winch's suggestion that it may be a never ending process means that one should take change as something to be integrated in our "images of organizations" instead of holding one's breath waiting for the "innovation wave" to pass.

The point which can be made more forcefully on the basis of Winch's insight is that the complexity of changes associated with technological innovation is due not as much to specific characteristics of technology but to discontinuities in the organizational processes by which actors make sense of a new technology. Clark and Staunton (1989) demonstrate that whereas traditionally the problems organizations had to solve were, in essence, the problem of efficiency, they are now faced with a dilemma between being efficient and being innovative. The fact that this constitutes a complex puzzle, whose contours are not clearly defined is not widely recognized in the recommendations concerning the process of implementing new technologies.

Consider for example Leonard-Barton's (1989) recommendations concerning the management of innovation. This process is defined as essentially a process of learning about the organization, dealing with knowledge of two kinds: knowledge of the organization and knowledge of the technology. The Implementation Knowledge Grid thus defined includes four quadrants representing different types of knowledge and concerns in new technology implementation.

The knowledge base necessary to implement new technologies adequately is reduced to these two types of knowledge.

KNOW-WHY

Links to Strategy (e.g. manufacturing excellence; total quality control) | Architectural Interdependencies with other technologies and other operating systems

ORGANIZATIONAL KNOWLEDGE ---------- Implementation Knowledge Domain ---------- TECHNICAL KNOWLEDGE

Impacts of the technology on organizational tasks and procedures | Operating rules; procedures for the new software

KNOW-HOW

Fig. 1.2. Implementation Knowledge Grid (adapted from Leonard-Barton, 1989, Figure 4).

The problem here is that while knowledge about the technology can conceivably be made explicit and transmissible, knowledge about the processes by which organizations change, and by which actors change their understanding of the organization, is of a different kind. Only at a very superficial level can for example the impacts of technological change on tasks and procedures be made explicit. In practice, there will be a host of "side-effects" at several levels which will be recognized by actors but which available models capture only sketchily.

1.9. Technical innovation and strategy

These types of studies apparently provide actors involved with the evidence that the changes associated with the introduction of new technologies are much deeper and wider than would be expected if the nature of these innovations were just concerned with doing more of the same with different machines. Although issues do tend to crystallize around these physical objects, and what to do with them, in fact they are inherently strategic and related to the more general problem of firms coping with an increasingly "turbulent" (Emery and Trist, 1965) environment.

The complexity of technological innovation processes arises chiefly from the organizational implications of adopting technologies which are based on an operating logic different from their "predecessors'" (e.g. CNC machines) or suppose by their design a change in modes of operating (e.g. flexible manufacturing systems). They appear, besides, in a context that differs significantly from the context where "traditional" equipment appeared, in social, economic, political, and cultural dimensions.

Solutions for innovation problems appear to require the simultaneous consideration of, and attempts to influence to some degree, intra-organizational and contextual dimensions in order to achieve some desired end state or goal. But these dimensions are, themselves, changing and the strategic assumptions which have held for the context where "traditional" technologies made their appearance may prove inadequate for newer contexts. Loveridge and Pitt (1990) speak about the "fluidity of the managerial context" recognized in many contemporary accounts of change. Contributing to this fluidity, is the variability of institutionalized structures of consumer demands, which undermines the efficacy of the operational technologies designed to serve such domains. Butler (1988) makes a similar point saying that technology can change the structure of particular industries and therefore become both a threat and an opportunity for particular companies. The significance of these contributions to the understanding of the nature of technological innovation as a strategic process is further clarified by Teece (1985) who suggests that new technologies are not a neutral commodity that can be taken in as a ready made solution for an organizational problem.

The "organizational neutrality" of technologies had been assumed for "traditional" technologies arguably because the process of installing them was in continuity with existing organizational procedures for machine replacement, or other capital investments, which were developed on the basis of relative environmental stability. Instead, new technologies appear as a means of coping with a novel context which requires a change in the paradigms, or recipes, or theories, used to make decisions concerning the relationships between technology, organizational design, and the organization's strategy.

It is possibly this change in the nature of the strategic context that makes new technology so relevant as an object of study in management. Because many of the organizational practices that could serve as anchors in the understanding of new technology are themselves changing, new technologies have increased "equivocality", in the sense that they can be made sense of and used in many different ways (Weick, 1990). Although one speaks of technological innovation, in fact all the taken for granted practices are changing in more or less visible ways. This leaves few reference points in all the process of innovating at the technological level. New technologies appear therefore as complex puzzles which put in motion new activity cycles (Weick, 1979) in order to be solved or managed. These new activity cycles involve the re-definition of organizational roles at several levels, a dynamic and complex process which cannot be totally planned. A wide scope for political action is therefore left in this re-definition.

The complex challenge in this process is that the introduction of new technologies can be seen as a matter of resorting to old recipes as a consequence of perceptions of increased environmental complexity. Yet, in the process of making sense of new technology, of deciding how it can be used to manage that complexity, people initiate processes which actually increase the complexity of the social structure where they act and generate a plurality of interpretations of the situation.

It follows that the stress some authors put in planning and controlling the process of innovation is somewhat misplaced. The explanation for the problems found in technological innovation processes is not insufficient planning. As the process unfolds it can reach levels of complexity which make it impossible for any actor to make predictions about it.

1.10. Towards a process-oriented approach to technological innovation.

Descriptions of technological innovation processes, at a very general level, suggest that this increase in complexity follows, or should follow, a progression starting with attempts to solve specific problems by introducing new technologies, followed by the awareness that (i) these technologies raise unexpected problems, related with organizational practices which were not previously related to the original problem and (ii) they open new possibilities which go beyond the simple solution of the original problem. These two understandings lead to a strategic consideration of technology, which takes the form of re-thinking organizational practices in order to make the organization more flexible and integrated.

This sequence should be taken carefully. It is the result of reasonings essentially grounded on linear approaches to the organizational changes involved in technological innovation. These tend to simplify excessively the details of the process (Clark and Starkey, 1988:79). Recommendations for greater integration and flexibility do not integrate comfortably political processes, apart from their shallow definition as obstacles to the implementation of "rational strategies". Such strategies are expected to be laboriously determined through the empirical examination of structures associated with better results in the actualization of the new technology potential.

There is no denying, however of the importance of a change in orientations concerning structural design. Clark and Staunton (1989) suggest that the view that organizations strive, or should strive, for efficiency is being replaced by a more complex dilemma between innovation and efficiency. It is the detailed understanding of the interactive, political processes triggered by attempts to introduce organizational changes which is needed.

The analysis of theoretical developments in the study of strategy suggests alternative ways of looking at these organizational processes, which show why recommendations based on linear approaches to planned organizational change are so fragile.

Barley (1990) suggests a reconsideration of the relationship between technology and structure based on the integration of micro- and macro-social processes. He makes a distinction between the relational and non-relational aspects of organizational roles: the relational aspects are those aspects which require interaction and cooperation, non-relational aspects are the aspects which can be carried out without concern for others. Barley argues that if a technology is to have some influence on organizational structure it cannot change solely the non-relational aspects of actors' roles. According to a definition of organizational structure as a global pattern which emerges from the relationships between the actors of an organization, changes in the relational aspects of roles are the bases for any relationships between changes in technology and changes in structure: the technology changes the relational aspects of roles and these changes institute a new structure.

Thus, structural change is grounded on changes in relationships between actors. These changes may happen, for example, because the new technology reduces, or increases dependencies between roles, because it requires interactions between members in previously separate functions or because it changes the logic of control.

> "Structural changes can therefore be understood as a transformation that emerges from the events at the dyadic level of analysis, rather than as an aggregation of events that affect individuals as individuals (Barley, 1990:70).

This formulation represents a move "down" in the level of analysis. The dyadic level of analysis enables descriptions of processes which could not be properly formulated at the organizational level, namely the processes by which a change in relational aspects of roles puts in motion political interactions in order to redefine the roles altered by the new technology.

The interest in this level of analysis is twofold: first, the interpersonal processes put in motion by the new technology are not totally determined by macro-social or organizational dimensions, therefore are not reducible to them; second, most interventions by consultants in organizations occur typically at the dyadic level, i.e., such interventions are based on dyadic interactions between consultants and actors in the organization and the changes they bring have effects on roles and role relationships. It follows that something new can be learned from research at this level, which can be usefully integrated in attempts to influence purposefully processes of technological innovation.

Barley analyzes the nature of these dyadic interactions as a political process. This entails the notion that people will act in ways difficult to predict. The difficulty arises from the fact that their behaviours will not be the rational outcome of explicitly stated objectives. On the contrary, in political games one expects to see deception as well as seduction, conformity as well as creativity, rationality along with the non-rational. It is thus a process difficult, if not impossible to predict.

Barley (1990) however, attributes to individual actors a central objective: the re-definition of their roles in a "favourable way" (1990:67). This is an excessively rationalistic and limiting definition of individual goals in political processes. In a way, it contradicts the importance Barley attributes to the dyadic relationships as instituting organizational structure. Such contradiction arises chiefly from conceiving power, taken as the ability to influence what happens around us (Pfeffer, 1992), as an individual attribute. In fact, when Barley mentions the source of activity, his focus is on the individual actor trying to redefine his or her role in a favourable way. Favourability, although not clearly described, refers to some definition which results from processes "internal" to the individual.

This interference of individual processes in the analysis of dyadic relationships amounts to a definition of the individual as the source of activity. This definition is limiting in the sense that it inevitably leads to the consideration of psychological rationality: the motives of people, or the needs of people, have not proven a very promising approach in the understanding of collective processes. The question is what alternatives do we have to the consideration of the individual as the source of action? How can we think of alternatives which situate the source of action at the dyadic level?

The answer to these questions requires a detailed understanding of the processes by which people make sense of their experience as organizational actors. More particularly, in the case of technological innovation, it requires the understanding of how the relevance of new technologies for actors in organizations is construed socially. The construction of meaning is what enables people to act and has therefore a bearing on the way new technology will effectively be implemented. The nature of this process can therefore help us in evaluating the appropriateness of the recommendations just reviewed.

This evaluation of models and recommendations for strategic technological innovation hinges on two concepts: (i) the relationship between technological innovation and organizational change as based on social processes which may well be beyond the participants' ability to influence intentionally; (ii) a notion of power as related to the process of sense-making in an organization, whose relevance to organizational change cannot be understood if we limit its analysis to the individual level.

Summary

In this chapter we examined how the relationship between technological innovation and company effectiveness has been described. The theoretical models show a progressive complexity in their attempts to understand what are the effects of introducing new technologies and how problems in this process develop.

There is a progressive awareness that the complexity of processes of technological change is due mainly to their political, interactive nature and to the failure of traditional understandings about how technologies are to be used. The possibility of planned organizational change is questioned on the basis that the unfolding of political interactions is difficult, if not impossible, to predict. It follows that any recommendations in the sense of better planning and control of technological innovation processes assume too much order in the process. This brings us to the examination of the notion of strategy, as a notion related to intentional action in organizational contexts, which will be the object of the next chapter.

CHAPTER 2: STRATEGY AND THE STRATEGIC PROCESS

2.1 The possibility of strategy.

The study of strategy is intimately related with the questions raised in the previous chapter. According to Chandler's (1962) classic definition, strategy is the determination of long term goals and objectives of a company, the definition of courses of action and the allocation of resources to carry out those goals.

Following a similar line, Johnson and Scholes (1988:8) define strategic decisions as being concerned with the following points:

- The scope of an organization's activities;

- Matching an organization's activities to its environment;

- Matching the activities of the organization to its resource capability;

- The allocation and reallocation of major resources in an organization;

- The values, expectations and goals of those influencing strategy;

- The direction an organization will move in the long term;

- Implications for change throughout the organization.

Somewhat humourously, Weick (1987) contrasts Chandler's definition with DeBono's (1984:143) definition of strategy as "good luck rationalized in retrospect". This is not, in my view, just a joke. Both definitions deal with what seems to be an essential dimension in the notion of strategy: it deals with the consequences of present choices and actions to the future of the organization as a whole.

As can be seen, strategy deals with what is essentially unknowable because it does not exist yet. Independently of the reassuring words one can use to describe the process of making strategy, there is no way around the fact that it is about specific organizational actors making decisions which involve risking the existing organization, its resources, the personal circumstances of the people who work in it, etc., against uncertain odds.

In essence, therefore, the study of how organizations define and implement strategies is the study of the conditions which make it possible for people to act intentionally and effectively in organizations. Intentionality and effectiveness entail the notion of a projection into the future: "I'll do this (now) because I want that (a valued outcome) to happen (later)". This is no simple matter, and the solutions which have been suggested are, at best, steps away from a problem which is by definition impossible to solve rationally. And yet, there are people who deal with these problems and get away with it.

Johnson (1987) suggests that one can identify three major approaches in the study of strategic processes: a rational approach, an incremental approach and an interpretative approach. This framework, which the author himself considers somewhat artificial, is nevertheless useful to organize a review of some of the contributions to the problem of making strategic decisions.

2.2. Rational approaches.

Descriptions of strategic processes in the rational tradition, emphasize the logical aspects of dealing with unpredictability in the relationship between an organization and its environment.

Its aim is to keep uncertainty within bounds as explicit as possible. Hence, this approach emphasizes the need to follow certain rules and prescriptions. These are basically geared at leaving strategists with the certainty that even though they cannot predict the future, at least they can do what is humanly possible to optimize the chances that it will turn out to be largely as expected, thus enabling them to make a profit, or minimizing losses, in the process.

Such a certainty is basically about a process, not about the outcomes of that process. Yet, if it enables people to act, it fulfils its mission. This is possibly the reason why it is still widely accepted as giving a valid input at some points in the strategic process, even if most strategic management writers would agree that by and large it does not represent the whole picture.

This perspective remains basically in what Mintzberg (1973) calls the "planning mode" of strategy making. In the sense of a planning framework, its main limitations are not in terms of its logic but rather, in practice, the limited ability of human beings to process vast amounts of complex information in an explicit way. These limitations have been widely studied by what has been termed the cognitive perspective in strategy making (Stubbart, 1989).

It has long been recognized that strategic behaviour is hardly describable as rational. Rationality in strategic processes is more an ideal than something one can reasonably expect to see actually taking place.

Most of the research in the cognitive perspective, therefore, basically attempts to gauge how far short of an ideal of total rationality strategic behaviour actually falls, and why (Stubbart, 1989).

March and Simon's (1958) notion of bounded rationality is a classical reference which contributed to the fundamental distinction between the logical structure of decision making and the way protagonists of that process actually perform in organizations.

More recently, a number of studies based on cognitive psychological models tried to describe and explain strategic behaviour, using various definitions of cognitive simplification processes, such as the notion of heuristics (Barnes, 1984; Schwenk, 1988). The availability heuristic (Barnes, 1984), for example, can be mobilized by the actor when evaluating the probability of the occurrence of a future event based on the availability of past occurrences in his or her memory. In other words, the more easily one can remember past instances of that event, the greater the probability s/he will attribute to it. Because frequently occurring events are easier to recall than infrequent ones, this heuristic can be, at times, a valid shortcut in the cognitive process. There are however other factors influencing the availability of past events in memory, which may introduce systematic error. Dramatic, intense experiences are available in memory long after they occurred. Recent events are easier to recall than long past ones.

These factors can distort the subjective judgement of probability based on the availability heuristic. Schwenk (1988) lists some of these heuristics and biases, and gives a summary description of their possible negative effects.

BIAS	EFFECTS
Availability	-Judgements of probability of easily recalled events distorted.
Selective perception	-Expectations may bias observations of variables relevant to strategy
Illusory correlation	-Encourages belief that unrelated variables are correlated
Conservatism	-Failure sufficiently to revise forecasts based on new information
Law of small numbers	-Overestimation of degree to which small samples are representative of populations
Regression bias	-Failure to allow for regression to mean
Wishful thinking	-Probability of desired outcomes judged to be innapropriately high
Illusion of control	-Overestimation of personal control over outcomes
Logical reconstruction	-"Logical" reconstruction of events which cannot be accurately recalled
Hindsight bias	-Overestimation of predictability of past events

Figure 2.1. Selected heuristics and biases (from Schwenk, 1988:44)

Heuristics and biases are assumed to decrease the quality of the decision making processes mainly by restricting the range of alternatives considered and the information used to evaluate them (Schwenk, 1988). They can however be functional in the sense that they simplify the organized complexity of strategic problems (Mason and Mitroff, 1981).

Decision makers must somehow remove the complexity from their image of the world if they are to take any action at all. Using heuristics reduces this complexity and the perceived uncertainty in the outcomes of present actions. The point in the study of these "narrow" cognitive variables is that decision makers can become stuck with a set of dysfunctional assumptions and heuristics which are not necessarily mobilized in a conscious way. In consequence, decision makers may be unable to change them by a "second order process of learning" (Argyris and Schon, 1978), making the whole process less rational.

In general, most of the studies on cognitive simplification processes, because they are based on cognitive psychological models, tend to share to some extent a common goal, which is to construct unified and stable models of the strategist. Stubbart identifies in these attempts a trend which, departing from the rational utility-maximizing decision-maker of economics theory, goes towards the "bounded-rational heuristic manager". However, he suggests, if the former was a little too "bright" the latter is a little too "dumb", and in reality people can be both. The author suggests therefore the need for a framework where "brightness" and "dumbness" can comfortably live together (Stubbart, 1989).

The type of framework suggested by Stubbart concentrates on individuals as the "source" of rational behaviour, which is no doubt a legitimate option for social psychology, but an unwarranted one when the object of study is the organization. An organizational actor who offers his or her views on organizational processes will produce a rational account, a discourse that the researcher as an outsider will very likely be able to understand. But this does not mean that this discourse will be considered rational by other actors in the same organization. Comments and hints on the irrationality of other members' behaviours are not uncommon when one interviews people in organizations, showing that a plurality of "rationalities" exists.

This suggests that even if we find that Company X's strategy is rational, it does not follow that a single actor in that company can be taken as the source of that rationality. This is so, not because actors' brains are limited in some way, but because the rationality one can attribute to an organization as a whole, is an external interpretation of a multi-layered, multiple-sided process constituted by the on-going debates between individuals, coalitions, etc., concerning several issues at the same time. To accede to this type of logic would mean stepping out of this debate and consider at a specific moment all the positions which are being simultaneously asserted and all the actions which are taking place. Such an option is not open to the organizational actor who is part of this structure of exchanges. It would change the nature of the actor's relationship with the organization, and of course the debate itself.

It follows that we should be clear as to the level of analysis we are referring to, and be careful not to mix evaluations of the appropriateness of individual actions with evaluations of the appropriateness of organizational moves.

Weick (1979) contributes to understanding how the process of creating a "higher order" type of logic may take place, introducing the notion of mutual equivalence structures. These are structures of interactions that come to existence when someone's ability to perform a consummatory act (this could be described as attaining a goal) depends on someone else performing an instrumental act (which could be compared to make a tactical move) and vice-versa. The interesting feature in mutual equivalence structures is that they can be built and sustained without the participants knowing the motives of one another, without having to share goals or even having a complete representation of the mutual equivalence structures which they contribute to maintain.

The notion of mutual equivalence structures explains why one can observe a plurality of rationalities in organizations and possibly very little or irrelevant agreements between perceptions of a situation in the organization.

The fact that individual-based rationality does not contribute to an accurate description of the organizational strategy process, however, does not mean the process is irrational or erratic. It suggests that if we are to use the notion of rationality at all it should correspond to the level of analysis we are referring to.

2.3. Incremental approaches.

As we have seen in the previous chapter although images of technological innovation processes tend to increase in complexity, they continue to assume its intrinsic manageability. By manageability is meant that the process can be deliberately influenced, by a unitary source of agency (an individual or a coalition) acting adequately, in a pre-determined direction. What this examination of the rational approach points to is to an alternative image of the technological innovation process as something which is not manageable in its entirety on the basis of unitary sources of agency.

A more complex picture of the strategy process began to emerge from behaviourally oriented studies of strategic processes (e.g. Mintzberg, 1978; Stewart, 1963). Studies of how managers actually generate strategies insert this question in a totally different framework. By observing managers in their social settings and daily activities, it became clear that the rational approach was not particularly relevant to describe, or explain, behavioural patterns identified in strategy making.

Strategy started to be seen as emerging in a variety of ways from the continual flux of actions, decisions, interactions, etc., that take place in an organization. Mintzberg (1978) described strategy as "a pattern in a stream of decisions", observed different ways in which strategies were formed and changed, and named some of these behavioural patterns: incremental changes, when new strategies developed by progressively building on existing practices; piecemeal changes, when some strategies were changed in an uncoordinated, fragmented way while others remained unchanged; global changes, where many strategies were changed at the same time, in a coordinated way; and periods where no change could be seen to take place, or where no strategy was apparent or the organization seemed to be reluctant to make any kind of decision.

Incremental perspectives differentiate themselves from rationalistic perspectives in the way they look at strategy. Strategy is depicted as the outcome of a process (Burnes, 1992), a process whereby the organization feels its way in its environment by trial and error (Johnson, 1987). This process is based on the interactive group of persons that has to make decisions. They contribute to it whether or not they are explicitly recognized as "decision makers" or "strategists", and whether or not their decisions are recognizable as "strategic" in the sense described by Johnson and Scholes (1988, above).

Incremental perspectives differ from rationalistic ones in a crucial point: while rationalistic perspectives take the strategist as a purposeful, conscious and essentially intentional agent, incremental perspectives entail no such notion. Furthermore, instead of describing strategy as essentially a proactive construction, incremental perspectives describe it chiefly as a retrospective construction.

This avoids the pitfalls inherent in the definition of the nature of strategic problems as essentially solvable, characteristic of rational approaches. Strategy is defined as an emergent property of a social system, to which the process of rational decision making certainly makes an input but of which it is not a good description. The organizational strategy itself is not attributable to the purposeful action of a single agent, at least in the general case, but rather to the actions of groups and coalitions in the organization.

Looking at strategy as the outcome of a process shifts the attention to the process itself, which has been described as a social intensive, political process (e.g. Bower and Doz, 1979). A further contribution of incremental perspectives is the recognition of the complexity involved in the process of organizational, strategic decision making.

2.3.1 Levels of complexity in organizational decision making.

The high levels of complexity involved in strategic decision making is widely accepted but its degree is seldom investigated. How do you measure the degree of complexity of something you do not know in its entirety?

Human beings are able to deal with processes whose complexity they can only suspect. If we consider language, the models used to describe language and the processes of speech production can be immensely complex and yet they just scratch the surface of the problem of understanding what is language, speech, etc. However, we use it everyday without thinking about it, unless we have some problem of language, like meeting a foreigner. So, the user of language is perfectly capable of mastering a very complex process.

By framing the question in this way, one is suggesting that a behavioural approach to complex objects is useful in some ways to think about the complexity involved. We know language is a very complex process because we hardly can describe it. But we also know that we are thinking about language with the same brain that so masterfully uses it, so there should be levels of comparable complexity in subject and object ensuring the requisite variety is present in the subject to cope with the complexity of the object.

If one thinks about the complexity of organizations along these lines, it will be useful to think about the users of organizations and observe their behaviour and levels of proficiency.

Organizational users, or actors, are masterful actors. They go on and on playing their game of surviving, running away, manipulating, bluffing, using power, getting power, etc.

The game metaphor is used here because game theory can be used to make a very important point about organizations and the way we think about them.

Let us consider the notion of complexity in game theory. If we take "naughts and crosses", to begin with, it is a game where players can use a perfect strategy, in the sense that none of them will loose if the strategy is followed (Guillen, 1983).

If we take checkers, now, Guillen suggests that this is a game where the perfect strategy is still to be discovered but probably within reach of the human mind.

Chess seems to be the game where one can state the possibility of a perfect strategy but where it seems definitely out of reach. This is not to say that there are not good strategies in chess, because they exist. What it means is that the perfect strategy, the one that makes sure that whoever uses it cannot loose, seems to be out of reach.

This line of thinking suggests that even in perfect information, two players games such as chess, there may be a limit to the amount of complexity the human brain can cope explicitly with. Guillen suggests that this ability stops somewhere between checkers and chess, which is a good description because we can gauge in explicit terms the degrees of complexity one is talking about even if we cannot cope with them.

Now if we come back to the problem of assessing complexity in organizations, we can possibly try and gauge explicitly their position in a complexity scale of this kind. My suggestion is that it will be well above the complexity of chess. A comparison that comes to mind is that the problems in the "organizational game" are akin to the problems Alice had in Wonderland playing croquet, batting live hedgehogs with live flamingoes. In organizations, of course, we are talking about a game more complex than croquet, or chess for that matter, and about live persons.

Lyles and Thomas (1988) suggest that the complexity of strategic problems leads to differing definitions of the nature of the problem and differing interpretations of situational clues. These differences are related to individual variables, like the person's background and previous experiences, and also to socio-political and socio-psychological factors. People can therefore interpret situations in very different ways which will be reflected in their decisions.

One of the socio-political factors that contribute to this differentiation of perceptions is the division of labour in organizations. Koopman and Pool (1991) argue that whilst such division can reduce complexity to manageable levels, it also raises several problems in what concerns the congruence across subunit decisions which in practice is difficult to obtain. This is problematic because, naturally, strategy is a process which is expected to concern the organization as a whole. Quinn (1980), however, shows convincingly that only a step-by-step approach is feasible, given the complexity involved. In this process, extended over time, differing assumptions about the nature of the problem can become relevant in different moments, as different actors manage to assert their views.

Lyles and Thomas (1988) suggest that the multiplicity of views is associated with more successful decision-making. The lack of congruence can be seen as the price to pay for the ability to deal with the complexity involved in strategic decision-making.

There seems to remain, at any rate, the need for integrative mechanisms in this learning process. The recognition that the complexity of strategic decision processes forces their distribution along the organization invalidates the "heroic view of the chief executive as the source of dicta" (Bower and Doz, 1979:157). It also creates the need to understand the operation of other integrative devices in the strategic process.

Bower and Doz (1979) describe shaping the premises of sub-unit decision processes by the chief executive as a possibility. The communication of purpose by the person or group who distributes the rewards in the organization is one way of influencing the decision premises. Purpose can be communicated in various ways, from the more formal definition of incentive systems, personnel practices, etc., to an explicit statement of strategy. The point is that it focuses the "attention of independent social activity" in the pursuit of objectives.

This formulation does not do complete justice to Bower and Doz's insight into this process. Basing their case on the work of Crozier (1964) they argue that the nature of this process is also essentially political. People will develop their bases of power mostly by showing they are relevant in controlling some of the uncertainties the organization has to cope with. In the work of Crozier (1964) and later Crozier and Friedberg (1977) the ability to control important uncertainties is at the core of political action. Not only will people use the leverage this specific ability gives them in relation to other actors, but they will develop this ability intentionally.

Crozier (1964) described how maintenance staff in the state monopoly of cigarette production acquired significant power by controlling the technical information necessary to repair and maintain the machines. This control went to the point of repairs manuals being destroyed, or hidden, and the relevant information being kept in the heads of maintenance staff. This gave this group significant power over other groups of workers, whose productivity pay depended on their machines working properly.

There can be many sides in the issue of determining the actual strategy that will be implemented, a recognition which is typical of incremental or processual perspectives. The relevance of these parties to the process of strategy definition and implementation is understandable in political terms:

people who for some reason can make themselves heard, i.e., be recognized as relevant partners in the debate are the people who influence strategy. This is a process which clearly does not depend on the formal hierarchical authority but on the ability to influence others.

This description, however, does not explain how this process of influence takes place, apart from the use of coercion described by Crozier. As we have seen above, Bower and Doz suggested that the communication of purpose by those who control rewards is a way of influencing sub-unit decision making. But the way this form of influence works is not totally clear. Given the political nature of the process of decision making, it is hard to see how this communication of intent may influence linearly the premises actors will bring to their decisions. It also leaves untouched how the premises of the actors controlling the rewards are influenced by others around them.

2.4. Interpretative approaches.

This notion of strategy as the outcome of a process and its consequences for understanding the relationship between the activity of individuals and organizational strategy is taken a step further in interpretative perspectives. These differ from incremental ones in the sense that they consider strategy as the result of interpretations superimposed on reality (Johnson, 1987). The notion of interpretation and the description of interpretation processes, naturally, become central to this type of analysis.

2.4.1. Frames of reference.

Shrivastava and Mitroff's (1983) work on frames of reference is an example of the utilization of cognitive dimensions to understand how reality is interpreted in strategic decision making. They assume that the frames of reference people mobilize are the most important factor in determining what kinds of scanning, information treatment and decisions will be used.

The elements of these frames of reference (Shrivastava and Mitroff, 1983:164-166) are:

- Cognitive elements: these are bits of information people possess and use. They are defined as internalized experiences. As such, they indicate an individual's selective preference for a type of experience as the source of valid data.

- Cognitive operators: methods by which individuals order and rearrange information extracting meaning from the mass of data received. Examples of cognitive operators are categorical schemes, models, analytical devices and common sense theories. If cognitive elements can be compared to isolated concepts, cognitive operators are the theories that link and organize those concepts. Cognitive operators orient the individual to a particular domain of inquiry, i.e., they delimit what is "out there" to be seen. In this sense, they influence the process of problem formulation, along with "external" influences such as situational, political and social factors.

- Set of reality tests: they represent definitions of what decision makers consider legitimate knowledge and legitimate processes of inquiry. Reality tests impart a sense of objective or inter-subjective reality to knowledge and to the process of inquiry.

- Cognitive maps of the domain of inquiry: these are the inquirer's assumptions about the scope of enquiry and the nature of its boundaries.

Shrivastava and Mitroff's work on frames of reference illustrate how subjective interpretations are superimposed on reality in order to make sense of it. Particularly interesting to the present work is their notion of reality test, a form of inter-subjective validation of knowledge about a particular domain. The notion of reality test can be seen as one of the possible channels by which influence may be exerted between actors, without resorting to forms of coercion. Indeed the process is clearly a two-way process in that it requires that a definition of reality is confirmed by the other part. It presupposes the existence, and the theoretical relevance, of communications and interactions amongst groups of people. By these interactions they build and change their frames of reference. Because the mobilization of frames of reference determines the organizational strategic problem domain (Lyles and Thomas, 1988) this inter-subjective validation process determines the contents of conversations and arguments, the reality organizational actors assume they have to deal with. As a consequence, groups and individuals who for any reason become influential in this process are very relevant to the understanding of the strategic process, whether or not they are explicitly recognized as "strategic" actors. In this way, we can start to conceive of the processes by which decision premises are shaped as a process of exchanges about "reality".

2.4.2. Attributions of causality.

Another approach to interpretative dimensions in organizational decision making, is advanced by Weick (1977, 1979; also Bougon et al., 1977). The authors' focus is on the attributions of causality people make.

Causal assumptions are taken as the foundation of sense making. As people are exposed to a continuous stream of experiences, they try to extract some sense out of it and reduce its equivocality. The experiential stream becomes meaningful when people punctuate it in order to isolate chunks that become the elements of perception (the objects in the world out there) and then establish relationships between these objects. The objects people construe and the relationships between them constitute the individual cognitive map. Causal maps are a particular case of cognitive maps where only causal relationships are considered. Understanding organizational processes is understanding how the causal maps of individuals relate to each other, to what extent and by what processes they become interlocked.

The centrality of causal relationships in these authors' work results from the centrality of action in their perspective. It is through action that people accede to the flow of experiences that they interpret, of which they make some sense. Action is made possible by the assumptions of causality people make: "If I do this that will happen" (Weick, 1977). People must construct causal assumptions that reduce some of the equivocality of their perception of the world so that they can act.

The crucial organizational process becomes the reduction of equivocality by negotiation of the portions of the stream of experience that are relevant and those which are not:

"...members collectively try to reach some workable agreement as to which portions of the elapsed streams should be punctuated into variables and which connections among variables are reasonable" (Weick, 1977:295).

In Weick's perspective there is no "external reality" independent of the activity of the subject.

Reality is construed at the individual and the inter-individual levels.

Weick's ontological position contrasts with the one shared by most researchers of technological innovation processes most clearly regarding the notion of environment and the relationship between mind and environment.

> "...organizations [are]... snapshots of ongoing processes selected and controlled by consciousness and attentiveness. In turn, ...consciousness and attentiveness [are] ...snapshots of ongoing cognitive processes or, more precisely, of epistemological processes whereby the mind acquires knowledge about its surroundings. In these epistemological processes, <u>both knowledge and environment are simultaneously and interactively constructed by the participants in an organization.</u> (Bougon et al., 1977:606, emphasis added).

An assumption shared by most researchers of the strategy making process is that there is an environment "out there" that the organization or the actors inside the organization have to deal with in order to survive. Weick's challenge to this perspective explores the possibilities opened by considering the alternative position in the relationship between subjective and objective reality.

2.5. Consensual domains and language.

Weick and colleagues' contributions described above amount to a reconsideration of the ontological nature of "organizational reality", raising the philosophical issue of the nature of reality, whether it is to be considered as independent of the activity of the subject or as a subjective construction. This issue is implicit in interpretative approaches to the strategy process, with their emphasis on subjective constructions as the source of strategic action.

Winograd and Flores (1986), in their reflections on the nature of cognition and interpretation, address this problem, basing their argument on the philosophy of Heidegger, and his notion of the primacy of experience and non-reflexive understanding.

Heidegger's contribution to this issue is better understood against the background of the philosophical debate on the nature of reality. The problems in establishing the existence of an objective reality, independent of the activity of the subject, led Kant to complain about the "scandal of philosophy", its inability to provide such a proof in the thousands of years of western philosophy.

Heidegger argued instead that the "scandal of philosophy" is that a proof of the existence of an objective world is expected and repeatedly attempted. He considered that the subject-object dualism inherited from classical philosophy "denies the more fundamental unity of "being-in-the-world" and removes one "from the primacy of experience and understanding that operates without reflection". The simple objective stance (the objective reality is the primary reality) and the simple subjective stance (my thoughts and feelings are the primary reality) are rejected: one cannot exist without the other. (Winograd and Flores, 1986:31).

This refusal of the subject-object dualism may be hard to take in because it shakes very fundamental assumptions of Western culture, but it also opens intriguing possibilities in overcoming the limitations identified in rationalistic models concerning the description of the "messy" organizational processes unveiled by incremental perspectives on strategy formation.

One of these is the reconsideration of cognitive processes. If the subject-object dualism is denied, cognition must be reconsidered. Rationalistic approaches to cognition assume that the subject relates to the objective world by having representations of it: subjects construct inner "mental models" (though designations vary across schools) which are in a relationship of correspondence to the external world (Winograd and Flores, 1986). It is this correspondence between external reality and internal models which makes the world intelligible.

Heidegger refuses this notion of mental representations on various grounds. First, if one focuses on direct experience of the world, "concernful activity" becomes the central activity by which one can understand this world. Representations of this world become less important as a means to relate to reality. The primacy is given to acting in the world, to being there, not to thinking about it.

This concern with action and experience, with <u>being-in-the-world</u>, has far reaching implications for the study of organizations and the strategy process. Incremental perspectives, by focusing on the actual, behavioural processes of emergence of strategies, reflect this same primacy of experience and action, of non-reflexive understanding, suggested by Heidegger as a way out of the endless debate on the primacy of objective or subjective reality.

Heidegger uses the term "thrownness" in relation to being-in-the-world. Just as we do not elaborate a theory of swimming when we dive in at the deep end of a swimming pool, we cannot avoid our condition of being "thrown" in a flow of experiences where it is impossible not to act and reflexive understanding is not possible.

Our condition of thrownness has yet another implication. It means that we do not act in isolation. Our actions are always social actions, in the context of a culture, with its own history. Even the most intimate or solitary behaviours are pervaded by the culture we were socialized into. Among other things, this entails that interpretation, as a construction of meanings is inherently a social process. Heidegger argues that "we must take social activity as the ultimate foundation of intelligibility". He suggests the inadequacy of the rationalistic view of cognition as an individual-centered phenomenon, by defining the person not as an individual subject or ego, but as a local manifestation of "being" "within a space of possibilities, situated within a world and within a tradition" (Winograd and Flores, 1986:33).

Winograd and Flores make the point that social processes like language and action are the domain within which reality, including organizational reality, becomes intelligible. They tie in at this point contributions from neurophysiology which clarify and develop the implications of Heidegger's thinking to the study of organizations.

Research on the neurophysiology of vision (Maturana et al., 1960, quoted in Winograd and Flores, 1986) demonstrated that a frog's retina has structural arrangements of cells, connected to a single nerve fibre that react not to variations in light intensity but to patterns of variations in intensity: this makes possible, for example, that a single nerve fibre responded selectively to a pattern described as a single dark spot surrounded by a lighter area. The excitement in this single nerve fibre triggers the sequence of activity that results in the frog catching a fly.

This and other studies, for example related to colour perception, suggest that perception should be studied "from the inside" as a function of the structure of the nervous system, and not as a function of the properties of stimuli. Maturana suggests that the nervous system is better understood as a closed network composed of interacting neurons. Structural changes at some point will change the activity of the system, but "the sequence of states in the system is generated by relations of neuronal activity as determined by its structure" (Winograd and Flores, 1986:43). In this sense there are no "inputs" to the nervous system, its changes of state are determined not by the structure of external stimuli but by its own structural arrangements. External perturbations trigger changes of state, they do not determine what these will be. Furthermore "it is the structure of the perturbed system that determines, or better specifies, what structural configurations of the medium can perturb it" (Winograd and Flores, 1986:43).

This view of the cognitive system which can do without "representations" or "images" of reality entails a change in our understanding of perception. The notion of correspondence between mental contents and reality, particularly, becomes meaningless. Perception is not of the same nature as mapping. "Elements in the medium" and "elements in the mind" are not in a relation of correspondence. Instead of speaking about inputs to the brain, one has to speak about structures of external stimuli that "match" the characteristic specification of that particular nervous system to trigger a change of state. This "matching" is called by Maturana "structural coupling". Structural coupling is the process by which "the structure of the nervous system generates patterns of activities that are triggered by specific perturbations in the medium".

It is the result of the species' and of the individual's history. The frog reacts to the fly against the skylight because of the structural coupling between its nervous system and the environment in which the particular frog one is studying and its ancestors survived and evolved. It does not react to a fly on the basis of an internal representation of a fly.

Part of the perturbations coming from the environment, originate in other organisms. Interactive organisms also undergo processes of structural coupling. Their mutual behaviours become an interlocked pattern. Each of these behaviours can be seen as triggering a sequence of changes of state in one organism which result in a behaviour being elicited, which in turn triggers another sequence of alterations in the other organism, and so forth. Mating rituals in mammals and birds are familiar, sometimes spectacular, examples.

> " The various conducts or behaviours involved are both arbitrary and contextual. The behaviours are arbitrary because they can have any form as long as they operate as triggering perturbations in the interactions; they are contextual because their participation in the interlocked interactions of the domain is defined only with respect to the interactions that constitute the domain. .. I shall call the domain of interlocked conducts... a consensual domain" (Maturana, 1978:47, quoted in Winograd and Flores, 1986:49)

The notion of consensual domain orients the observer to the patterns of interlocked behaviours generated by interacting organisms, such as people in organizations. Behaviour in this consensual domain is essentially linguistic. Maturana defines linguistic behaviour in a very global way to include "any mutually generated domain of interactions", not just verbal behaviours. Looking at speech in organizations as linguistic behaviour in a consensual domain is to look at the orienting role of speech. As Maturana points out "language is connotative, not denotative and ... its function is to orient the orientee within his or her cognitive domain, and not to point to independent unities" (Winograd and Flores, 1986).

This exploration of the related notions of language and perception brings the use of language in the organization to the forefront. In order to understand how people may influence each other's interpretations of a situation we may choose to look at language. Its use in the organization is chiefly a mean to involve others in a definition of reality, rather than a mean to make statements about reality with no concern for how these statements are received by others.

2.6. Romanticism, Modernism, Postmodernism.

The main reason for going into the notion of strategy at some length was the need felt to enlarge our referents in what concerns the process by which people make sense of the organization, as a basis for action. As discussed in Chapter 1, both the organizational and the individual level of analysis were felt as inadequate to the detailed understanding of the interactive processes that take place with technological innovation and the associated organizational changes.

The possibility of thinking about the ability to influence actions other than the individual- or the organization-based became more clear with this analysis of the concepts of strategy. At the core of this process of interpreting reality we find language. Language is used to build an image of the situation which influences the premises people take into the decision making process.

Gergen (1992) sheds some light on this question by analyzing the concept of the person underlying the romantic, modern and postmodern cultural currents.

Romanticism contributed to the prevailing concept of the person chiefly by the "rhetorical creation of the deep interior" (Gergen, 1992:208). Constituent of the "deep interior" is a notion of an "interior force", variously described as inspiration, creativity, genius, power of will, etc. The romanticist vocabulary can be found in many humanistic approaches to organizations where notions of the person, the individual, are invested with a central explanatory power. Gergen enumerates some of the approaches to organizations issued from romanticism, among which are psychoanalytic approaches to the organization, the Human Relations school and some aspects of Japanese management practices, emphasizing bonds between individual employees and the organization.

Modernism asserted the powers of reason, the search for fundamentals and the faith in progress. Modernist presumptions clearly influence mainstream organizational and managerial research. Scientific Management and General Systems Theory, including contemporary contingency theory, are among the theoretical models which can be described as modernist. It is interesting to notice that criticisms of contingency perspectives reviewed above draw chiefly from the romantic tradition, asserting the value of the individual as an explanatory concept, alternative to the blind, mechanical interplay of contextual and organizational variables. As we have seen with Barley (1990), this may lead to some theoretical instability.

The "postmodern transformation" can be described as reversing the modernist view of language as a mirror of reality. In essence the modernist concept of language saw it as keeping with reality a relation of master to slave (Gergen, 1992:212).

> "The essentials of the universe (atoms, neurons, economies, and so on) served as masters, fixed and foremost, and the language was to be their servant - flexibly bending to the contours of the essential." (Gergen, 1992:212).

A postmodernist alternative to the modernist world-view moves essentially towards a replacement of the real by the representational, inverting this relationship between language and reality, and the definition of representations as communal artifacts.

The postmodern notion of language becomes clear if we assume that knowledge is essentially a body of discourse. As such, it can be seen as constrained by ideology and values, by social processes and by the rules and conventions of language formation (Gergen, 1992:213). It follows that the existence of objective, interest-free knowledge is problematic, because when we are "doing science" we are always moving within the realms of the subjective, the social, the ideological. This does not mean, however, that we can say what we want and claim a scientific status for our discourse. Taking discourse as constrained by social processes implies that the meaning and the truth-value of what we say is a matter of community judgement and acceptance. Sense-making is a collective manifestation, it requires the coordinated participation of two or more persons (Gergen, 1992:214).

A consequence to our vision of the person is that whereas we were socialized into thinking that we produce discourse and knowledge, we may start thinking that it is the other way around, that it is the discourse networks where we live that determine us. When we speak we are not asserting ourselves through discourse, it is the discourse which asserts itself through us.

Postmodern evaluation of scientific discourse is not concerned with its relationship with reality but with its relationship with other discursive practices and the possibilities for interpreting reality, and consequently for action, they open.

Coming back to the question of power and the source of action, taking language as what enables action implies that the source of action can be seen in processes which are essentially inter-individual.

A discursive practice does not exist without someone to listen and to confirm or reject whatever meanings are being asserted. So the notion of power implicit in this vision is radically different from the romanticist notion (power as a personal attribute, coming from the person's interior energy) or the modernist notion (power as the result of a correct representation of reality). A tentative definition of power will be the possibility of specific discourses being accepted and influencing the discourse of others, changing the relationships those others maintained with the "universe of discursive practices". Power appears associated not with individuality but with the participation in specific sets of discourses which become prominent momentarily, relegating other discourses to marginal, less prominent positions.

2.7. Conclusion.

In this chapter we have seen how rationalistic approaches to the strategy process have focused on the conditions and processes by which decision makers can make sound decisions. From this approach several recommendations can be made which typically are based on models of the process by which the individual decision maker can reach a decision which maximizes the probability of a desired outcome.

We have also seen the limits of this type of approach to understand the social processes involved in the definition and implementation of strategies in organizational contexts. The complexity of the strategy process in organizational contexts makes it inevitable that decisions are distributed among several people which may have different interests and therefore will pursue different objectives, maintaining a political relationship between them. Rationalistic perspectives assume implicitly that once a decision is reached implementation can or should be straightforward. Defining the strategic process as a social, political one suggests it is much more complex and dynamic than rationalistic perspectives imply.

Incremental perspectives focused on the process by which a strategy comes into existence in organizations. In this sense they are much less prescriptive than rationalistic approaches, in that they centered on the actual processes which relate to the definition and implementation of strategy. A central contribution of these perspectives can be seen in a greater awareness of the levels of complexity involved in organizational strategy making and the consequent understanding of strategy as essentially a social process. This raises the issue of understanding whether and how the strategy process can be intentionally influenced. One possibility is to influence the premises which actors bring to their decision making.

Interpretative approaches lay the ground for a better understanding of how this may be achieved. By relating strategy to the actors' interpretations of "reality" interpretative approaches define a new domain of phenomena to be explored. Interpretation is essentially a social process mediated through language. Language is used to describe what exists and to commit other actors to this description. It follows that influence on the strategic process is dependent on influence on the way people use language in an organization.

In the first chapter we saw how recommendations concerning the process of technological innovation became progressively concerned with the radical organizational changes enabling the strategic use of new technologies. These recommendations were criticized for assuming too much linearity in the process of implementation of decisions which entail changes in actors' organizational roles. These changes in organizational roles prompt the actors to actively re-define their roles in an inherently political process. What is at stake in these processes is both the role content, as new technologies change the tasks which have to be carried out, and role inter-dependencies, with the concurrent changes in status and relative power.

In the second chapter we saw how the process of strategy formation is distributed through the organization mostly as a consequence of the complexity involved. The fact that this process is distributed implies that several perspectives are asserted by different actors, which are not necessarily compatible between them. This distribution therefore highlights the need to understand the processes by which actors interpret their experience in order to make sense of the organizational processes. Such an understanding becomes relevant not only as a means of understanding how strategies are formed through this distributed process but also how this process may be influenced.

Organizational change processes associated with technological innovation processes may be highly complex because its nature if that of a process which is distributed among several actors whose roles are altered and who therefore will initiate processes of political interaction, not with the candid objective of implementing a rational strategic plan but with a definitely biased view on how their roles will be re-defined.

CHAPTER 3: METHOD

3.1. Rationale.

The understanding of the strategy process as essentially a matter of interpretative processes, has created the need for methods to deal with the collective processes of a subjective nature involved in organizational action. Interpretation, or sense-making, has been usually approached by the use of cognitive maps. In this chapter we will discuss the nature of these maps and the problems with their use to understand organizational interpretative processes. This will help situate the method developed in this research.

3.1.1. Cognitive maps.

Cognitive mapping as a method of description and intervention in organizations appeared at the center of this effort to connect the way people think and the way they act in organizations.

The graphical representation of subjective dimensions takes many forms and is used in the context of different approaches to the strategic process.

Of particular interest in this research is the tradition started with Axelrod (1976) and Bougon et al. (1977) who started representing causal relationships between the variables identified by their subjects as directed graphs. Bougon et al. (1977) developed a graphical representation and subsequent analysis of the way musicians in a jazz orchestra conceptualized the variables relevant to their performance and the causal relationships between these variables.

The label "cognitive mapping", which became associated with techniques used in research along these lines actually covers different data collection procedures and types of graphical representation (Fiol and Huff, 1992).

3.1.2. Nature of cognitive maps.

There is some ambiguity regarding exactly what the nature of cognitive maps is and what they represent. To start with a negative definition, Eden (1992) suggests that they are not models of cognition because that would require maps to be based on a modelling technique which would be a good representation of an adequate cognitive theory; this is neither the case nor even the concern of most research using cognitive mapping (Eden, 1992:261). A second reason why cognitive maps do not qualify as models of cognition is what makes them promising techniques for intervention: the elicitation of cognitive processes is found to change these processes, in a cathartic experience which provides added value because it actually changes the way people think (Eden, 1992). Cognitive therapy depends upon much the same processes.

Fiol and Huff (1992:267) define a cognitive map as a "graphic representation that locates people in relation to their information environment", providing "a framework for what is known and believed". This definition pictures maps essentially as tools to analyze and understand structures of knowledge.

Cossette and Audet define a cognitive map as

> "... a graphic representation of a set of discursive representations made by a subject with regards to an object in the context of a

> particular interaction. It is the work of a researcher who constructs a graphical representation of a discourse..." (Cossette and Audet, 1992:327).

Their definition is more specific in that it includes the agent which creates the map. It also specifies a map as a representation of a discourse about an object. Such discourse can be described as public and directed at an actual or potential interlocutor.

Langfield-Smith (1992) defines a cognitive map as a description of an individual's conscious perception of reality, therefore introducing the notion of consciousness. This can be compared to the previous definition of maps as a representation of discourse, on the assumption that discourse is a conscious activity (even if some dimensions and structures of discourse, are not).

Maps have been used in various ways in the effort to improve the functioning of organizations. This effort has taken place either at the individual level, relying essentially on the "emancipatory properties" of cognitive maps (Cossette and Audet, 1992), or at the organizational level. At this level, according to Cossette and Audet (1992) cognitive maps have been used (i) as an aid to decision making and problem solving (for instance, Eden et al., 1983) or as a research instrument useful to depict the epistemological structure which constitutes the essence of the organization (Weick and Bougon, 1986). It is this last use of cognitive mapping which is more relevant to this research.

3.1.3. Collective maps.

The problematic nature of cognitive maps suggested by Eden (1992) becomes more evident when one considers the notion of collective cognitive maps. These problems can be clarified by looking at two techniques used to build collective maps. One, mostly used in situations where the map is to be used as a decision-making, problem solving or negotiation device, is a group session where the same discussion one would have in order to build an individual map, takes place within a group (e.g. Eden et al. 1983). The nature of the outcome of such an approach is not difficult to apprehend. It is a self validating methodology in the sense that it yields an instrument which is used as the basis for communication and exploration of group processes and never gets out of the group control. Naturally, some negotiation and use of power takes place but this should not be taken as a limitation of the validity of this type of map, as these processes can be assumed to be similar to those taking place in the "real" situation. In a way, the advantage of this type of map is to make explicit and visible the prevailing understanding of what a situation is and what should be done about it.

The cognitive maps resulting from this approach are not "hard" models of organizational processes. Instead they should be taken as the product of a stage in a process of sense-making, which can be used to direct this process towards an understanding of a situation which participants feel is more useful.

It is when collective cognitive maps are intended as a representation of the organization that the theoretical and methodological problems become more complex.

Organizational theories have for a long time spoken of actions of organizations, organizational objectives and organizational strategies as if the concept of organization applied to unitary entities. Such a notion was a logical corollary for instance in the systems perspective, but it also raised the theoretical problems which showed the limitations of the biological metaphor underpinning the systems approach (Morgan, 1986).

Organizational cognitive maps, if we take the expression literally, suggest the existence of something like collective cognition. Now the notion of cognition is clearly a psychological concept which applies to individuals, not groups or other collective entities.

Some researchers actually use the expression collective cognitions in a slightly modified way, to denote the temporary agreement which is the outcome of social processes in collective encounters (e.g. Langfield-Smith, 1992). However, this notion of temporary convergence in perceptions relates to phenomena which can be better described in terms of group processes without resorting to the unwarranted notion of collective cognitive processes. Power and the structuring of communication channels, for example, can explain the communalities in speech, attitudes or actions observed in closely interacting groups.

The search for common ground in perception is based on the assumption that in order to act effectively people in an organization should share to some extent the same view of what their organization is about (Langfield-Smith, 1992; Louis, 1980, Sapienza, 1985).

One can trace this assumption back to studies of corporate culture (e.g. Schein, 1985) conceived as the common ground enabling communication and concerted action. The central role attributed to Japanese culture in the transformation of a semi-feudal society into an industrial potency suggested that culture could be a strong integrating force in the creation of homogeneous and consensus-based organizations (Martin et al. 1985). Although not all research on organizational culture took this extremely pragmatic view of culture it definitively influenced research in this area to a significant extent (Gomes, 1990).

To this "integration paradigm" can be opposed a "differentiation paradigm" (Martin et al., 1985) which looks at subcultures reflecting hierarchical or professional differentiations, or even counter-cultures which challenge the dominant culture (Gomes, 1990; Martin and Siehl, 1983; Van Maanen and Barley, 1984).

The search for common ground has been translated into methodologies for building "average" (Bougon et al., 1977) or "aggregated" (Eden, 1989) cognitive maps. The problem with these methods lies in their use of cognition as the internalization of models, or representations as the bases on which people are presumed to communicate. In Chapter 2 the problems with this notion of cognition were discussed. The suggestion of Maturana (1978) that structural coupling may be sufficient to describe the dynamics of interaction between organisms and the "primacy of the representational" over the real suggested by Gergen (1992) suggest other approaches to organizational discourse. Instead of looking for commonalities in order to build representations of discourses one should look for the structure of the distribution of discourses along a social network, with no previous assumptions concerning the shape of this distribution. If researchers assume that common ground must exist because the group they observe is still working together, then they will tend to select what is shared and ignore what is different. My suggestion is that both what is shared and what is not shared are important in the process of sense-making.

A possible re-interpretation of the effect of exploring cognitive maps in groups is that they embody a new discourse to which the group is exposed. This discourse states, in essence, a very simple thing: that the world may be interpreted in terms of interdependent variables. As the people explore the implications of this discourse they start participating in it. In consequence, they generate new interpretations of their experience and what is more, in interaction with the group where those interpretations may become relevant. Even if not all of them agree on a single interpretation, they will generate a whole new set of discourses, they are aware of who adheres to this or that interpretation and they can interact in a whole new basis.

When the map is used as an instrument to further group discussion, researchers' previous assumptions are not a serious shortcoming, as the process is self validating. If the researcher is trying to say something about the epistemological system of the organization, for instance, then different problems of validity are raised.

3.1.4. Maps, language and organizing.

Cossette and Audet's definition of cognitive maps makes it clear that irrespective of the use one makes of them they are representations of discourse. As the re-interpretation of cognitive maps above suggests, they are not only representations of discourse, they introduce a whole new set of discursive practices.

Contributions coming from research using cognitive maps are therefore relevant to the present research because they reveal something about the distribution of discourses along social networks. Bougon and collaborators (Bougon, 1992; Bougon and Komocar, 1990;

Bougon et al. 1990) established a very clear differentiation between the "concept" as the subjective meaning of a word or expression and its "label". By establishing this differentiation, the authors not only avoid oversimplification of the process by which we relate to and use words, but also contribute to the development of the view of organizations as interpretive systems.

Labels are the words or expressions people use to communicate, either verbally or in writing. As far as the subjective meaning of labels is concerned, it can differ markedly between people. For example, they can be inserted in very different individual cognitive maps. The important thing is that people use these labels socially and this usage enables them to act. This reflects a "minimalist orientation to social construction" (Bougon, 1992:372) in that the participants in a social system congregate not on the basis of shared meanings but on the basis of a few but crucial labels. Bougon calls these "cryptic labels", implying that their meaning is idiosyncratic and private. He suggests that it is their usage in social interaction and the causal loops that people establish between them that create the organization (Bougon, 1992).

Bougon's approach to the social construction of the organization however, leaves us in the dark as to what constitutes the nature of interactions between actors.

His distinction between "label" and "concept" is a valuable insight into the process of social construction of the organization, putting the emphasis on communicative, linguistic behaviour. But he also assumes that these labels are neutral in terms of the political dimensions of interactions between actors. People can differentiate their discourse as a means of political action. It someone wants to influence a social process in which s/he is involved, it is usually appropriate to find a new, yet relevant thing to say to someone, perhaps in a formal meeting to everybody, over the coffee break to the colleague next door or in a written report to the managing director. And this process makes labels which are not as widely shared as Bougon's "cryptic labels" at least as relevant to the understanding of organizational processes.

While cryptic labels can be seen to provide for "bridges" across individual actors' discourses, the not so widely shared labels indicate what is actually "bridged" by those labels.

A more detailed analysis of discourse is called for in light of such a criterion. It becomes relevant to understand how different labels are distributed across several individuals' discursive practices. By defining the meaning of labels used as idiosyncratic and private Bougon locates his conceptual "black box" at the individual level, defining no intermediate level between the individual and the organizational.

The notion of role and dyadic interaction discussed in the first chapter leads to the consideration of an intermediary level where political action can be understood as a process based on partial alliances and cliques. At this level it is possible to find labels which are not shared by the totality of organizational members but which are not individual. They define groups, people who come together in the way they refer to specific processes, or in the way they define this or that aspect of their experience in the organization. It follows that one of the criteria for an adequate methodology is the ability to show not only what is common in the discursive practices in the organization but also what is different, and how these differences are distributed.

3.1.5. The analysis of discourse.

Innovation processes were described as dynamically complex processes. They are based on the political interaction of actors in the organization, namely the interactions by which they mutually redefine their roles by taking a stand on an issue.

This re-definition may be usefully approached by studying the discourses which are put forward in the actors' interactions. Discourse is used here in the sense of a set of ideas, meanings, theories, rules, etc., which are understood or accepted by a number of people. Discourse analysis in linguistics is associated with the study of speech units larger than the sentence (e.g. Van Dijk, 1988:32). These larger units are studied by reference to the linguistic production of individuals, although not necessarily in isolation from specific contexts. In this research the analysis takes a different approach, which looks at discourse as something which is distributed among actors.

In chapter 2 we saw how discourse can be conceived of as orienting behaviour. We also saw how the process of making individual experience meaningful is intrinsically a social process. The identification of different discourses which concern the same object and the description of how these different discourses are distributed in a group can be transformed into a picture of the structure and contents of the sense-making process in a group, concerning that object. The strategic process can be defined as the result of linguistic interactions between the organizational actors, which, as orienting behaviours, will condition what decisions are made and what actions take place.

These interactions concern all the aspects of organizational life which, in a particular moment in time become relevant for the actors. Because of my research interests, it becomes necessary to focus on the discourses that are more relevant to the problem being researched, namely the exchanges that deal with the introduction of new machinery. This restriction is necessary because one is only interested in a few of the multiple layers of meanings in conversations.

The methodological problem is therefore how to approach the discourses produced in the organization in order to describe their distributive structure and to locate the members in that structure. If interpretations of reality take place as a social process and if these interpretations are constituted by discursive practices then it makes sense to look at discourse as essentially a social process. What becomes relevant is how the discursive practices which constitute meanings or interpretations are distributed amongst a group of people. This distribution should be closely connected with processes of sense-making and with processes of organizational politics. The analysis should therefore distinguish between discursive practices which are shared by the majority in a group, discursive practices which are only shared by some of the actors (and which actors are these) and discursive practices which are not shared inside the group being studied.

The method which was developed in this research makes it possible to depict the discourse structures of groups along these lines. Furthermore, it makes it possible to understand which specific discourses are shared or are isolated. It is therefore a helpful device to understand how interpretation as a social process takes place.

3.2. Procedure.

On the bases of this rationale, the research consisted in collecting samples of discourses from several managers in three organizations which had started using CNC machines not long ago, with the objective of identifying the discourses which were being voiced in this group during the period of data collection; these interviews were transcribed and codified; this information was analyzed in order to describe the distribution of discourses in the management group. Each of these steps, and the options made in them, will be discussed in detail in the following sections.

3.2.1. Access.

The companies were selected from a database according to the following criteria:

- the main activity should be engineering, both because it was decided to restrict the study to CNC machines and to enable some similarity between the processes where these machines were used;

- small to medium companies were selected mainly because it was anticipated that access to the management group would be less problematic in those companies and the complexity of the structures to be explored would be lower if less people were involved;

- the location of the companies in the West Midlands was selected in order to keep the logistic problems to a minimum.

Access to the organizations studied was gained through an initial contact by telephone. In this contact there was a first selection of the company on the basis of whether or not they were using CNC machines. The telephone call proved to be a fruitful access strategy because switchboard operators have relevant information about who is who in the organization. As a consequence, once the research was described as dealing with CNC machines, the call was put through to someone accessible yet relevant.

Such a strategy resulted in access being made through the operational side of the company. Once an initial interview took place and a positive relationship had taken place it became easy to identify and have access to other members of the organization, using this first contact as a reference. Sometimes the first contact made the presentations to the subsequent actor. Coming in in such a way also had the advantage that the researcher's presence in the organization was fairly unobtrusive at least if compared with getting formal permission from higher levels. This is relevant for the research because it minimizes the structuring of expectation concerning the interview.

3.2.2. Interviews.

Semi-structured interviews (Bryman, 1989) were carried out on the basis of an open ended interview guide (see appendix 1) which was used in a very flexible manner, mainly as a means to make sure that a consistent set of questions were presented to all interviewees in order to trigger the production of speech. From the moment people began speaking, they were encouraged to continue to do so as freely as possible, in a non-directive manner. I defined myself from the start of interviews as basically ignorant of the technological aspects of production (which was certainly true in the beginning) and kept that attitude during all the interviews in the same company. The clear recognition of my lack of familiarity with production and engineering prompted interviewees to develop clear explanations and descriptions of the CNC machines, the production process, the problems they had in it and so on. It was also instrumental in creating a non-threatening situation, in that interviewees had no motives to feel that their competence was being evaluated.

The interviews were tape-recorded. There was no special emphasis put on the confidentiality of individual interviews in what concerned other members of the organization. This means that people were aware that there was the possibility of what they said being known by other members of the organization.

Interviews took typically between 45 and 90 minutes. The interviews were transcribed and the excerpts of the transcript that referred to the introduction of CNC machines, its effects in the company, the problems with their implementation, etc., were selected to be analyzed. This selection was based on the simple criterion of whether or not people were speaking about the CNC machines or issues which could be directly related to them.

3.2.3. Coding.

The coding procedure is an intermediary solution between coding on the basis of pre-established categories and coding with no previous categorization at all. Each of these approaches has advantages and disadvantages.

It was felt that the use of pre-established categories would make the process excessively rigid, while the use of no categories would create problems in comparing the verbal production of individuals in the same organization. This option would entail analyzing the interviews at the word level. This was actually tried at an early stage of development of the method but it was felt that the results were not clear and only interpretations of what people meant when they were using specific words could make the results intelligible. It was therefore felt as more appropriate that interpretations should be based on the intact verbal production. The solution adopted was the use of three pre-established categories, very general and mutually exclusive, and the creation of sub-categories each time a new theme appeared in the interviews. These three categories were developed after examination of the selected interview excerpts in order to cover most of what people had to say about the CNC machines in the context of that particular type of interview. Interviewees, when explaining what happened with the introduction of the CNC machines, always gave descriptions of the machines, described actual decisions that had been made or action which took place because of this introduction and situated these actions in the context of objectives or orientations. Of the endless possibilities for imposing structure on the interview texts this one emerged as adequately exhaustive, logical and simple.

These three first level categories were as follow:

a) Themes related to the description of the CNC machine. Sub-categories were created for each new characteristic described. (Example: Speed; Accuracy.)

b) Themes related to objectives or guidelines in the implementation of machinery. Sub-categories were created each time a new objective or guideline was evoked. (Example: Increasing the utilization rate; Increasing productivity.)

c) Decisions made and actions taken because the CNC machine was introduced. A new sub-category was created each time a different decision or action was described as a consequence of CNC introduction. (Example: Selling old machines; Training people for CNC use.)

Each category was used separately, i.e. each interview was analyzed first looking for characteristics, then for objectives or guidelines and finally for accounts of decisions and actions. For each of these categories, sub-categories were created whenever the existing ones did not correspond to the interviewee's verbal production. In the first coding, there was not the concern to use sub-categories consistently, as it was felt that this would interfere with the understanding of what the text was about. After a set of sub-categories was thus generated, they were listed, together with the text to which they applied, in order to detect sub-categories which refered to similar themes. Whenever this was the case, those sub-categories were merged together. Finally, all the interviews were re-analyzed in order to make the coding procedure more consistent across different interviews.

The categories were created in order to organize the information with minimal selection. The main problem with these categories is that in a way they impose a rationalistic structure on a discourse which is not necessarily or exclusively rational. There are, however, good reasons for doing this.

First, the structure imposed is in many ways a minimal structure. The three categories are just the first level in the codification procedure and in each category subcategories can be created in order to cover as much production as possible. Second, when explaining the organization to an outsider with whom only a superficial relationship exists, organizational actors try to demonstrate logically the value of their choices, in view of objectives and available resources.

The choice of a rational structure is therefore consistent with the discourse being analyzed. Third, although the structure is rational it is not evaluative, i.e., it does not impose any type of rationality as an ideal. The consistency between objectives, resources and decisions is not evaluated, so even if the discourse analyzed describes decisions hard to justify rationally this discourse can be described by the categories chosen. Finally, the structure was derived from the discourse itself, i.e., only after becoming familiarized with all the interviews were these first level categories defined and used throughout the actors' production.

3.2.4. Factor analysis of the distribution of categories.

It is in the distribution analysis that the methodological problems become more complex. The methodology adopted was based on the comparison of individual profiles, described by the categories above using analysis of correspondence. Each company's discourse structure was analyzed by cross-tabulating all the discourse categories identified at the coding stage by all the actors and assigning value 1 or value 0 to the matrix cells, representing whether or not a particular actor used a particular category during the interview. In this way, each actor is described by the discourse categories identified in the text of his interview.

Analysis of correspondence in then used to identify how similar are the discourses of the different actors. It starts by building a matrix of values which correspond to the situation of independence between the two variables (actors X discourse categories), a process similar to that used in the chi-square test. This second matrix is then subtracted to the values (1 or 0) in the original matrix. The resulting matrix is then factor analyzed. The values which actually influence the factors extracted are therefore the differences in relation to an hypothetical situation of independence. In terms of discourse this would mean that everybody was saying exactly the same things in the same way, a very unlikely situation. The more an actor's verbal production is differentiated from this "average discourse", the more important his or her production will be in determining the factors. This is the reason why some of the first factors in the cases studied show one actor isolated from the others (this can be checked by looking at the magnitude and sign of the factorial coordinates). This happens because he does not share any discourse categories with others, thus creating a very important deviation from the situation of independence.

Geometrically, the values which correspond to the situation of independence are located in the origin of the system of coordinates constituted by the orthogonal factors extracted. The more different an actor's production is, the further away from this centre s/he will be. Conversely, a discourse category which is taken by everybody will differ very little from the independence situation. These categories appear near the centre of the system of coordinates and contribute less to the definition of factors. In other words they bring little variety to the discourses in the group.

In addition to being different from the "average discourse", actors are different from each other. Therefore, they will be scattered in a space defined by the factors. The position of each actor or discourse category on a factor is therefore a vertical projection of his or her real position in that space.

If the actor is very distant from the factor s/he is not well represented by this factor, a fact which has to be taken into account when interpreting the factors. The value Cos2 in the tables of results represents how well an actor, or category is represented.

This analysis shows in summary how different is each value in the matrix by comparison with an average value and how different are the values by comparison between them. A more detailed description of the method is presented in Appendix 4.

In Figure 3.1. is represented the plot of the two first factors extracted by factor analysis of correspondences of a matrix representing the distribution of Characteristics of CNC from Company 2. On the basis of this plot one can identify for example similarities between the Managing Director and the Commercial Director in describing the machine as Accurate (northwest of plot). Towards the southwest of the plot, we find the Toolroom Machining Manager defining the CNC machine as fast. At the centre of the plot can be seen three actors around a description of the machine as controlled by a programme (instead of an operator).

In this way it is possible to identify different areas interpretable as different ways of talking about the machine, and to identify the actors located in those areas. It should be noted that not all actors are sufficiently well represented in this plot, as it is based only on the two first factors. A third dimension, perpendicular to the plan of this plot, would show that these actors and categories are in fact at different heights in relation to the plan of this plot, thus defining other areas. And so would the other factors.

```
+---Self-threading------------------------------------------------------+
!    Wire       !                                                       !
!               !                                                       !
COMMERCIAL DIR. !                                                       !
    MANAGING DIR.                                                   ZZ 1!
!   Accuracy    !                                                       !
!               !                                  TECHNICAL DIR.       !
!        QUALITY                                                        !
!       ASSURANCE MGR                                                   !
!               !                                                       !
!               !                                                       !
!     TOOLROOM  Controlled     PRODUCTION                               !
+------MGR------by programme--SERVICES MGR------------------------------+
!        FINANCIAL DIR                                                  !
!               !                                                       !
!               !                                                       !
! TOOLROOM MACHINING MGR                                                !
!        Speed  !                                                       !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!       Learning                                                        !
!       curve for                                                       !
!        CNC    !                                                       !
!               !   PRODUCTION                                          !
!               !   ENGINEERING MGR                                     !
!               !                                                       !
!               !                                                       !
!               !                                                       !
!               !   Relevant for                                        !
!               !   Toolroom use                                        !
+---------------+---only------------------------------------------------+
```

Fig. 3.1. Example of a plot of factors extracted by correspondence analysis: Factor I (horizontal) X Factor II (vertical) of Characteristics in Company 2.

For this reason, this plot is presented here only as a means of clarification of why correspondence analysis is relevant for this research. In the interpretation of factors they will be analyzed individually and not on the basis of a plot like this one.

The analysis was done using "Tri-deux" (Cibois, 1987), a set of programmes specifically designed to analyze the distribution of themes across different sources.

The software starts with a file where all the associations between actors and themes are listed, one per record, and carries out a sequence of operations in order to build the matrix which will be analyzed. In this first set of operations the software aggregates the rows with similar profiles. As we have seen this does not change the structure of the matrix. Correspondence analysis is carried out on this matrix and the output shows, for each factor extracted:

- the coordinate of each discourse category or actor along that factor; this value indicates the distance from the origin of the plot.

- the contribution of that factor to the explanation of the amount each actor or theme brings to the total matrix chi-square, which should be interpreted as the degree to which the category or actor is well represented by this factor; this value varies between zero and the total amount of the contribution of that item to the total matrix chi-square. The contribution of each item (discourse category or actor) to the matrix chi-square are shown in appendix 2.)

- the contribution of each actor or discourse category to the total chi-square explained by the factor. This is presented in thousandths of the total chi-square explained by the factor. Therefore, if we add the contributions to the factor of actors or discourse categories <u>separately</u> they add up to 1000.

An example of a table of results extracted from one of the cases studied is shown in Fig. 3.1. with the explanation of the conventions used.

Each of these elements is important in the interpretation of factors. In the presentation of results, for each factor will be given this information.

```
+-------------------------> Abbreviation of Discourse
|                          Category (normal character)
|                          or Actor (bold character)
|
|    +-------------------> Position along Factor
|    |
|    |   +---------------> Contribution of factor to
|    |   |                 the explanation of each
|    |   |                 Category or Actor
|    |   |
|    |   |    +----------> Contribution of each
|    |   |    |            Category or Actor to the
|    |   |    |            factor
|    |   |    |
|    |   |    |    +-----> Percentage of matrix
|    |   |    |    |       information explained by
|    |   |    |    |       this factor
|    |   |    |    |
|    |   |    |    |                 +--> Meaning
|    |   |    |    |                 |    of codes
```

Item	1#F	Cos2	CTF	Percentage explained=
ZZ 3	-2256	925	704	A cluster of categories
PD	**-1683**	**976**	**783**	Actor (Production Services Director)
QD	**-341**	**73**	**16**	
ACC*	-254	252	45	Discourse Category (Accuracy)
TE	**298**	**61**	**37**	
DD	**298**	**61**	**37**	
ZZ 1	399	48	22	
ZZ 2	399	48	22	
TD	**480**	**292**	**127**	Note: Only the meaning of codes which are relevant for the interpretation of factor are given.
DIFF	521	303	75	
GEOL	521	303	75	
ZZ 4	643	184	57	

Fig. 3.2. Example of a table of results.

In addition, for each of the items (category or actor) is given

- its contribution to the chi-square of the matrix,

- its weight (in the case of the categories the weight is proportional to the number of times it appears across all actors in the matrix, and in the case of actors to the number of categories they evoke) and

- its moment (which is proportional to its distance from the origin of the system of coordinates).

These elements determine the relative positions of the items. They are presented in appendix 2.

3.2.5. Interpretation of factors.

The null-hypothesis in the case of category distribution would be that there is no differentiation. In this case, all the people would use the same categories. If we defined a space where differences in individual categories were translated into distances, the type of space needed to describe the null-hypothesis would have no dimensions, it would be reduced to a point, all people and all categories occupying the same position, their inter-distances being equal to zero.

If one person uses a set of different categories, the type of space needed would be uni-dimensional, i.e., there would be a point representing a cluster of people using exactly the same categories and another point representing the "deviant", differentiated from this cluster.

If two persons use sets of categories that differ from the initial cluster, the problem becomes more complex because one has to deal with three inter-distances, but still a two dimensional space (a plan) would be enough. Depending on the number of categories shared, they could be represented either by three points in a straight line or by a triangle. This level of complexity would still be easy to represent in a sheet of paper and easily understandable. Three-dimensional spaces, required for a little more complex domain raise some problems in terms of representation but are still within the kind of space one is familiar with from everyday life.

As differentiation increases, the distances between people require more than the familiar three-dimensional space and can only be represented in an n-dimensional space. Each factor then represents a dimension which describes some kind of similarity between people and concepts. Interpreting the factors is to identify what is the similarity among these people and categories which appear together along the factor.

3.2.5.1. Criteria for selecting factors to be interpreted.

Interpretation started by the factor explaining more of the matrix information, and proceeded until all factors were explained or until they became impossible to interpret. In fact, the last factors, although they refer to actual differences in category distribution, may be irrelevant, either because these differences are too small or because they just do not fit in with any reasonable interpretation.

Factor analysis is generally used to reduce the number of variables one is dealing with. In this case, the effort to interpret as many factors as possible is a consequence of the theoretical model used. The proximity between actors on the basis of the categories they share is an indication of their participation in the same discourse. If we want to have a good approximation of all the discourses which exist in the organization, then we should try to include as many similarities in our description as possible. It follows that in principle, every factor describes potentially interesting discourses.

In this sense, factor analysis is used here more as a means of organizing the information, i.e. of making intelligible the structure of discourse distribution, than as a means of reducing drastically the amount of information one has to deal with. It is here that the method developed shows its usefulness by comparison with just paying attention to what people have to say and building an impressionistic image of the commonalities and differences. By providing structure to the data collected it helps understand patterns which otherwise would go unnoticed.

3.2.5.2. Criteria for inclusion of variables in the interpretation of factors.

In the inclusion of variables in the interpretation of factors one has to attend simultaneously to three criteria:

- The contribution of each category or actor to the factor (the CTF column in Fig. 3.2.). Each category contributes to a certain extent to the definition of each factor. Obviously, the meaning which can attributed to each factor depends on the items which contribute to its definition.

- The amount of category or actor chi-square explained by the factor (the Cos2 column in Fig. 3.2.) compared to the total amount explained by the factor (described by the "Percentage explained" value in Fig. 3.2.). Each factor explains a certain amount of an item chi-square. Some items are better explained than others by a particular factor. This has to be compared with the total amount of chi-square explained by the factor. The first factor, for example explains the greatest amount of chi-square in the matrix. Therefore it is likely (though not inevitable) that it explains at least some of the chi-square of all the items. However, the items which are important for interpreting the factor are only those which it explains best. A cutting point has to be decided for inclusion of items in the interpretation of the factor, which is proportional to the total amount of chi-square explained by the factor.

- the distribution of each category or actor chi-square along all the factors extracted.

These criteria define the following rules for inclusion:

- The category or actor gives a contribution above average to the factor (CTF >= 1000/Number of actors or categories in the analysis) and/or

- the amount of item or actor chi-square explained by the factor (Cos2) is equal or higher than the percentage of total chi-square explained by the factor (Cos2 >= percentage explained by factor X item or actor chi-square) and/or

- actor or category Cos2 is one of the three highest values across all the factors (this is a flexible rule, in that sometimes a single factor explains all or most of a single item chi-square).

Factors were interpreted on the basis of items (discourse categories or actors) retained following these rules. Variables retained tend to be grouped at the extremes of the factors. The factors were interpreted therefore as dimensions along which actors could be classified in mutually exclusive classes. Defining these classes as discourses in which the actors participate suggests that each factor identifies opposing discourses. Opposition is not taken here in the sense of negation, i.e., opposite discourses are not the negation of each other. Rather, opposition means that, <u>along the dimension defined by the factor</u>, actors who participate in one of the discourses do not participate in the other.

3.2.6. Second level analysis and the diagram of a company's discourse structure.

Each of the first level categories (Characteristics, Objectives and Decisions and Actions) was analyzed separately and only then was a second factor analysis carried out on the basis of the factor positions in the first analysis. Although at first sight this may seem cumbersome, in reality the simultaneous analysis of the three types of sub-categories raised a good deal of problems. These were related with the lack of uniformity in the subcategories grouped by the factors extracted. The solution adopted involves a first interpretation of the factors extracted from the first level categories separately, and this makes the second level analysis (all categories together) easier to interpret.

Therefore, in effect, four analyses were carried out for each company. The first three analyses enable the identification of (i) different discourses concerning the definition of the machines, (ii) different discourses concerning the objectives or guidelines in their implementation and (iii) different discourses concerning what happened with their introduction. Finally, the fourth analysis (or second level analysis) showed how people were differentiated by their participation in these different discourses.

Naturally, this gain in clarity costs some loss of information. However, this loss is minimal if compared with the inevitable loss involved in the attempt to interpret factors extracted by analyzing immediately all the second level categories together. The first level analysis serves as a selection of the more relevant information, i.e., the one contained in the categories which contribute more to identify different discourses. In effect it is these items which are used to interpret the first level factors, as can be seen from the criteria for inclusion of items in interpretation. The second level analysis then operates on the basis of actors' participation in the discourses identified in the first level analysis. The interpretation of these second level factors makes it possible to construe a diagram of the structure of discourses in a particular company showing who participates in what discourses which define a set of issues around an object.

The diagram of the structure of discourses of a company is not a representation of the processes by which actors make sense of their experience. These processes should be seen as inaccessible directly. It can nevertheless be seen as a trace left by these processes, focused on a set of issues related to a specific object, the CNC machines in the case of this research. Such a diagram can, of course, be construed in respect of any other set of issues.

The diagram of a discourse structure is based on the participation of actors on the several discourses identified in the interpretation of factors extracted in the second level analysis. Each discourse is represented by a coloured boundary which surrounds the actors who participate in that discourse. Because actors participate in several discourses there will be some intersections of these boundaries. In order to make it easier to identify which discourse was identified by which factor the boundaries have different colours and a label indicating the factor by which they were identified.

In the central area of the discourse structure are the discursive elements which are shared by the majority of actors. Because these elements do not differentiate between actors they do not contribute greatly to the definition of factors. In geometrical terms they are located near the origin of the system of coordinates. Because both differences and similarities between actors are important to understand the interpretative process of a company, as discussed above, it was decided to include them as a central area.

There are several differences between this method and cognitive maps. Both are representations of discourses but while cognitive maps tend to minimize the differences in perspectives among actors, the structure of discourses shows clearly those differences enabling the analysis of sense-making as a political process. The corresponding strength of cognitive maps is related to the fact that because they explore the causal relationships attributed by actors to relevant variables, they are directly oriented to action, while the structure of discourse is more oriented to description. In this sense the two approaches can complement each other as instruments of analysis and intervention.

3.3. Methodological problems.

There are several questions concerning the validity of this procedure which can be raised.

The main validity problem is to what extent the description of a company's discourse structure built on the basis of face to face interviews corresponds to the actual processes of sense-making in that company.

There is no straight answer to this. The existence of processes of sense-making in organizations is not an empirical fact, it is a construction which helps interpret several experiences and observations that members and researchers go through. It is a concept which focuses attention on the way people speak of their experiences. In this sense, the contribution of this methodology is to enable what might be called a qualified listening to what people have to say. Having said that, it still is relevant to identify the points in the process where methodological issues are more problematic.

To start with the interviews one has to reckon the extent to which they are representative of what people have to say about their experience.

The assumption underlying the use of interviews in this method is that they represent a good sampling of what organizational actors want to say to an outsider. This is not just a case of "stating the obvious". Discourse is constrained by the contexts where it occurs. There can be no certainty that what people say in an interview is related to what they say to other actors in the organization. The main safeguard against being totally misled in this is to put no emphasis at all on issues of privacy or secrecy concerning what is said in the interview. This may go against several recommendations concerning interviewing in organizations but the point is that it is important that people are constrained by the organizational context in their discourse during the interview. The issue is not to minimize the influence of the organizational context but to control the differences in this context introduced by the researcher. That is the reason for using semi-structured interviews in the interviewees usual setting and for not defining the interaction as private.

The coding process is another step in the methodology where problems arise, although of a different nature. It is at this point that similarities between interviewees are identified. Because these similarities constitute the basis on which a discourse structure is defined this step is critical. The validity of the structure of discourse categories has already been discussed above. The reliability of this structure is more problematic. The evaluation of the reliability of a coding procedure involves always a repeated application of the procedure, preferably using a panel of judges and measuring the degree of agreement between these different applications. It was felt that within the limitations of time and resources for this research it was preferable to concentrate on the critical task of devising a method which could be used to explore the dimensions of a company's interpretative process. Such an option is certainly open to criticism. But given that the demonstration of the viability of the method was the main priority and that methods to improve its reliability at this specific point are already available, it was an option which certainly generated more "added value" in terms of knowledge. At any rate, it was also felt that the process should be open to scrutiny, the reason why the passages of the interviews which were analyzed, together with the codes applied to them are presented as an appendix (Appendix 3).

In the following chapters the results of this method for analyzing the interpretative process of three companies are presented.

CHAPTER 4:
COMPANY 1

4.1. Brief description of Company 1

Company 1 was a medium sized company that produced moulded plastic components. It had started 25 years before, founded by four toolmakers who decided to begin their own business based on their experience, at Lucas, in the Midlands. They produced mainly for the motor industry, their main customer being Ford. Although they had previously tried to diversify their production into other markets, at the time of the study they were working almost exclusively for the motor industry.

At the time of the study the company employed 130 people, of which around 20 worked in the toolroom, 5 were setters for the presses, 3 worked in the design office (including the Technical Director and the Design Director), 6-8 in quality control and 4 administrative.

The main operations in the production process are the manufacture of the tool, i.e. the mould that will be used to shape the components, and the moulding of the actual components. There is a clear distinction between the two operations. The toolroom, where the CNC machines are installed, is well differentiated spatially from the presses and staffed mainly by skilled white men. This is where the parts of the tool are manufactured and then assembled and adjusted if needed. It is a skill intensive area.

In the presses, the work is repetitive, unskilled, and it is executed by men and women, with a significant percentage of people from ethnic minorities. There are no recognized unions in the company.

4.2. Process of innovation

The company always kept a close relationship with Lucas, in the Midlands. The need to invest on new technology was accepted initially as a result of Lucas's efforts to develop their suppliers, making them aware of the need to invest on this kind of technology to improve reliability and product quality. This was made through courses, which the Managing Director attended. Lucas' initiative gave the signal of what one of their main customers expected from them concerning quality and reliability, and how the new technology would help in that. Since then the company has invested heavily into new technologies, mainly in production and quality control.

They had 4 CNC milling machines which were located in the toolroom. These had been purchased 4 years before. In the design office there was a Computer Aided Design (CAD) workstation, which had been introduced more recently, on the basis that they offered a design service to their customers. Another reason for introducing CAD was that some of their customers would order components which were designed on CAD, thus some compatibility with their systems would be an advantage. The Design Director did not feel at ease with CAD so it was used by a young apprentice draftsman. Basically it was used to produce the programmes which were then introduced manually in the CNC machines by the operators. They also had introduced statistical process control (SPC) in quality control, a fairly complex setup which involved the integration and feedback of data taken at various points of the production process.

All these applications were implemented and used independently although they could be integrated. Integrating all the equipment was a project the Technical Director referred to but no significant steps seemed to have been taken in that direction. At the time of the study, the only link that existed was between the CAD workstation and the CNC machines but even this link was not being systematically used as the operators did programme their machines following the designs from the design office or the programmes generated in the CAD workstation. In general, the process of technological innovation was imposed from the outside but at the time of the study most of the interviewees were in no doubt that they had made the right decision.

Another outcome of this process was the organization of training, mainly concerning the toolroom. Two of the Directors also went into a management course because it was felt that the company's management had to become more professional.

It was generally recognized that going in this direction was paying off. Their participation for the first time in a trade exhibition was mentioned by some of the interviewees as a sign of the positive changes brought by the new technology.

4.3. The actors.

In this company five people were interviewed: the Toolroom Director and Company Secretary (TD); the Quality Director (QD); the Design Director (DD); the Production Services Director (PD) and the Technical Director (TE). The Technical Director and the Toolroom Director were two of the company founders, the other one being the Managing Director. The Managing Director was ill at the time and could not be interviewed.

The Technical Director appeared to be the one who championed the effort to innovate technologically. The Toolroom Director appeared to accept the need for these changes but did not appear to be at ease with these machines. The Production Services Director voiced a good deal of criticism of the decision to invest on CNC machines as well as the difficulty he had in getting the corresponding investment in process control technologies. He was responsible for distributing the work through the presses and appeared to have a very acute sense of the need to use intensively and adequately the equipment available. The Design Director seemed to accept well all the technological changes going on, except that he had not come to terms with the CAD workstation. Being a draftsman himself this seemed a problematic option though he seemed satisfied that the apprentice draftsman did not appear to have any trouble with the workstation. This company's management structure is described in the following figure, adapted from the organigram provided by the Design Director.

```
                      +-----------------+
                      |MANAGING DIRECTOR|
                      +--------+--------+
          +-----------------+--------+-----------------+
+--------+   +----+-----+   +---+----+        ...---+----+
|TOOLROOM|   |PRODUCTION|   |QUALITY |        |TECHNICAL|
|DIRECTOR|   |SERVICES  |   |DIRECTOR|        |DIRECTOR |
|--------+   |DIRECTOR  |   +--------+        +----+----+
|            |----------+   |                  ...---|----+
|            |              |                  |DESIGN   |
|            |              |                  |DIRECTOR|
|            |              |                  |--------+
|            |              |                  |
|            |              |                  |
+-Toolmakers +-Setters      +-Quality          +-Electrical and
|-Accounts   +-Trim shop      control       Mechanical Engineer
+-Admin.     +-Materials
             |  control
             +-Stores
```

Fig. 4.1. Company 1 Management Structure.

4.4. Analysis of discourse structure in Company 1

A. Characteristics

The distribution of themes related to the characteristics of the CNC machine is summarized in the following table.

Actors	TD	PD	TE	DD	QD	MEANING
NThemes	4	2	3	3	1	
ACC*	1	1	1	1	1	ACCURACY
DIFF	1	0	0	1	0	DIFFICULT TO ADAPT TO
GEOL	1	0	1	0	0	RECOGNIZES A FINITE SET OF GEOMETRICAL SHAPES
ZZ 1	0	0	0	1	0	(CONTROLLED BY PROGRAMME; DIFFICULTS CONTROL OF OPERATORS; NOVELTY)
ZZ 2	0	0	1	0	0	(PROGRAMMING NEEDS LENGTHY CALCULATIONS; COMPATIBILITY WITH OTHER EQUIPMENT; LEARNING CURVE; SPEED)
ZZ 3	0	1	0	0	0	(COST OF REPAIRS; OPERATION COSTS; EASY TO USE; FOREIGN ORIGIN; DIFFICULT TO REPAIR; OPTIMAL CYCLE LENGTH; OPTIMAL TYPE OF WORK FOR CNC; PAYBACK TIME; OPTIMAL BATCH SIZE)
ZZ 4	1	0	0	0	0	(COST OF CNC; OVERCOMES LACK OF SKILLED WORKERS; UNBALANCES WORK IN TOOLROOM)

Table 4.1 Distribution of Characteristics.

Correspondence analysis of this matrix extracted the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	.55634	37.506	37.506
II	.50000	33.708	71.214
III	.30368	20.473	91.687
IV	.12331	8.313	100.000

Table 4.2. Characteristics - Factors extracted.

The three first factors all explain a significant proportion of the matrix chi-square, while the fourth one gives only a small contribution to this explanation.

Interpretation of Factors

Factor I: Incremental Novelty X Radical Novelty

Item	1#F	Cos2	CTF	Percentage explained= 37.5%
ZZ 3	-2256	925	704	(COST OF REPAIRS; OPERATION COSTS; EASY TO USE; FOREIGN ORIGIN; DIFFICULT TO REPAIR; OPTIMAL CYCLE LENGTH; OPTIMAL TYPE OF WORK FOR CNC; PAYBACK TIME; OPTIMAL BATCH SIZE)
PD	**-1683**	**976**	**783**	Production Services Director
QD	**-341**	**73**	**16**	
ACC*	-254	252	45	
TE	**298**	**61**	**37**	
DD	**298**	**61**	**37**	
ZZ 1	399	48	22	
ZZ 2	399	48	22	
TD	**480**	**292**	**127**	Toolroom Director
DIFF	521	303	75	DIFFICULT TO OPERATE
GEOL	521	303	75	RECOGNIZES/PRODUCES FINITE SET OF GEOMETRICAL FORMS
ZZ 4	643	184	57	(COST OF CNC; OVERCOMES LACK OF SKILLED WORKERS; UNBALANCES WORK IN TOOLROOM)

Table 4.3. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I differentiates between the Production Services Director's and the Toolroom Director's productions. The characteristics evoked by the Production Services Director (cluster ZZ 3) have in common the description of the CNC machine as a capital investment to be recovered by using it in the most effective way. This consistency and the fact that no one else evokes similar characteristics, constitutes a large variance in relation to the other actors. At the other end of this factor, although not as well represented, we find characteristics of the CNC machines which concern its introduction and the discontinuity it represents in relation to traditional machines.

This factor can be said to describe an opposition between perceiving the machine as an **incremental novelty** (negative end of factor) as opposed to seeing it as a **radical novelty** (positive end). This opposition parallels the opposition between looking at new technology as a piece of equipment which the company is ready to use and looking at new technology as something which the company may not have the immediate ability to use without undergoing some degree of change, a notion suggested, among others by Teece (1985). In this sense, the Toolroom Manager voices a more strategic perception of the machine, as something whose relationship with on-going processes and existing practices is problematic, requiring non-routine decisions.

Although none of the other actors contributes to this factor or is well represented by it, it should be noted that the Technical Director and the Design Director are on the positive side of the factor while the Quality Director can be found at the negative side. Their positions in this factor show that their respective productions are globally more similar to the Toolroom Director's and the Production Services Director's, respectively. Their specific contributions will be described by the following factors.

Factor II: A Technical Problem X An Organizational Problem.

Item	2#F	Cos2	CTF	Percentage explained= 33.7%
ZZ 2	-1472	650	333	(PROGRAMMING NEEDS LENGTHY CALCULATIONS; COMPATIBILITY WITH OTHER EQUIPMENT; LEARNING CURVE; SPEED)
TE	**-1041**	**744**	**500**	Technical Director
GEOL	-736	605	167	RECOGNIZES A FINITE SET OF GEOMETRICAL SHAPES
ZZ 3	0	0	0	
ZZ 4	0	0	0	
ACC*	0	0	0	
TD	**0**	**0**	**0**	
PD	**0**	**0**	**0**	
QD	**0**	**0**	**0**	
DIFF	736	605	167	DIFFICULT TO ADAPT TO.
DD	**1041**	**744**	**500**	Design Director
ZZ 1	1472	650	333	(CONTROLLED BY PROGRAMME; DIFFICULTS CONTROL OF OPERATORS; NOVELTY)

Table 4.4. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates the Technical Director's production from the Design Director's. These two actors were on the positive side of the first factor, which suggest that while they both tend to perceive the CNC machine as a radical innovation, in the sense described above, their perception is modulated by other considerations. At the negative end of the factor, we find characteristics which have mostly to do with technical characteristics of the CNC machine. At the positive end we find characteristics mostly related to the adaptation of operators and managers to the machine. The factor can thus be labelled as differentiating between characterizations of the machine as a **technical problem** as opposed to an **organizational problem.**

Factor III: Global Changes X Local Changes

Item	3#F	Cos2	CTF	Percentage explained= 20.5%
ZZ 1	-940	265	224	(CONTROLLED BY PROGRAMME; MAKES DIFFICULT CONTROL OF OPERATORS; NOVELTY)
ZZ 2	-940	265	224	(PROGRAMMING NEEDS LENGTHY CALCULATIONS; COMPATIBILITY WITH OTHER EQUIPMENT; LEARNING CURVE; SPEED)
TE	**-518**	**184**	**204**	Technical Director
DD	**-518**	**184**	**204**	Design Director
QD	**-224**	**31**	**13**	
ACC*	-124	59	19	
PD	**173**	**10**	**15**	
DIFF	207	48	22	
GEOL	207	48	22	
ZZ 3	315	18	25	
TD	**746**	**707**	**564**	Toolroom Director
ZZ 4	1354	815	465	(COST OF CNC; OVERCOMES LACK OF SKILLED WORKERS; UNBALANCES WORK IN TOOLROOM)

Table 4.5. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III groups the Technical Director's and the Design Director's production and opposes these to the Toolroom Director's production. These three actors were on the "radical novelty" side of factor I; factor III can be said to differentiate further between their varying forms of looking at the machine. The items that differentiate between them are the clusters of characteristics evoked individually, i.e., not shared. What the two actors in the negative side have in common, which the Toolroom Director has not, are descriptions of the potential of the machine to introduce more or less global changes. The Toolroom Director, on the other hand, points to changes which are local, concerning the management of the toolroom, where the machines are installed. A possible label for this factor is the opposition between descriptions of CNC machines as inducers of global changes as opposed to local changes

This differentiation seems to reflect also the actors' organizational roles. The Toolroom Director concentrates on characteristics which are relevant to the management of the toolroom and to the company financial situation (the Toolroom Director was the Secretary of the company as well). The proximity between the two other actors, also found in the first factor reflects a convergence in perceptions which can be helped by their physical proximity: they share the same office and consequently interact more systematically with each other than with the Toolroom Director.

Factor IV: Accuracy.

Item	4#F	Cos2	CTF	Percentage explained = 8.3%
QD	**-1197**	**896**	**894**	Quality Director
ACC*	-420	689	551	ACCURACY
TD	16	0	1	
ZZ 4	45	1	1	
TE	124	10	29	
DD	124	10	29	
PD	196	13	48	
DIFF	199	44	49	
GEOL	199	44	49	
ZZ 1	352	37	77	
ZZ 2	352	37	77	
ZZ 3	558	57	194	

Table 4.6. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV differentiated 'Accuracy' from all the other characteristics evoked by actors. This factor explains very little of the information in the matrix. It reflects the fact that the Quality Director, although evoking a concept that everybody else does, evokes no other concept, which makes him a unique case in relation to all the others: not because he says different things but because he only says what everybody else says. Interesting as it is from the point of view of data analysis, it is probably more prudent to accept that this may be due to a sampling error than to an actual characteristic of this actor. Nevertheless, it is not surprising to observe a Quality Director very concerned with the accuracy of the tools machined in the CNC's.

The fact that 'Accuracy' is a concept evoked by everybody suggests it can be taken as a "cryptic label" (Bougon, 1992), i.e., one of the central pieces in the sense-making process of this group. Its cryptic nature is obvious if we note that each actor has his own way of perceiving the CNC machines and their role in the company operation and that 'Accuracy' makes part of all these different perceptions, taking different meanings for each actor.

The analysis of characteristics evoked by the different actors suggests that there is a nucleus of actors, consisting of the Technical Director, the Toolroom Director and the Design Director whose perceptions are different but which show complementarities. They differ clearly in their form of being "strategic". Each of them voices different but critical aspects of the technical innovation process. It should be noted that these actors have other things in common: two of them are founders of the company, and the three of them are older than the other two directors, having climbed up through their respective professional careers in the more traditional form.

The Production Services Director, a younger person who could only have climbed the organizational ladder very quickly, is clearly differentiated from this nucleus, suggesting that he represents a different perspective in the process of asserting itself. The discourse differentiation he establishes can thus be seen as an attempt to identify problems and issues which he can include in his role definition. The reason this is described as a strategy still in the process of asserting itself is that no other actor shares his perceptions, so he is isolated in his perspective, though not as isolated as to the point of not sharing the central concept of Accuracy.

B. Objectives

The distribution of themes related to objectives and guidelines for action is summarized in the following table.

Actors	TD	PD	TE	DD	QD	MEANING
NThemes	1	2	3	3	2	
EFFI	0	0	0	0	1	EFFICIENCY
COOP	0	0	0	1	0	CONTROL WORKERS
INTG	0	0	1	0	0	INTEGRATION PRODUCTION PROCESS AND TECHNOLOGY
CIMA	0	0	1	0	1	GOOD CUSTOMER RELATIONS
CEXP	0	0	1	1	0	SATISFY CUSTOMER EXPECTATIONS REGARDING NEW TECHNOLOGY
OUTI	0	1	0	0	0	OPTIMIZE UTILIZATION
ZZ 1	0	1	0	1	0	(REDUCE MAN/MACHINE RATIO; INCREASE UTILIZATION)
ZZ 2	1	0	0	0	0	(REMAIN COMPETITIVE; KEEP GOOD FINANCIAL SITUATION; HARMONIZE CNC AND TRADITIONAL MACHINES; MOTIVATE WORKERS TO WORK WITH CNC)

Table 4.7. Distribution of Objectives.

Correspondence analysis of this matrix extracted the following factors:

NUM	EIGEN VALUE	PERCENT	CUMUL %
I	1.00000	35.294	35.294
II	.86436	30.507	65.801
III	.58333	20.588	86.389
IV	.38564	13.611	100.000

Table 4.8. Objectives: Factors extracted

Interpretation of Factors

Factor I: Avoid risks.

Item	1#F	Cos2	CTF	Percentage explained = 35.3%
EFFI	0	0	0	
COOP	0	0	0	
INTG	0	0	0	
CIMA	0	0	0	
CEXP	0	0	0	
OUTI	0	0	0	
ZZ 1	0	0	0	
PD	**0**	**0**	**0**	
TE	**0**	**0**	**0**	
DD	**0**	**0**	**0**	
QD	**0**	**0**	**0**	
ZZ 2	3317	1100	1000	(REMAIN COMPETITIVE; KEEP GOOD FINANCIAL SITUATION; HARMONIZE CNC AND TRADITIONAL MACHINES; MOTIVATE WORKERS TO WORK WITH CNC)
TD	**3317**	**1100**	**1000**	Toolroom Director

Table 4.9. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I singles out the cluster of objectives evoked only by the Toolroom Director. This constitutes the total production of this actor, which makes it a large variance in the results matrix. If we look at the cluster content keeping in mind that no one else evoked similar ideas, Factor I can be seen as describing a very prudent approach to new technology implementation, which could be transformed into a single rule: **Avoid risks**.

This is consistent with a comment of the Design Director, who said that the Toolroom Director was not at all enthusiastic about the introduction of CNC machines. The Toolroom Director's caution about the implementation process is clearly not shared by other actors. This suggests that his ability to influence other actors in this respect was reduced with the introduction of the CNC machines.

Factor II: Operational Concerns X Strategic Concerns

Item	2#F	Cos2	CTF	Percentage explained = 30.5%
OUTI	-1447	465	220	OPTIMIZE UTILIZATION
PD	**-1345**	**579**	**381**	Production Services Director
ZZ 1	-1054	860	234	(REDUCE MAN/MACHINE RATIO; INCREASE UTILIZATION)
COOP	-662	164	46	
DD	**-615**	**262**	**119**	Design Director
CEXP	0	0	0	
ZZ 2	0	0	0	
TD	**0**	**0**	**0**	
TE	**615**	**262**	**119**	Technical Director
INTG	662	164	46	
CIMA	1054	860	234	GOOD CUSTOMER RELATIONS
QD	**1345**	**579**	**381**	Quality Director
EFFI	1447	465	220	EFFICIENCY

Table 4.10. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates between the Production Services Director and Design Director at its negative end and the Technical Director and Quality Director at its positive end. It should be noted however that the Technical Director and the Quality Director are not as far apart in this factor as are the other two actors. They do not contribute as much to the factor and are not as well represented by it.

The objectives grouped at the negative end concern improvements in operations efficiency; at the positive end are grouped objectives which concern the company efficiency and its relationship with customers. Although it does not cover all the range of what might be called strategic behaviours, this combination can be labelled "strategic" in the sense that it covers both internal and external objectives, denoting the concern with changes in the environment which is usually associated with strategy making.

The factor can thus be described as opposing **operational** to **strategic concerns**. This discourse differentiation can be related to the organizational roles: both the Quality Director and the Technical Director are in positions where customers are a significant direct influence while the Production Services Director and the Design Director have not so much contact with customers, as part of their roles. This discourse differentiation therefore reflects the definition of these actors' respective organizational roles, the issues or uncertainties they wish to be perceived as able to deal with.

Factor III: Market oriented implementation X Production oriented implementation

Item	3#F	Cos2	CTF	Percentage explained = 20.6%
COOP	-856	275	114	CONTROL WORKERS
INTG	-856	275	114	INTEGRATE PRODUCTION PROCESS AND TECHNOLOGY
CEXP	-856	880	229	SATISFY CUSTOMER EXPECTATIONS REGARDING NEW TECHNOLOGIES
TE	**-654**	**296**	**200**	Technical Director
DD	**-654**	**296**	**200**	Design Director
ZZ 2	0	0	0	
TD	0	0	0	
CIMA	214	35	14	
ZZ 1	214	35	14	
PD	**981**	**308**	**300**	Production Services Director
QD	**981**	**308**	**300**	**Quality Director**
EFFI	1285	367	257	EFFICIENCY
OUTI	1285	367	257	OPTIMIZE UTILIZATION

Table 4.11. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III opposes two orientations to technology implementation, one concerned with the credibility new technology can give, regarding actual or potential customers (negative end of the factor) and the other concerned with the efficiency of resource use in production (positive end of the factor). The two extremes of Factor III can thus be respectively labelled **market oriented implementation** and **production oriented implementation**, an opposition that reminds of the notion of market driven implementation (Lee, 1987) mentioned in the first chapter.

This factor establishes a differentiation which put together with that of factor II, suggests that there are different ways of being oriented to strategy or to operations, and that these differences do not follow strictly the division of labour. For example, while the Quality Director appears at the "strategic" side in factor II he appears at the "production" side in factor III. While he appears together with the Technical Director in his "strategic" orientation, he appears alone in his "strategic/production" orientation. These differentiations can be interpreted as constituting individual strategies of role differentiation, or of establishing role boundaries in order to define which issues belong to their sphere of influence.

Factor IV: Enhance the System X Enhance the Technology

Item	4#F	Cos2	CTF	Percentage explained = 13.6%
COOP	-1181	523	329	CONTROL WORKERS
EFFI	-811	146	155	EFFICIENCY
DD	**-734**	**373**	**381**	Design Director
QD	**-503**	**81**	**119**	
ZZ 1	-185	27	16	
CEXP	0	0	0	
ZZ 2	0	0	0	
TD	**0**	**0**	**0**	
CIMA	185	27	16	
PD	**503**	**81**	**119**	
TE	**734**	**373**	**381**	Technical Director
OUTI	811	146	155	OPTIMIZE UTILIZATION
INTG	1181	523	329	INTEGRATE PRODUCTION PROCESS AND TECHNOLOGY

Table 4.12. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV opposes concerns with the management of people and with generic performance to concerns with the technology, its development and efficient use. It can thus be labelled as **Enhance the system** (on the negative side) opposed to **Enhance technology** (on the positive side). It represents a further differentiation between the Design Director and the Technical Director, who were very close on Factor III. This differentiation parallels the differentiation in Factor II of Characteristics, where the Design Director appeared as defining the machine more as an organizational problem while the Technical Director defined it more as a technical problem.

C. Decisions and actions

The distribution of themes related to decisions and actions in the implementation of CNC machines among the actors is summarized in Table 4.13.

Actors	TD	PD	TE	DD	QD	MEANING
NThemes	3	1	3	3	1	
MMIN	0	0	0	0	1	MACHINE MORE IN-HOUSE
MPRO	1	0	1	0	0	INVOLVE OPERATORS IN PROGRAMMING
OFFP	0	0	1	1	0	OFF-LINE PROGRAMMING
SADO	1	0	0	1	0	ADOPT SLOWLY
ZZ 1	0	0	0	1	0	CHANGES IN WORKFLOW; TRAIN OPERATORS; TRUST OPERATORS
ZZ 2	0	0	1	0	0	(ACCEPT COMPLEX 3D ORDERS; DESIGN WITHIN CNC GEOM. PARAMETERS; USE CAD TO HELP OPERATORS; CONCENTRATE ON MOTOR TRADE; ACCEPT SPECS ON COMPUTER TAPE; ACCEPT URGENT ORDERS)
ZZ 3	0	1	0	0	0	(MAKE SURE JOB REQUIRES CNC; PRODUCE NEW TYPES OF TOOLS; SEND CNC GERMANY FOR SOME REPAIRS)
ZZ 4	1	0	0	0	0	(KEEP TRADITIONAL SKILLS; INCREASE THROUGHPUT; REDUCE MAN/MACHINE RATIO)

Table 4.13. Distribution of Decisions and Actions.;

Correspondence analysis extracted the following factors:

FACTOR	EIGEN VAL	PERCENT	CUMUL
I	1.00000	33.333	33.333
II	1.00000	33.333	66.667
III	.50000	16.667	83.333
IV	.50000	16.667	100.000

Table 4.14. Decisions and actions: Factors extracted.

Interpretation of Factors

Factor I: Managing CNC implementation.

Item	1#F	Cos2	CTF	Percentage explained = 33.3%
TD	**-1018**	**717**	**283**	Toolroom Director
TE	**-1018**	**717**	**283**	Technical Director
DD	**-1018**	**717**	**283**	Design Director
OFFP	-1018	1243	188	PROGRAMME CNC FROM CAD
SADO	-1018	1243	188	ADOPT SLOWLY
MPRO	-1018	1243	188	INVOLVE OPERATORS IN PROGRAMING
ZZ 1	-1018	389	94	
ZZ 2	-1018	389	94	
ZZ 4	-1018	389	94	
MMIN	0	0	0	
QD	**0**	**0**	**0**	
ZZ 3	1294	167	152	(MAKE SURE JOB REQUIRES CNC; PRODUCE NEW TYPES OF TOOLS; SEND CNC GERMANY FOR SOME REPAIRS)
PD	**1294**	**167**	**152**	Production Services Director

Table 4.15. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I opposes actions and decisions referred to by the Production Services Director to decisions and actions referred to by the Toolroom Director, the Technical Director, and the Design Director.

It should be noted that Factor I accounts for the same amount of information in the results matrix as does Factor II, which isolates the contribution of the Quality Director, and reflects the same pattern of distribution of themes. These factors will thus be discussed simultaneously.

Factor II: Increase vertical integration.

Both factors thus oppose the production of the Toolroom Director, the Technical Director and the Design Director to the Production Services Director's production, for factor I, and the Quality Director's production.

Item	2#F	Cos2	CTF	Percentage explained = 33.3%
ZZ 1	0	0	0	
ZZ 2	0	0	0	
OFFP	0	0	0	
ZZ 3	0	0	0	
ZZ 4	0	0	0	
SADO	0	0	0	
MPRO	0	0	0	
TD	0	0	0	
PD	0	0	0	
TE	0	0	0	
DD	0	0	0	
MMIN	3317	1100	1000	MACHINE MORE TOOLS IN-HOUSE
QD	3317	1100	1000	Quality Director

Table 4.16. Factorial Coordinates, Chi-square explained and contributions to Factor II.

The Toolroom Director, the Technical Director and the Design Director's productions concern the organizational problems of introducing new practices at the shopfloor (toolroom), namely concerning the location of programming tasks and taking into account workers reactions to the new technology.

The Production Services Director's production concerns the effective use of the capital investment represented by the CNC machines. Making sure the proper jobs go into CNC and the production of new types of tools enabled by the CNC's are both accounts of new practices which began with the implementation of CNC and which stress the importance of a high level of utilization. Sending the machines to Germany for repairs was voiced very much as a complaint against the time the whole process required and the resulting reduction of the utilization rate. There was implicit some criticism of the decision to buy that specific equipment.

Put together, the three items result in an account of the implementation process centered on the problems of achieving an acceptable rate of utilization.

The Quality Director, mentioned solely how the CNC machines enabled the company to produce more tools in-house, tools that previously had t be contracted out.

Factor I can thus be described as opposing accounts centered on the process of **managing CNC implementation** (at the negative end of the factor) to accounts stressing the **problems in CNC utilization** (on the positive side of the factor.

Factor II describes only the positive pole of this opposition, which can be labelled as accounts of the **use of CNC to increase vertical integration.**

Factor III: Changes at Company Level X Changes at Toolroom Level

Item	3#F	Cos2	CTF	Percentage explained = 16.7%
ZZ 1	-782	229	111	(CHANGE WORKFLOW; TRAIN OPERATORS; TRUST OPERATORS)
ZZ 2	-782	229	111	(ACCEPT COMPLEX 3D ORDERS; DESIGN WITHIN CNC GEOM. PARAMETERS; USE CAD TO HELP OPERATORS; CONCENTRATE ON MOTOR TRADE; ACCEPT SPECS ON COMPUTER TAPE; ACCEPT URGENT ORDERS)
OFFP	-782	733	222	PROGRAMME CNC FROM CAD
TE	**-553**	**212**	**167**	Technical Director
DD	**-553**	**212**	**167**	Design Director
MMIN	0	0	0	
ZZ 3	0	0	0	
PD	**0**	**0**	**0**	
QD	**0**	**0**	**0**	
SADO	391	183	56	
MPRO	391	183	56	
TD	**1106**	**846**	**667**	Toolroom Director
ZZ 4	1563	917	444	(KEEP TRADITIONAL SKILLS; INCREASE THROUGHPUT; REDUCE MAN/MACHINE RATIO)

Table 4.17. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III opposes the cluster ZZ4 (by the Toolroom Director) to 'Programme CNC from CAD' and the two clusters ZZ1 and ZZ2. If we take clusters ZZ1 and ZZ2, although not as well represented in this factor as 'Programme CNC from CAD' we can take the concern with programming from CAD as a sign of more general concerns in the design office with general, strategic issues. To these general concerns is opposed a more operational concern with the effective management of the toolroom. We can therefore describe this factor as differentiating between accounts of **changes at the company level** (negative end) and accounts of **changes at the toolroom level.**

Factor IV: Actions Regarding People X Actions Regarding the Production System as a Whole.

Item	4#F	Cos2	CTF	Percentage explained = 16.7
ZZ 2	-1354	688	333	(ACCEPT COMPLEX 3D ORDERS; DESIGN WITHIN CNC GEOM. PARAMETERS; USE CAD TO HELP OPERATORS; CONCENTRATE ON MOTOR TRADE; ACCEPT SPECS ON COMPUTER TAPE; ACCEPT URGENT ORDERS)
TE	**-957**	**635**	**500**	Technical Director
MPRO	-677	550	167	INVOLVE OPERATORS IN PROGRAMMING
MMIN	0	0	0	
OFFP	0	0	0	
ZZ 3	0	0	0	
ZZ 4	0	0	0	
TD	0	0	0	
PD	0	0	0	
QD	0	0	0	
SADO	677	550	167	ADOPT SLOWLY
DD	**957**	**635**	**500**	Design Director
ZZ 1	1354	688	333	(CHANGE WORKFLOW; TRAIN OPERATORS; TRUST OPERATORS)

Table 4.18. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV opposes ZZ2 (by the Technical Director) and 'Involve operators in programming', to ZZ1 (by the Design Director) and 'Adopt slowly'. These two actors have not been differentiated so far, which means that their accounts of the process of implementation have a good deal in common. The differentiation established by this factor is based mainly on their clusters of individual themes. If we consider only these clusters the factor can be interpreted as describing an opposition between accounts more centered on **actions**

regarding people (positive side of the factor) to accounts more centered on **actions regarding the production system as a whole**, its smooth running and longer term prospects of survival (negative side of the factor).

This distinction is not as clear cut as in other factors. It should be noted that the amount of information the factor explains is quite small. For this reason it will not be included in the second level analysis.

D. Second Level Analysis.

The analysis of aggregated results follows the same method as the partial analyses and is based on the positions people occupied in the interpretable factors. The interpretation of factor consisted in labelling the extremes of the factors so, for convenience, we will refer to these as "labels". These labels, as we have seen, identify different ways of talking about the CNC machines, the objectives or guidelines for action in the implementation process and the implementation process itself. These different perspectives were shared in different degrees by different people, so the social distribution of these labels gives a picture of the existing discourses about the episode of technological innovation which was taking place in this Company, and how people are situated in relation to them.

The distribution of labels is summarized in the following table.

Actors	DD	PD	QD	TD	TE	
Themes	4	3	3	2	4	MEANING
A1-	1	0	0	1	1	CAREFUL MANAGEMENT OF CNC IMPLEMENTATION
A2+	0	0	1	0	0	USE OF CNC TO INCREASE VERTICAL INTEGRATION
O2+	0	0	1	0	1	STRATEGIC CONCERNS
O2-	1	1	0	0	0	OPERATIONAL CONCERNS
O3+	0	1	1	0	0	PRODUCTION ORIENTED IMPLEMENTATION
ZZ 1	0	0	0	0	1	[SOURCE OF TECHNICAL PROBLEMS (C2-); ENHANCE TECHNOLOGY (O4+)]
ZZ 2	0	0	0	1	0	[RADICAL NOVELTY (C1+); SOURCE OF LOCAL CHANGES (C3+); RISK AVOIDANCE (O1+); CHANGES AT TOOLROOM LEVEL (A3+)]
ZZ 3	0	1	0	0	0	[INCREMENTAL NOVELTY (C1-); PROBLEMS W/ CNC UTILIZATION (A1+)]
ZZ 4	1	0	0	0	0	[ORGANIZATIONAL PROBLEM (C2+); ENHANCE SYSTEM (O4-)]
ZZ 5	1	0	0	0	1	[SOURCE OF GLOBAL CHANGES (C3-);MARKET ORIENTED IMPLEMENTATION (O3-); CHANGES AT COMPANY LEVEL (A3-)]

Table 4.19. Distribution of labels - second level analysis.

The analysis of this matrix yielded the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	.76551	35.331	35.331
II	.59479	27.452	62.783
III	.52615	24.284	87.067
IV	.28021	12.933	100.000

Table 4.20. Factors extracted - Second level.

Interpretation of Factors

Factor I: Departure from Established Practices X Continuity in Established Practices.

Item	1#F	COS2	CTF	Percentage explained = 35.3%
ZZ 2	-1648	388	222	[RADICAL NOVELTY (C1+); SOURCE OF LOCAL CHANGES (C3+); RISK AVOIDANCE (O1+); CHANGES AT TOOLROOM LEVEL (A3+)]
TD	**-1442**	**480**	**340**	Toolroom Director
A1-	-875	985	188	CAREFUL MANAGEMENT OF CNC IMPLEMENTATION
ZZ 1	-489	80	20	
ZZ 4	-489	80	20	
ZZ 5	-489	239	39	[SOURCE OF GLOBAL CHANGES (C3-); MARKET ORIENTED IMPLEMENTATION (O3-); CHANGES AT COMPANY LEVEL (A3-)]
DD	**-428**	**137**	**60**	Design Director
TE	**-428**	**137**	**60**	Technical Director
O2+	356	95	21	
O2-	356	95	21	OPERATIONAL CONCERNS
PD	**1051**	**432**	**270**	Production Services Manager
QD	**1051**	**432**	**270**	Quality Director
A2+	1201	333	118	USE OF CNC TO INCREASE VERTICAL INTEGRATION
ZZ 3	1201	333	118	[INCREMENTAL NOVELTY (C1-); PROBLEMS W/ CNC UTILIZATION (A1+)]
O3+	1201	866	236	PRODUCTION ORIENTED IMPLEMENTATION

Table 4.21. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I describes the largest discourse differentiation in this group. It opposes the Toolroom Director, the Design Director and the Technical Director (negative end of the factor) to the Production Services and the Quality Directors (positive end). The main theme running through the labels at the negative end of the factor has to do with the type of changes associated with the introduction of CNC machines. This side of the factor can be seen as describing a discourse about the technological change episode where the machines are described as a radical novelty which produces significant changes. The main concern associated with this innovation is the process of introducing the machines. It is described as having to be carefully managed, i.e., the changes brought by the machine have to be explicitly considered and non-routine decisions are to be made.

At the opposite end of the factor we find the machines defined as an incremental novelty which is not expected to change greatly the nature of the present set up; therefore they are expected to be contributing to production as soon and as efficiently as possible, just like any other machine. The account of the implementation process, in consequence, is centered on the problems with their utilization rate. This can be seen as an extension of the normal way of looking at capital investments. The different perspectives described by this factor can be seen more clearly in the following figure.

DEPARTURE FROM ESTABLISHED PRACTICES	FACTOR I	CONTINUITY IN ESTABLISHED PRACTICES
TOOLROOM DIRECTOR DESIGN DIRECTOR TECHNICAL DIRECTOR		PRODUCTION SERVICES DIRECTOR QUALITY DIRECTOR
CNC MACHINES ARE: - a radical novelty; - a source of local and global changes.		CNC MACHINES ARE: - an incremental novelty.
GUIDELINES IN THEIR INTRODUCTION: - avoidance of risks - market oriented implementation		GUIDELINES IN THEIR INTRODUCTION: - production oriented implementation.
WITH THEIR INTRODUCTION: - there must be a careful management of its implementation; - there were changes at the toolroom and at the Company level.		WITH THEIR INTRODUCTION: - there are problems with their utilization rate - they were used to increase vertical integration.

Fig. 4.2. Second Level Analysis - Factor I.

In summary, the main difference in the way people speak about the introduction of CNC machines regards the nature of the change these machines have brought. There can be said to exist two clearly differentiated discourses regarding this change which describe it either as a departure from established practices or as a continuation of established practices.

In the following factors, finer differentiations will be established concerning these two perspectives.

Factor II: "Strategic" Discourse X "Operational" Discourse

Item	2#F	COS2	CTF	Percentage explained = 27.4%
A2+	-1365	430	196	USE OF CNC TO INCREASE VERTICAL INTEGRATION
O2+	-1071	860	241	STRATEGIC CONCERNS
QD	**-1053**	**434**	**349**	Quality Director
ZZ 1	-776	201	63	[SOURCE OF TECHNICAL PROBLEMS (C2-); ENHANCE TECHNOLOGY (O4+)]
TE	**-599**	**269**	**151**	Technical Director
ZZ 2	0	0	0	
O3+	0	0	0	
ZZ 5	0	0	0	
A1-*	0	0	0	
TD	**0**	**0**	**0**	
DD	**599**	**269**	**151**	Design Director
ZZ 4	776	201	63	[SOURCE OF ORGANIZATIONAL PROBLEMS (C2+); ENHANCE SYSTEM (O4-)]
PD	**1053**	**434**	**349**	Production Services Director
O2-	1071	860	241	OPERATIONAL CONCERNS
ZZ 3	1365	430	196	[INCREMENTAL NOVELTY (C1-); PROBLEMS W/ CNC UTILIZATION (A1+)]

Table 4.22. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II describes a distinction between the Production Services Director and the Quality Director, who were together in Factor I. This distinction hinges on the opposition between a more strategic orientation and a more operational orientation. As discussed above, the label "strategic" should be taken with some care: it is intended to denote the attention given to environmental processes, which is a rather limited notion of strategy, than a full range of what one would call strategic behaviours.

On the "strategic" side we find the description of one of the results of CNC introduction, its use to increase the vertical integration; on the "operational" side we find the machines described as an incremental novelty and the account of the implementation process centered on problems with CNC utilization rate.

"STRATEGIC" DISCOURSE	FACTOR II	"OPERATIONAL" DISCOURSE
QUALITY DIRECTOR TECHNICAL DIRECTOR		PRODUCTION SERVICES DIRECTOR DESIGN DIRECTOR
CNC MACHINES ARE: - a source of technical problems		CNC MACHINES ARE: - an incremental novelty - a source of organizational problems
GUIDELINES IN THEIR INTRODUCTION: - strategic concerns - enhance the technology		GUIDELINES IN THEIR INTRODUCTION: - operational concerns - enhance the system
WITH THEIR INTRODUCTION: - they were used to increase vertical integration		WITH THEIR INTRODUCTION: - there are problems with their utilization rate

Fig. 4.3. Second Level Analysis - Factor II.

It should be noted that on the "strategic" side of the factor we also find the Technical Director along with a description of the machines as essentially a source of technical problems and the enhancement of the technological dimensions of the company as an important guideline. On the "operational" side one finds the Design Director along with his definition of the machines as sources of organizational problems and the enhancement of the organization, globally as a guideline for action. Although they contribute little to the factor, they are fairly well represented in it (the chi-square brought by these two actors to the overall chi-square has a fairly balanced distribution across the four factors). They are not however as far apart as the other two actors. In other words, they do not differ as much as the other two in what concerns this strategic/operational opposition. It is nevertheless interesting to note that the operational concerns appear closer to concerns with the impact of CNC machines on the organization and the strategic concerns appear closer to concerns about the technology. To put this in perspective, it should be noted that the introduction of CNC machines and other new technologies was influenced by pressures coming from important customers regarding the type of technology used.

This suggests that the pressures coming from their largest customer worked by making available and highly relevant a whole new set of meanings which these two actors took more clearly. In this set of meanings survival of the company and technological change are linked, as one would expect, coming from a large company trying to influence their suppliers in the sense of using different technologies and methods.

This is a power strategy used by a large customer. It worked not only because someone got the message (the Managing Director in this case) but also because other people began speaking in those terms, introducing in the company this new set of meanings.

Factor III: Organizational/global Discourse X Departmental/local Discourse

Item	3#F	COS2	CTF	Percentage explained = 24.3%
ZZ 1	-872	254	90	[SOURCE OF TECHNICAL PROBLEMS (C2-); ENHANCE TECHNOLOGY (O4+)]
ZZ 4	-872	254	90	[ORGANIZATIONAL PROBLEM (C2+); ENHANCE SYSTEM (O4-)]
ZZ 5	-872	761	181	[SOURCE OF GLOBAL CHANGES (C3-); MARKET ORIENTED IMPLEMENTATION (O3-); CHANGES AT COMPANY LEVEL (A3-)]
DD	**-633**	**300**	**190**	Design Director
TE	**-633**	**300**	**190**	Technical Director
O2+	-200	30	9	
O2-	-200	30	9	
A1-*	108	15	4	
PD	**343**	**46**	**42**	
QD	**343**	**46**	**42**	
A2+	473	52	27	
ZZ 3	473	52	27	
O3+	473	134	53	
TD	**1501**	**520**	**535**	Toolroom Director
ZZ 2	2070	612	509	[RADICAL NOVELTY (C1+); SOURCE OF LOCAL CHANGES (C3+); RISK AVOIDANCE (O1+); CHANGES AT TOOLROOM LEVEL (A3+)]

Table 4.23. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III differentiates between the Design and the Technical Director on one side, and the Toolroom

Director on the other. These three actors were fairly close on Factor I, sharing the notion that the introduction of CNC was about radical changes. But while the Toolroom Director is aware that important changes are going on, he does not articulate clearly the nature of these changes. Therefore he is only able to adopt as a guideline for action the avoidance of risks and can only describe the changes at the toolroom level. The Technical and the Design Directors, on the other hand, have a more articulate discourse about the CNC machines, the changes they brought and the guidelines for the management of these changes.

This difference can be described as an opposition between an organizational/global discourse about change (negative end of the factor) and a localized, or departmental, discourse about change (positive end of the factor). It can be seen more clearly on the following table.

ORGANIZATIONAL/GLOBAL DISCOURSE	FACTOR III	DEPARTMENTAL/LOCAL DISCOURSE
DESIGN DIRECTOR TECHNICAL DIRECTOR		TOOLROOM DIRECTOR
CNC MACHINES ARE: - a source of global changes - a source of technical problems - a source of organizational problems		CNC MACHINES ARE: - a radical novelty - a source of local changes
GUIDELINES IN THEIR INTRODUCTION: - market oriented implementation - enhance the technology - enhance the system		GUIDELINES IN THEIR INTRODUCTION: - avoidance of risks
WITH THEIR INTRODUCTION: - changes at company level took place		WITH THEIR INTRODUCTION: - changes at toolroom level took place

Fig. 4.4. Second Level Analysis - Factor III.

Factor IV: Organizational orientation X Technical Orientation

Item	4#F	COS2	CTF	Percentage explained = 12.9%
ZZ 4	-1182	466	312	[ORGANIZATIONAL PROBLEM (C2+); ENHANCE SYSTEM (O4-)]
A2+	-896	185	179	USE OF CNC TO INCREASE VERTICAL INTEGRATION
DD	**-626**	**294**	**349**	Design Director
QD	**-475**	**88**	**151**	Quality Director
O2-	-143	15	9	
ZZ 2	0	0	0	
O3+	0	0	0	
ZZ 5	0	0	0	
A1-*	0	0	0	
TD	**0**	**0**	**0**	
O2+	143	15	9	
PD	**475**	**88**	**151**	Production Services Director
TE	**626**	**294**	**349**	Technical Director
ZZ 3	896	185	179	[INCREMENTAL NOVELTY (C1-); PROBLEMS W/ CNC UTILIZATION (A1+)]
ZZ 1	1182	466	312	[SOURCE OF TECHNICAL PROBLEMS (C2-); ENHANCE TECHNOLOGY (O4+)]

Table 4.24. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV describes essentially the differences between the Technical Director and the Design Director. These actors, who have a good deal in common as can be seen by their positions in the previous factors, diverge in what concerns the nature of the changes brought by the CNC machines. While the Technical Director defines this change essentially along technical dimensions, the Design Director describes it along organizational dimensions. The Quality Director and the Production Services Director are much less well represented in this factor, but they contribute to enrich this opposition by the inclusion of a specific practice which can be associated with organizational change (the increase in vertical integration, by the Quality Director) and the problems in the use of technology (namely the utilization rate, by the Production Services Director).

ORGANIZATIONAL ORIENTATION	FACTOR IV	TECHNICAL ORIENTATION
DESIGN DIRECTOR QUALITY DIRECTOR		TECHNICAL DIRECTOR PRODUCTION SERVICES DIRECTOR
CNC MACHINES ARE: - a source of organizational problems		CNC MACHINES ARE: - a source of technical problems - an incremental novelty
GUIDELINES IN THEIR INTRODUCTION: - enhance the system		GUIDELINES IN THEIR INTRODUCTION: - enhance the technology
WITH THEIR INTRODUCTION: - they were used to increase vertical integration		WITH THEIR INTRODUCTION: - there are problems with their utilization rate

Fig. 4.5. Second Level Analysis - Factor IV.

4.5. Discussion of Discourse Structure Analysis

The second level analysis shows various aspects of the structure of discourses in the management group of Company 1.

This structure can be depicted as a central core of concepts shared by a majority of people in the organization, surrounded by the discourse differentiations identified in the second level analysis, as in Figure 4.6. The individual clusters, in the periphery of the diagram, give some cues to the process by which actors redefine their individual roles in the organization, considering the changes associated with the CNC machines.

In Company 1, the core is constituted by the notion of Accuracy, which is held by everybody as a characteristic of the CNC machines. As discussed before (Chapter 3), this notion is akin to the notion of "cryptic label" (Bougon, 1992) and this analysis of discourse shows that they can be seen as "pivots" around which people differentiate their discourse without becoming estranged from the group.

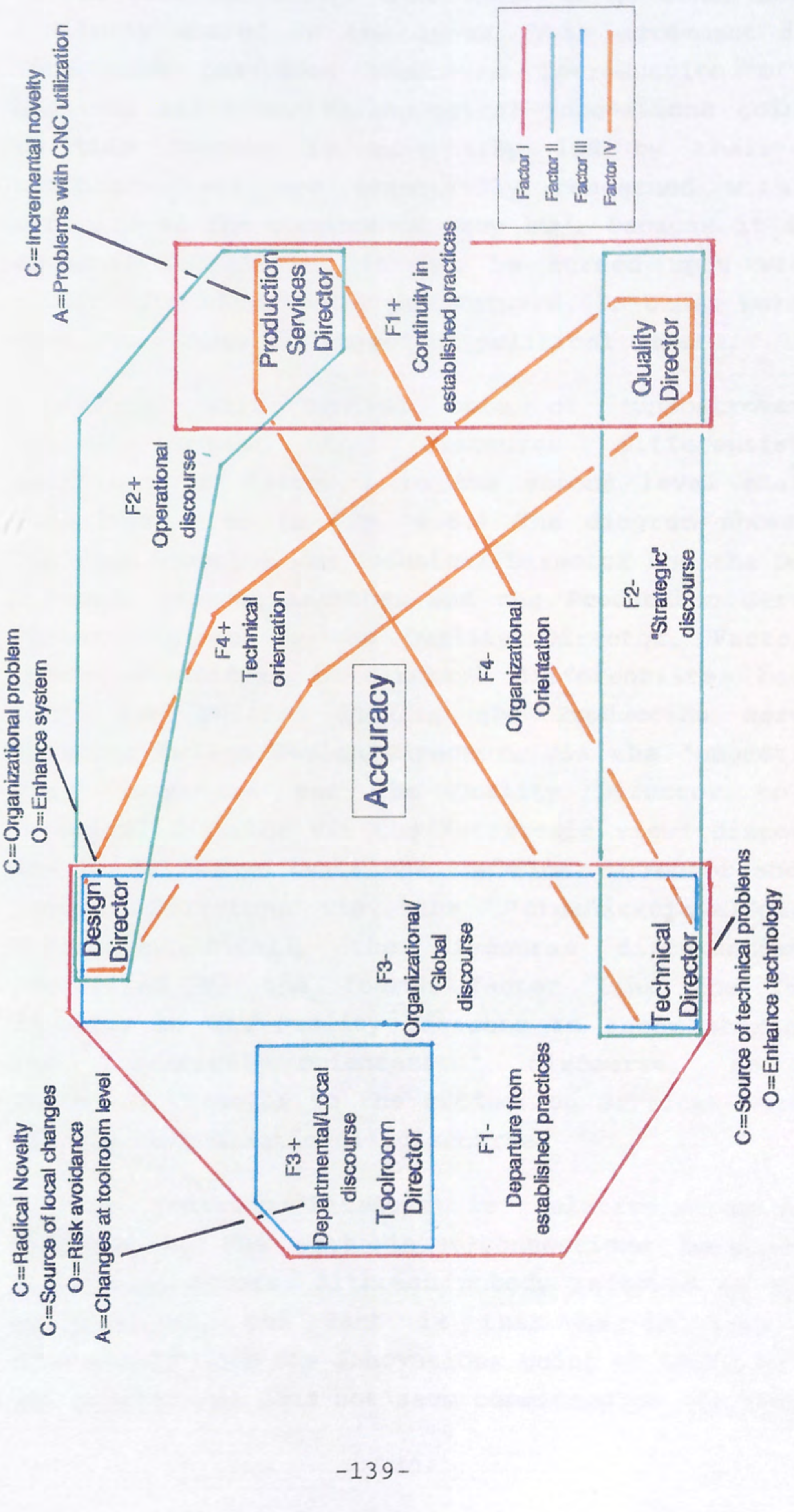

Fig. 4.6. Company 1 - Structure of Discourses about CNC implementation

In this particular case there is no other concept similarly shared in the group. This agreement is in line with the idea that the introduction of CNC machines and other technological innovations going on in this Company is externally led by their main customers, who are essentially concerned with the accuracy of the components they buy. Because it is an external imposition, it can be agreed upon without alternative views being put forward. In other words it does not become the object of political debate.

Around this central core of "uncontroversial truths" appear the discourse differentiations identified by factor I in the second level analysis (Red boundaries in Fig. 4.6.) The diagram shows the Toolroom Director the Technical Director and the Design Director grouped together and the Production Services Director close to the Quality Director. Factor II (green boundaries in diagram) differentiates between these two actors, linking the Production Services Director to the Design Director, via the "operational view" discourse and the Quality Director to the Technical Director via the "strategic view" discourse. The third factor links the Technical Director and the Design Director via the "organizational/global" discourse. Finally the discourse differentiations identified by the fourth factor link the Design Director to the Quality Director in their sharing of the "technical orientation" discourse, and the Technical Director to the Production Services Director via the "organizational" discourse.

The Toolroom Director is relatively isolated, compared to the rich inter-connections between the other four actors. Although nobody referred to him as an outsider, the fact is that he is less than comfortable with the innovations going on which he does not control and does not seem committed to. In terms of political power, it can be said that insofar as technological innovation is concerned, he is the one less likely to influence perceptions of the situation. His individual cluster seems to reflect the fact that the CNC machines brought to his role some elements which he is unable to control. In consequence, he defines the machine as a radical novelty with impacts chiefly in the toolroom. This actor's concern with the financial risks of this type of investment suggests that he his stressing more the other formal part of his role, as Company Secretary, given his inability to take charge of issues related to the CNC machines.

An interesting feature of this structure is the degree of interconnectedness between the other four actors. The power to influence the process of innovation in this Company, or at any rate the contributions to an interpretation of the CNC machines as a strategic asset seem to be within this group. This was clearly felt in the interviews, and this analysis of discourse confirms that impression. Such a level of interconnectedness associated with the fact that these are possibly the more influential actors suggests that being connected to other actors via different discourses is closely related to the power to influence what happens.

The Technical Director, identified as the actor more committed to the innovation process, is within this group. In his individual cluster the CNC machines are defined as essentially a technical problem, to be approached in a technical manner. Clearly his individual role has been changed by the introduction of the CNC machines but he managed to be deal adequately with those changes, actually incorporating many of the issues raised by the new technology in his role definition.

The Design Director's individual cluster suggests a more problematic vision of the machines, and raises several issues on their impact on the organization. In his case we see new questions being raised, which are not shared but which seems to make sense. At any rate, they define issues which can become relevant for this group. His case is interesting in that we have an actor who clearly does not control the technical aspects of this innovation, yet manages to have something to say about it, to re-define his role as different from the other directors.

Finally the Production Services Manager advances the description of the machines as incremental changes and raises the issues of their utilization. As we have mentioned before this is clearly a new issue which starts being raised by this actor in the re-definition of his role. It is likely then that when the issue of the utilization rates becomes relevant in the toolroom the Production Services Director will be the person expected to do something about it.

CHAPTER 5:
COMPANY 2

5.1. Brief description of Company 2

Company 2 is a small company located in Birmingham, employing around 30 people at the time of the study.

The Company operates in the old Victorian building where it started, which survived World War II bombings. It is located near the city centre, with narrow spaces that constitute a problem whenever bulky machines have to be moved, and which do not allow for any expansion.

It was founded in 1862 and started as a manufacturer of steel pen nibs. The two World Wars provided opportunities for diversification into different type of manufacturing. During World War I the Company branched into the manufacture of cartridge clips for the armed forces. Between the two wars, they started the manufacture of pressed parts for the motor industry, thus laying the foundations for its present experience in presswork. During World War II the Company was busy manufacturing pressed parts for military applications. After the war, and following a period where they tried to revert to steel pen nibs, the present managing director steered a move away from pen nibs and into precision pressing for electrical and later electronics industries.

These components are pressed and cut out of metal tape of various types, by means of a progression tool. A progression tool is composed of various parts and performs a sequence of operations, step by step, shaping the plain metal tape into the finished components, found for example in electrical plugs. Basically, at each point of the tool the metal tape is pressed between two parts and is shaped as desired. These components may come out attached to the tape so they can be fed into an automatic process elsewhere. This process, called tape-to-tape pressing requires a very high standard of accuracy and consistency during all the operation, otherwise the components will vary from the beginning to the end of the tape and this variance will be introduced into the customer's process.

The tool performing these operations must therefore be machined to a level of accuracy in the order of the micron, and has to be made in materials that can withstand the millions of blows they are to receive in the presses during the process of production without being deformed. It also has to have an accurately finished surface so that any irregularities are not pressed into the components being made.

The complexity of the shapes in the tool requires very careful design. It usually involves decomposing the tool into component parts that can be machined separately and then assembled in such a way that it comes out as expected.

Operations are divided into two main areas: tool making in the toolroom, and production of components in the presses.

The Company is well positioned as a producer of precision pressing. It relied not on just a single major customer and exported a good deal of their production to Europe.

At the time of the study they were setting up a completely automated line for the production of computer disk shutters and hub rings. This line was expected, when fully functional, to produce, clean and package the shutters and rings ready to be shipped to their customer in Japan, totally unmanned except for ancillary services like maintenance and raw materials supply. This effort, to which the managing director appeared strongly committed, was an example of the Company's determination to keep its edge as a manufacturer by means of widespread automation, a concern which, as we shall see, had some bearing on the way the CNC machine was used.

5.2. Process of innovation

The Company introduced a CNC machine three to four years ago, a self-threading wire spark eroder which was the only CNC machine used at the time of the study. It was used to machine some of the hard component parts of the tools, and its specific characteristics enabled a simplification of tool design. This became possible because the machine cuts metal in the same way a jig-saw cuts wood, following very complex shapes, thus reducing the need to decompose the tool into simpler parts to be assembled later.

The CNC machine provided also for good surface finish in the same operation. In the traditional production of tools, the tool parts are machined up to a certain point and then finished in optical profile grinders (OPG), a very skilled operation, which involves careful removal of layers of metal until the desired surface finish is achieved. A common complaint was the existence of a permanent bottleneck in the OPG section which the CNC wire eroder was expected to resolve eventually.

The introduction of the CNC machine was championed by the Technical Director who had previously worked for this Company, then started a business on his own as tool designer and finally came back on the basis of a presumably informal agreement that the Company would invest in this type of technology. He prepared the capital case and managed the introduction of the machine. There was thus a strong commitment on his part to make sure the machine turned out to be as good an investment as possible.

The CNC machine was located in the ground floor, just below the toolroom, in a vibration free area. This is important, from a technical point of view, because this area is only a few meters away from the presses, which generate a good deal of vibrations on their own, apart from the normal vibration to be expected from the heavy traffic passing on the road. If we consider the very low tolerances acceptable on the tools, it is understandable that all this investment had been made. It also had nevertheless increased the importance of the investment to be made.

The CNC machine works typically long jobs, running for hours. It signals the end of a job by lighting a lamp in the toolroom immediately above, freeing its operator from the need to constantly check the operation.

Its introduction seems to have had some effects on the power structure of the Company: one was the reduction of the optical profile grinders' importance; another was the increased importance of the Toolroom Machining Manager.

Before the CNC machine was introduced optical profile grinders had a key role in the production of tools. Although they did only a small amount of the work going into a tool, they performed the critical task of surface finishing. They probably derived a significant amount of power from this circumstance and the generalized complaint about a bottleneck in the OPG section was possibly a signal that they would effectively use this power to pursue their interests. The CNC machine was to change this circumstance, undermining their source of power and possibly creating some tensions. In addition, the OPG people were older than the Toolroom Machining Manager, some nearing retirement. This may have prevented them from getting involved in the CNC machine introduction, and led the Company not to invest in their training

In what concerns the Toolroom Machining Manager, there was a different process: he was in charge of the CNC machine, which he actually programmed and appeared to have great autonomy in this task. This autonomy generated probably some tensions with the Toolroom Manager who did not understand how the machine worked but had nevertheless to adapt to the new design of the tools whose assembly and correction he supervised. The Toolroom Machining Manager and the Technical Director seemed to have some kind of alliance, which is understandable given that the Technical Director had all the interest in the CNC machine being a success story. In the management structure provided by the Managing Director, the Toolroom Manager and the Toolroom Machining Manager appear at the same level but this probably represented a promotion for the Toolroom Machining Manager after the machine was introduced, so in fact, the Toolroom Manager might feel that his authority had been reduced with the introduction of the CNC machine. All this might have contributed to the increased power of the Toolroom Machining Manager and the isolation of the Toolroom Manager from the process of learning about the CNC machine.

5.3. The actors

In general, people in this Company seemed to relate in a fairly informal way. After the first contact with the Toolroom Machining Manager, who arranged a first interview with the Technical Director, there was no problem in getting other interviews. Except for the Financial and the Commercial Director, who were somewhat reluctant to give their views on "technical matters", everyone was quite willing to talk about their own work, the CNC machine, the problems they were having and the way they solved them.

The management structure is depicted below, following the description provided by the Managing Director.

```
                     +-----------+
                     | Chairman  |
                     +-----+-----+
                           |
                +----------+----------+
                | Managing Director*  |
                |        (MD)         |
                +----------+----------+
     +---------------------+--------------------------+
+----+------+        +-----+-----+           +-----+-----+
|Financial  |        |Technical  |           |Commercial |
|Director*  |        |Director*  |           |Director*  |
|  (FD)     |        |  (TD)     |           |  (CD)     |
+-----------+        +-----+-----+           +-----------+
                           |
                           |
          +----------------+----------------+
Production|Services        |            Quality Control
Manager*(SM)               |            Manager*(QM)
           +---------------+------------+---------+
           |               |            |         |
      Production           |        Toolroom   Toolroom
      Engineering          |        Manager*   Machining
      Manager*(EM)         |        (TM)       Manager*(MM)
                       Drawing
                       Office
```

Fig. 5.1 Company 2 Management Structure (* indicates people interviewed).

5.4 Discourse Structure Analysis

A. Characteristics.

The distribution of themes related to the characteristics of the CNC machine is summarized in the following table.

POSITION	TD	MD	TM	QM	SM	CD	FD	MM	EM	MEANING
N Themes	2	3	0	2	1	1	0	4	3	
SPCL	0	0	0	0	0	0	0	0	1	RELEVANT FOR TOOLROOM ONLY
SPEE	0	0	0	0	0	0	0	1	0	SPEED
LEAR	0	0	0	0	0	0	0	1	1	LEARNING CURVE FOR CNC
STWI	0	1	0	0	0	0	0	0	0	SELF-THREADING WIRE
ACCU	0	1	0	1	0	1	0	1	0	ACCURACY
CPR*	1	1	0	1	1	0	0	1	1	CONTROLLED BY COMPUTER
ZZ1	1	0	0	0	0	0	0	0	0	(MAINTENANCE COSTS; OPERATING COSTS; INCLUDES SMALL COMPUTER; MORE EFFICIENT WITH COMPLEX SHAPES)

Table 5.1 Distribution of themes among actors.

Correspondence analysis applied to this table extracted the following factors.

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	.55361	32.275	32.275
II	.53078	30.945	63.219
III	.30787	17.948	81.168
IV	.18383	10.717	91.885
V	.13920	8.115	100.000

Table 5.2 Factors extracted (Characteristics)

Interpretation of Factors

Factor I: Effectiveness X Cost-effectiveness.

Item	1#F	Cos2	CTF	Percentage explained = 32%
CD	**-900**	**270**	**91**	**Commercial Director**
ACCU	-669	414	202	ACCURACY, REPEATABILITY.
STWI	-617	88	43	
SPEE	-483	78	26	
MD	**-459**	**139**	**71**	
MM	**-360**	**141**	**58**	
QM	**-274**	**113**	**17**	
LEAR	-179	24	7	
TM	**0**	**0**	**0**	
FD	**0**	**0**	**0**	
EM	**93**	**4**	**3**	
SPCL	125	4	2	
CPR*	262	231	46	
SM	**352**	**74**	**14**	
TD	**1816**	**900**	**745**	**Technical Director**
ZZ 1	2441	851	673	(MAINTENANCE COSTS; OPERATING COSTS; INCLUDES SMALL COMPUTER; MORE EFFICIENT WITH COMPLEX SHAPES)

Table 5.3. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I opposes a cluster of characteristics evoked by the Technical Director (ZZ1) which have in common looking at the machine in terms of its **cost-effectiveness** (at the positive end of the factor) to a characteristic evoked by a number of people that stresses the extent to which it machines to the level of accuracy expected, i.e., its **effectiveness** (at the negative end of the factor) with no mention of its cost.

The fact that no one else evokes cost-effectiveness as a characteristic of the machine can be surprising. One has to consider the fact that the Technical Director prepared the capital case for the CNC machine, an activity where this kind of concern is highly relevant. This probably also made this type of concern his "hallmark": it became part of his job to worry about these aspects of the use of CNC equipment.

Factor II: Restricted relevance X Global relevance.

Item	2#F	Cos2	CTF	Percentage explained = 31%
SPCL	-1749	706	360	RELEVANT FOR TOOLROOM USE, ONLY.
EM	**-1274**	**827**	**574**	**Production Engineering Manager**
LEAR	-1080	875	275	LEARNING CURVE FOR CNC.
SPEE	-411	56	20	
MM	-299	98	42	
TM	0	0	0	
FD	0	0	0	
CPR*	44	7	1	
SM	60	2	0	
QM	424	270	42	
TD	521	74	64	
ACCU	574	304	155	ACCURACY; REPEATABILITY.
ZZ 1	715	73	60	
MD	761	381	204	Managing Director
CD	788	207	73	Commercial Director
STWI	1044	251	128	SELF-THREADING WIRE

Table 5.4. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates between the Managing Director and the Production Engineering Manager. It opposes two groups of characteristics, one related to a perception of specific machine characteristics (its learning curve and the fact that it is only directly relevant for the toolroom) and the other related with perceptions of the machine at a more general level (accuracy).

By suggesting that the machine is only relevant to the toolroom the actor (the **Production Engineering Manager**, who is responsible for the presses) reflects in his discourse the functional differentiation of roles in the organization. Although quite clearly the machine makes a change in the tools he uses in the presses, making tools is not his problem, hence the definition of the machine as something that concerns others. With these he shares the concern with having new machines accepted and used by the workforce, hence the concern with the 'learning curve for CNC'. This is a description of the machine that could be labelled as "department-centered". To this type of perception is opposed a description of the machine as something with wider implications for the Company because of its accuracy, a central concern in precision press work. This perception is further clarified by the evocation of the self-threading wire facility because it enables running jobs that take more than the normal working hours, something that can make wide ranging changes to forms of operating.

Factor II can thus be described as opposing perceptions of the machine as something which has **restricted relevance** (negative end of the factor) as opposed to having **global relevance** (positive end of the factor).

This factor may be taken as reflecting a more general discourse differentiation between senior and lower level management. In the appropriation of this technology, the concept of accuracy becomes for the Managing Director not just an interesting characteristic of the machine but a concept which encapsulates his perception of the right direction for the Company to follow: high quality press work at low price.

Factor III: CNC enables change X CNC enables continuity.

Item	3#F	Cos2	CTF	Percentage explained = 18%
STWI	-1319	402	353	SELF-THREADING WIRE
SPCL	-919	195	171	RELEVANT FOR TOOLROOM USE, ONLY.
MD	-732	353	326	Managing Director
EM	-510	132	158	Production Engineering Manager
SM	-249	37	13	
CPR*	-138	64	23	
TM	0	0	0	
FD	0	0	0	
QM	91	12	3	
TD	199	11	16	
LEAR	208	33	18	
ACCU	239	53	46	
ZZ 1	359	18	26	
CD	430	62	38	
MM	741	599	446	Toolroom Machining Manager
SPEE	1335	594	362	SPEED

Table 5.5. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III distinguishes between the **Managing Director** and the **Production Engineering Manager** at the negative end, and the **Toolroom Machining Manager** at the positive end. It groups at its negative end descriptions of the machine as a disruption: in one case the actor is trying to define its place in the organization ('relevant for toolroom use only'), thus suggesting that available "recipes" can not be applied to this machine, in the other case because the actor is perceiving a characteristic which has wide possibilities in terms of introducing novel practices. To these two, the factor opposes 'Speed' evoked by the **Toolroom Machining Manager**, a characteristic which he is the only one to evoke. Speed is relevant because the toolroom is always under pressure from the presses to produce or replace tools very quickly. Therefore it can be taken as signalling a perception of the machine as solving the specific, on-going problem of the toolroom backlog. <u>Factor III</u> can thus be considered as differentiating between characteristics that **enable**

changes at different levels, to characteristics that **enable continuity** in the logic of production, by resolving particular problems.

It is worth noting that the **Toolroom Machining Manager** is the user of the machine, i.e. the one whose job is directly changed. In this sense, what speed means is the possibility of doing a better job in a key process, hence of improving his position as a relevant actor.

Factor IV: Accurate Machine X Advanced Machine.

Item	4#F	Cos2	CTF	Percentage explained = 11%
CD	-1117	416	424	Commercial Director
SPCL	-542	68	100	
ACCU	-479	212	312	ACCURACY; REPEATABILITY.
QM	-478	343	155	Quality Assurance Manager
EM	-232	28	55	
ZZ 1	-109	2	4	
TD	-47	1	1	
TM	0	0	0	
FD	0	0	0	
CPR*	69	16	10	
SM	161	15	9	
LEAR	174	23	21	
MM	382	159	198	Toolroom Machining Manager
MD	392	101	157	Managing Director
SPEE	891	264	270	SPEED
STWI	914	193	284	SELF-THREADING WIRE

Table 5.6. Factorial Coordinates, Chi-square explained and contributions to Factor .

Factor IV differentiates between the Commercial Director and the Quality Assurance Manager at the negative end of the factor and the Toolroom Machining Manager and the Managing Director, at the positive end. It should be noted that the factor explains a fairly small amount of the matrix information.

The four people share the concept of 'accuracy' but while the Managing Director and the Toolroom Machining

Manager evoke several other characteristics, this is the only one evoked by the Commercial Director and one of the two evoked by the Quality Assurance Manager. Thus, what the factor describes is this difference in the overall production, the fact that accuracy is more central in these last two actors.

This is easily understandable looking at their positions. Being both at the end of the transformation process it is the characteristic relevant to the quality of the end product which is stressed in their discourse. The factor can thus be described as differentiating between a description of the machine as an **accurate machine** and its description as an **advanced machine**, a distinction which is not trivial because different implications for action may follow.

Factor IV and Factor V (which is not discussed at length because it explains very little of the information in the matrix) both deal with concepts shared by a large proportion of actors: "Accuracy" and "Controlled by programme/computer". These two themes can be seen as the cryptic labels that serve as currency in the about what the machine is. It is interesting to see that even the two actors who contribute less with characteristics share at least one of these concepts.

B. Objectives.

The distribution of themes related to objectives among the actors is summarized in the following table.

ACTORS	TD	MD	TM	QM	SM	CD	FD	MM	EM	MEANING
Nthemes	9	7	2	1	0	2	1	6	4	
ALOO	0	1	0	0	0	0	0	0	0	RUN MACHINES UNATTENDED
CDEL	0	1	0	0	0	0	0	0	1	INCREASE RELIABILITY IN DELIVERY TIMES
CIMA	0	1	0	0	0	1	0	0	1	IMPRESS CUSTOMER
IPRO	1	0	0	0	0	0	0	1	0	INCREASE PRODUCTION
ISET	1	0	0	0	0	0	0	1	1	REDUCE DOWNTIME IN PRESSES
ILMR	1	0	0	0	0	0	1	0	0	KEEP GOOD RELATIONS WITH WORKFORCE
QUAT	1	0	1	0	0	0	0	0	0	PRODUCE HIGH PERFORMANCE, ACCURATE TOOLS
CPTV	1	1	0	0	0	0	0	0	1	COMPETITIVENESS
ACCO	1	1	0	0	0	0	0	1	0	ACCURACY
RLAC	1	1	0	0	0	1	0	1	0	REDUCE LABOUR COSTS/USE COST/EFFECTIVELY
ITOO	1	1	1	0	0	0	0	1	0	REDUCE TIMES PRODUCING/ASSEMBLING TOOLS
ZZ 1	0	0	0	0	0	0	0	1	0	(INCREASE PROFITS TO BE SHARED; REDUCE MANPOWER)
ZZ 2	0	0	0	1	0	0	0	0	0	(INCREASE DESIGNER CONTROL OVER MACHINING; INCREASE PRODUCT QUALITY
ZZ 3	1	0	0	0	0	0	0	0	0	(SIMPLIFY AND AUTOMATE DESIGN; ENTER NEW MARKETS; INCREASE CONTROL OF OPERATORS; PUT DISK DRIVES IN CNC; DEVELOP CO SKILL BASIS; USE CNC TO REDUCE OPERATING COSTS INCREASE CNC MACHINE UTILIZATION)

Table 5.7. Distribution of Objectives.

Correspondence analysis extracted the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	1.00000	34.976	34.976
II	.57994	20.284	55.260
III	.45573	15.939	71.199
IV	.32457	11.352	82.551
V	.21149	7.397	89.948
VI	.16763	5.863	95.811
VII	.11977	4.189	100.000

Table 5.8 Factors extracted (Objectives)

Interpretation of factors

Factor I: Improve competitiveness.

Item	1#F	Cos2	CTF	Percentage explained = 35%
ZZ 2	-14	0	0	(INCREASE DESIGNER CONTROL OVER MACHINING; INCREASE PRODUCT QUALITY
QM	-14	0	0	Quality Assurance Manager
SM	0	0	0	
ZZ 1	1016	238	32	
ALOO	1016	289	32	
ZZ 3	1016	404	32	
FD	1016	69	32	
CDEL	1016	482	65	INCREASE RELIABILITY IN DELIVERY TIMES
IPRO	1016	845	65	INCREASE PRODUCTION
ILMR	1016	131	65	
QUAT	1016	265	65	
TM	1016	206	65	
CD	1016	282	65	
CIMA	1016	475	97	IMPRESS CUSTOMER
ISET	1016	1178	97	REDUCE DOWNTIME IN PRESSES
CPTV	1016	1304	97	COMPETITIVENESS
ACCO	1016	2083	97	ACCURACY
RLAC	1016	1227	129	REDUCE LABOUR COSTS/ USE COST-EFFECTIVELY
ITOO	1016	1227	129	REDUCE TIMES PRODUCING/ASSEMBLING TOOLS
EM	1016	516	129	Production Engineering Manager
MM	1016	753	194	Toolroom Machining Manager
MD	1016	1076	226	Managing Director
TD	1016	1779	290	Technical Director

Table 5.8. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I isolates the Quality Assurance Manager's production from all the other actors and themes. Because he does not share any of the themes with the others actors, the Quality Assurance Manager becomes 'more different' than any other.

At the positive end of the factor we find the four actors and the eight themes best represented by this factor. This grouping indicates a central objective concerning CNC implementation which could be labelled "Improving competitive position".

Factor II: improve customer service X improve workplace relations.

Item	2#F	Cos2	CTF	Percentage explained = 20%
CIMA	-948	413	145	IMPRESS CUSTOMER
CDEL	-888	368	85	INCREASE RELIABILITY IN DELIVERY TIMES
CD	-814	181	71	
ALOO	-776	169	32	
EM	-761	289	125	Production Engineering Manager
MD	-591	365	132	Managing Director
CPTV	-375	177	23	
RLAC	-292	101	18	
ISET	-107	13	2	
ACCO	-33	2	0	
ZZ 2	0	0	0	
QM	0	0	0	
SM	0	0	0	
MM	21	0	0	
ZZ 1	27	0	0	
ITOO	159	30	5	
IPRO	339	94	12	
TD	496	424	119	Technical Director
TM	560	63	34	
ZZ 3	651	166	23	
QUAT	693	124	52	
ILMR	2363	708	602	KEEP GOOD RELATIONS WITH WORKFORCE
FD	3103	642	519	Financial Director

Table 5.9. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates between the Production Engineering Manager and the Managing Director on one side and the Technical Director and the Financial Director on the other. The themes associated with each of these groups of actors suggest respectively concerns with **customer service** (on the negative side of the factor) to concerns with **workplace relations** (on the positive side).

It is interesting to note how the differentiation described by this factor groups people who are fairly apart both in the formal structure and functionally, as is the case of the Technical Director and the Financial Director. This similarity in discourse suggests that the capital case was an important provider of meaning, something similar to Lee's (1987) description of how the capital case can influence the management of technological innovation processes.

Factor III: Good engineering X Good management.

Item	3#F	Cos2	CTF	Percentage explained = 16%
TM	-1394	389	266	Toolroom Manager
QUAT	-1176	356	190	PRODUCE HIGH PERFORMANCE, ACCURATE TOOLS.
ZZ 1	-917	194	58	(INCREASE PROFITS TO BE SHARED; REDUCE MANPOWER)
ITOO	-705	592	136	REDUCE TIMES PRODUCING/ASSEMBLING TOOLS
MM	-619	279	158	Toolroom Machining Manager
IPRO	-602	297	50	INCREASE PRODUCTION
ZZ 3	-288	33	6	
ACCO	-252	128	13	
TD	-195	65	23	
ISET	-66	5	1	
ZZ 2	0	0	0	
QM	0	0	0	
SM	0	0	0	
RLAC	36	2	0	
MD	302	95	44	
CPTV	389	191	31	
ALOO	448	56	14	
CD	609	101	51	
EM	680	231	127	Production Engineering Manager
CDEL	728	247	73	INCREASE RELIABILITY IN AND REDUCE DELIVERY TIMES
CIMA	786	284	127	IMPRESS CUSTOMER
ILMR	1483	279	302	KEEP GOOD RELATIONS WITH WORKFORCE
FD	2197	322	331	Financial Director

Table 5.10. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III groups the Toolroom Manager and the Toolroom Machining Manager at its negative end and the Engineering Manager and the Financial Manager at its positive end. The factor opposes what can be described as professional concerns with efficient, good quality engineering to concerns with good management, namely the Company's relationship with its customers and the maintenance of a favourable industrial relations climate internally. The extremes of factor III can thus be labelled respectively **"concern with good engineering"** (negative side) and **"concern with good management"** (positive side).

This discourse differentiation, is consistent with the formal role definitions of the people who contribute to it. Thus, we have the Toolroom Manager and the Toolroom Machining Manager both concerned with good engineering and the Financial Director concerned with good management, which is roughly what one expects to find.

The "odd man out" in this differentiation is the Engineering Manager. In the three factors concerning objectives analyzed so far he consistently appears closer to senior management than any other manager. This can be taken, speculatively, as a clue to his personal strategy of alliances and commitments: apparently he is not directly involved in the implementation and use of the CNC machine, so his discourse becomes closer to other senior managers in a bid to develop alternative sources of power.

Factor IV: Increasing Toolroom Performance X Increasing General Performance.

Item	4#F	Cos2	CTF	Percentage explained = 11%
TM	-1520	462	445	Toolroom Manager
QUAT	-1352	470	352	PRODUCE HIGH PERFORMANCE, ACCURATE TOOLS.
ALOO	-436	53	18	
CDEL	-410	78	32	
ITOO	-380	172	56	REDUCE TIMES PRODUCING/ASSEMBLING TOOLS
CPTV	-285	103	23	
MD	-249	64	42	
EM	-218	24	18	
CIMA	-203	19	12	
ZZ 3	-36	1	0	
TD	-20	1	0	
ZZ 2	0	0	0	
QM	0	0	0	
SM	0	0	0	
ILMR	33	0	0	
FD	58	0	0	
CD	120	4	3	
RLAC	340	137	44	
ACCO	383	295	42	
ISET	400	183	46	
IPRO	792	513	121	INCREASE PRODUCTION
MM	923	621	492	Toolroom Machining Manager
ZZ 1	1620	605	253	(INCREASE PROFITS TO BE SHARED; REDUCE MANPOWER)

Table 5.11. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV differentiates the Toolroom Manager from the Toolroom Machining Manager. Whereas in the previous factor these appeared together, sharing concerns about good engineering, their personal concerns become differentiated in this factor. The factor seems to highlight the incentive scheme influence over people's objectives. It opposes concerns with the quality of tools, a critical factor in Company performance in that it determines the costs and quality of end product, to concerns with productivity increases associated with concerns with increasing the profits to be shared by the number of people working. Factor IV thus can be described as opposing a concern with **increasing toolroom performance** (negative side) to a concern with **increasing general performance** (positive side of the factor).

This is not to say that if prompted the Toolroom Manager would not voice concerns with general performance. The fact is that, both unprompted, the Toolroom Machining Manager voiced such concerns and the Toolroom Manager did not. It is this ability to voice meanings that is instrumental in influencing the social structure of issues.

It is also interesting to note how the Toolroom Machining Manager integrates personal interests and Company interests in the form incentive schemes are expected to work. Even more to the point, he is the only one who does that. Although the incentive scheme applies to everyone in the Company the Toolroom Machining Manager is the only one to use it as a referent in his discourse. This illustrates how people punctuate their on-going stream of experiences in many different ways thus introducing new dimensions in the discourse.

Factor V: Improve localized aspects of performance X Improve system wide aspects of Company performance.

Item	5#F	Cos2	CTF	Percentage explained = 7%
EM	-747	279	330	Production Engineering Manager
CDEL	-696	226	143	INCREASE RELIABILITY IN AND REDUCE DELIVERY TIMES
ISET	-656	490	191	REDUCE DOWNTIME IN PRESSES
CPTV	-581	426	149	COMPETITIVENESS
ZZ 3	-349	48	18	
IPRO	-172	24	9	
TD	-161	44	34	
ACCO	-37	3	1	
ZZ 2	0	0	0	
QM	0	0	0	
SM	0	0	0	
MM	3	0	0	
ZZ 1	6	0	0	
MD	106	12	12	
ITOO	127	19	10	
ILMR	128	2	5	
QUAT	135	5	5	
ALOO	231	15	8	
FD	278	5	11	
TM	285	16	24	
CIMA	559	144	139	IMPRESS CUSTOMER
RLAC	739	650	323	REDUCE LABOUR COSTS/ USE COST-EFFECTIVELY
CD	1412	544	589	Commercial Director

Table 5.12. Factorial Coordinates, Chi-square explained and contributions to Factor V.

Factor V differentiates between themes that have in common the fact that they concern various aspects of Company performance. On the negative side are grouped themes related to **improving localized aspects of the Company performance;** on the positive side we find themes which deal with **improving system wide aspects of Company performance.**

C. Decisions and Actions.

The distribution of themes related to actions and decisions is summarized in the following table.

Actors	TD	MD	TM	QM	SM	CD	FD	MM	EM	MEANING
N themes	6	4	1	3	1	4	1	7	3	
ALO*	1	1	0	1	1	1	0	1	0	RUN MACHINE UNATTENDED
CDZN	0	0	1	0	0	0	0	0	1	SIMPLIFY TOOL DESIGN & MANUFACTURE
CFPG	0	0	0	0	0	0	0	0	1	LESS CONTROL FROM ENGINEERING DEPARTMENT OVER TOOL PRODUCTION
ELOP	1	1	0	0	0	0	0	0	0	ELIMINATE OPERATIONS
EXPR	1	0	0	0	0	0	0	1	0	DEVELOP NEW MACHINING TECHNIQUES
REDM	0	0	0	0	0	1	0	1	0	REDUCE MAN/MACHINE RATIO
ROPG	0	1	0	0	0	0	0	1	1	REDUCE BOTTLENECK IN OPG
RPGR	0	0	0	0	0	1	1	1	0	REDUCE OPTICAL PROFILE GRINDERS
SHOW	0	0	0	0	0	1	0	0	0	SHOW MACHINE TO CUSTOMERS
TRAI	1	0	0	1	0	0	0	0	0	TRAINING BEFORE IMPLEMENTATION
ZZ 1	0	0	0	0	0	0	0	1	0	ZZ1 (LOOK FOR OTHER IMPROVEMENTS IN TECHNOLOGY; RETAIN OPG GRINDERS; INCREASED PROFITS WERE SHARED
ZZ 2	0	1	0	0	0	0	0	0	0	ZZ2 (MAKE MORE OPERATION AFTER HEAT TREATMENT; ELIMINATE JIG BORER POSITION; SELL JIG BORER)
ZZ 3	1	0	0	0	0	0	0	0	0	ZZ3 (ORGANIZE TRAINING: (APPRENTICESHIP & MANAGEMENT TRAINING); INTRODUCE CLOSER MONITORING OF PRODUCTION SYSTEM; DESIGN ON CAD; REASSURE WORKFORCE ABOUT QUALITY OF WIRE ERODED PARTS; USE CNC TO REDUCE COSTS OF CNC USE; MAKE MORE PROTOTYPE TOOLS; TRY TO ENTER NEW MARKETS (JAPAN); OFFER WIRE EROSION SERVICES; PROGRAMME FROM CNC; SET SHIFTWORK SYSTEM)
ZZ 4	1	0	0	1	0	0	0	1	0	ZZ4 (SELECT PEOPLE FOR CNC OPERATION AND TRAINING; MACHINE MORE SPARES)

Table 5.13. Distribution of Decisions and Actions.

Correspondence analysis extracted the following factors:

FACT	EIGEN VALUE	PERCENT	CUMUL %
I	.84052	29.015	29.015
II	.61667	21.288	50.303
III	.43330	14.958	65.261
IV	.28944	9.992	75.252
V	.24163	8.341	83.594
VI	.20633	7.122	90.716
VII	.17431	6.017	96.733
VIII	.09463	3.267	100.000

Table 5.14. Factors extracted: Decisions and Actions.

Interpretation of Factors

Factor I: Changes in control over tool production.

Item	1#F	Cos2	CTF	Percentage explained = 29%
TM	-2983	636	353	Toolroom Manager
CDZN	-2735	831	593	SIMPLIFY TOOL DESIGN AND MANUFACTURE
CFPG	-2216	546	195	LESS CONTROL FROM ENGINEERING DEPARTMENT OVER TOOL PRODUCTION
EM	-2032	807	491	Production Engineering Manager
ROPG	-637	285	48	
ZZ 2	0	0	0	
MD	0	0	0	
ELOP	247	29	5	
MM	280	83	22	
ZZ 1	305	28	4	
ALO*	390	194	36	
EXPR	399	121	13	
REDM	424	93	14	
SM	426	45	7	
ZZ 4	445	173	24	
TD	453	137	49	
RPGR	469	60	26	
QM	491	103	29	
ZZ 3	494	61	10	
CD	498	90	39	
FD	511	29	10	
TRAI	514	96	21	
SHOW	543	45	12	
			1000	

Table 5.15. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I singles out two actors, the Toolroom Manager and the Engineering Manager, together with two themes. These themes describe some of the changes in the process by which tools are made, and the corresponding changes in the perceptions people have of their own control over this crucial aspect of the Company operation, the press tool. Factor I thus helps identify accounts centered on the **changes in control over tool production**, which is a major source of uncertainty in the Company.

This is a speech differentiation which reflects what can be described as a change in the informal power structure of the Company. Both these actors must have seen their control over tool production modified. It became more a matter of design (on CAD) and of operating the CNC machine. In a way they reflect the 'bypass' of the toolroom manager which the CNC accomplished and of the probable link which existed between him and the Engineering Manager. Their reaction is not necessarily a negative one but nevertheless they isolate a change which they both sensed clearly.

Factor II: Changes at the operational level X Changes in the Company's commercial profile.

Item	2#F	Cos2	CTF	Percentage explained = 21%
ZZ 3	-1064	283	61	(ORGANIZE TRAINING: (APPRENTICESHIP & MANAGEMENT TRAINING); INTRODUCE CLOSER MONITORING OF PRODUCTION SYSTEM; DESIGN ON CAD; REASSURE WORKFORCE ABOUT QUALITY OF WIRE ERODED PARTS; USE CNC TO REDUCE COSTS OF CNC USE; MAKE MORE PROTOTYPE TOOLS; TRY TO ENTER NEW MARKETS (JAPAN); OFFER WIRE EROSION SERVICES; PROGRAMME FROM CNC; SET SHIFTWORK SYSTEM)
TRAI	-971	343	102	TRAINING BEFORE IMPLEMENTATION
ELOP	-941	417	96	ELIMINATE OPERATIONS
TD	-836	466	226	Technical Director
ZZ 2	-818	103	36	
QM	-689	204	77	
MD	-643	150	89	
ZZ 4	-498	217	40	
EXPR	-308	72	10	
SM	-197	10	2	
ALO*	-155	31	8	
ROPG	-104	8	2	
EM	46	0	0	
CFPG	58	0	0	
CDZN	153	3	3	
TM	195	3	2	
MM	352	132	47	
ZZ 1	448	61	11	
REDM	1041	557	117	REDUCE MAN/MACHINE RATIO
CD	1283	599	356	Commercial Director
RPGR	1510	626	370	REDUCE OPTICAL PROFILE GRINDERS
SHOW	1634	411	144	SHOW MACHINE TO CUSTOMERS
FD	1923	411	200	Financial Director

Table 5.16. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates the Technical Director from the Commercial Director and the Financial Director. It differentiates between accounts of decisions concerning the adaptation of the production system to the new machine, such as training and the elimination of some of the operations now performed by the CNC (mostly related to surface finishing and tool assembly) to decisions concerning the impact of CNC on the structure of costs, via changes in labour utilization. Reducing costs and using the technology as a selling point are both tactics that make the Company more attractive to potential and actual customers.

Both groups of decisions were made because of CNC implementation but its impact is perceived along different lines. Factor II can be labelled as opposing accounts of the **management changes at the operational level** to accounts of **changes in the commercial profile of the Company.**

This distinction parallels functional specialization, each actor giving an account of the introduction of the CNC machine which highlights its contribution to their respective positions. In a sense this a demarcation of their respective areas of responsibility and power.

Factor III: Adapt production system to CNC operation X Adapt people to CNC operation.

Item	3#F	Cos2	CTF	Percentage explained = 15%
ZZ 2	-2233	767	383	(MAKE MORE OPERATIONS AFTER HEAT TREATMENT; ELIMINATE JIG BORER POSITION; SELL JIG BORER)
MD	-1470	785	665	Managing Director
ROPG	-782	430	141	REDUCE BOTTLENECK IN OPG
ELOP	-759	271	89	ELIMINATE OPERATIONS
CFPG	-220	5	4	
SM	-146	5	2	
EM	-145	4	5	
ALO*	-96	12	4	
SHOW	-93	1	1	
CD	-61	1	1	
REDM	7	0	0	
RPGR	21	0	0	
FD	32	0	0	
MM	71	5	3	
ZZ 1	107	3	1	
EXPR	411	128	26	
TD	471	148	102	Technical Director
ZZ 4	657	377	100	(SELECT PEOPLE FOR CNC TRAINING AND OPERATION; MACHINE MORE SPARES)
ZZ 3	715	128	39	
CDZN	716	57	79	
QM	755	245	132	Quality Assurance Manager
TRAI	931	315	133	TRAIN PEOPLE
TM	1088	84	91	
			1000	

Table 5.17. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III differentiates between the Managing Director on one side and the Quality Manager and the Technical Director on the other. It opposes accounts that describe the **adaptation of the production systems to CNC operation** at the negative end of the factor to accounts that stress the **adaptation of people to CNC operation** and, more generally improving the reliability of the system (training, having spare tools) at the positive end of the factor.

Although these last concerns are shared by a number of people it is in the Quality Manager's production where they appear as more central. He is therefore better represented by this factor than the Technical Director. This suggests that even if he is not directly involved in tool making and CNC use, nor for that matter in any aspect of direct production, he has a word to say concerning those aspects of the management of operations which concern more clearly (in his view) the quality of the final product.

Factor IV: Innovative practices in tool manufacturing X Innovative practices Company wide.

Item	4#F	Cos2	CTF	Percentage explained = 10%
ZZ 1	-1187	429	162	(LOOK FOR OTHER IMPROVEMENTS IN TECHNOLOGY; RETAIN OPG GRINDERS;INCREASED PROFITS WERE SHARED)
CFPG	-1035	119	123	LESS CONTROL FROM ENGINEERING DEPARTMENT OVER TOOL PRODUCTION
MM	-638	434	329	Toolroom Machining Manager
EXPR	-587	261	79	DEVELOP NEW MACHINING
ROPG	-575	233	114	REDUCE BOTTLENECK IN OPG
EM	-557	61	107	
FD	-467	24	25	
ZZ 4	-260	59	23	
RPGR	-251	17	22	
TD	6	0	0	
ZZ 3	12	0	0	
REDM	57	2	1	
TRAI	203	15	9	
QM	212	19	16	
ELOP	254	30	15	
MD	267	26	33	
ALO*	399	203	110	RUN MACHINE UNATTENDED
ZZ 2	496	38	28	
CD	700	178	226	Commercial Director
CDZN	712	56	117	SIMPLIFY TOOL DESIGN
SM	742	138	63	Production Services Manager
SHOW	1301	260	195	SHOW CNC MACHINE TO CUSTOMERS
TM	1323	125	201	Toolroom Manager

Table 5.17. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV differentiates between the Toolroom Machining Manager on one side, the Commercial Director and the Toolroom Manager on the other. This differentiation is based on accounts of innovative practices introduced in the Company because of CNC introduction. At the negative end of the factor are grouped accounts of **innovative practices in tool manufacturing**; at the positive end one finds a mix of **innovative practices at different levels**.

D. Second Level Analysis.

The following matrix represents the actors' positions in the factors extracted in the first level analysis.

ACTOR	TD	MD	TM	QM	SM	CD	FD	MM	EM	FACTORIAL LABELS
NTHEMES	4	5	4	2	1	5	3	4	5	
A1-	0	0	1	0	0	0	0	0	1	CHANGES IN CONTROL OVER TOOL PRODUCTION
A2+	0	0	0	0	0	1	1	0	0	CHANGES IN COMMERCIAL PROFILE
A3+	1	0	0	1	0	0	0	0	0	ADAPTATION OF PEOPLE TO CNC OPERATION
A3-	0	1	0	0	0	0	0	0	0	ADAPTATION OF PRODUCTION SYSTEM TO CNC
A4+	0	0	1	0	1	1	0	0	0	DEVELOPMENT OF INNOVATIVE PRACTICES COMPANY WIDE
C2+	0	1	0	0	0	1	0	0	0	GLOBAL RELEVANCE
C4+	0	1	0	0	0	0	0	1	0	TECHNOLOGICALLY ADVANCED MACHINE
C4-	0	0	0	1	0	1	0	0	0	ACCURATE MACHINE
O1+	1	1	0	0	0	0	0	1	1	IMPROVE COMPETITIVE POSITION
O2+	1	0	0	0	0	0	1	0	0	IMPROVE WORKPLACE RELATIONS
O3+	0	0	0	0	0	0	1	0	1	CONCERN WITH GOOD MANAGEMENT
O3-	0	0	1	0	0	0	0	1	0	CONCERN WITH GOOD ENGINEERING
O4-	0	0	1	0	0	0	0	0	0	INCREASE TOOLROOM PERFORMANCE
ZZ 1	0	0	0	0	0	0	0	0	1	[RESTRICTED RELEVANCE (C2-); IMPROVE LOCALIZED ASPECTS OF COMPANY PERFORMANCE (O5-)]
ZZ 2	0	0	0	0	0	0	0	1	0	[ENABLES CONTINUITY (C3+); INCREASE GENERAL PERFORMANCE (O4+); DEVELOPMENT OF INNOVATIVE PRACTICES IN TOOL MANUFACTURING (A4-)]
ZZ 3	0	0	0	0	0	1	0	0	0	[EFFECTIVENESS (C1-); IMPROVE GENERAL ASPECTS OF COMPANY PERFORMANCE (O5+)
ZZ 4	0	1	0	0	0	0	0	0	1	[ENABLES CHANGES AT DIFFERENT LEVELS (C3-); IMPROVE CUSTOMER SERVICE]
ZZ 5	1	0	0	0	0	0	0	0	0	[COST-EFFECTIVENESS (C1+); CHANGES AT OPERATIONAL LEVEL (A2-)]

Table 5.18. Actor's factorial positions in first level analysis

Factor analysis extracted the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	.74594	20.115	20.115
II	.69605	18.770	38.885
III	.57913	15.617	54.502
IV	.55325	14.919	69.421
V	.42598	11.487	80.908
VI	.33144	8.938	89.846
VII	.21762	5.868	95.715
VIII	.15891	4.285	100.000

Table 5.19. Factors extracted (Second level analysis).

Interpretation of factors

Factor I: Technical approach X Social approach.

Item	1#F	Cos2	CTF	% explained = 20%
ZZ 2	-1188	195	57	
O3-	-1129	408	104	CONCERN WITH GOOD ENGINEERING
O4-	-1070	158	46	
MM	**-1026**	**289**	**171**	**Toolroom Machining Manager**
TM	**-924**	**224**	**139**	**Toolroom Manager**
C4+	-918	311	68	TECHNOLOGICALLY ADVANCED MACHINE
A1-	-820	248	55	CHANGES IN CONTROL OVER TOOL PRODUCTION
A3-	-648	75	17	
ZZ 4	-609	161	30	
ZZ 1	-570	58	13	
MD	**-560**	**119**	**64**	
EM	**-492**	**92**	**49**	
O1+	-309	112	16	
SM	**-201**	**4**	**2**	
A4+	-174	7	4	
C2+	67	2	0	
O3+	183	10	3	
CD	**675**	**166**	**93**	
ZZ 3	781	109	25	
FD	**808**	**145**	**80**	
A2+	858	217	60	CHANGES IN COMMERCIAL PROFILE
TD	**1009**	**280**	**166**	**Technical Director**
O2+	1052	290	90	IMPROVE WORKPLACE RELATIONS
ZZ 5	1169	188	55	
C4-	1382	400	155	ACCURATE MACHINE
A3+	1575	478	202	ADAPTATION OF PEOPLE TO CNC OPERATION
QM	**1712**	**404**	**238**	**Quality Assurance Manager**

Table 5.20. Factorial Coordinates, Chi-square explained and contributions to Factor I (Second level analysis).

Factor I helps identify what might be called the operational/technical discourse: the machine is described by reference to its intrinsic characteristics, as a technologically advanced machine, good engineering appears as a value in itself, not a means to an end, and the account of changes brought by the CNC machine stresses the reduction of control from the engineering department over tool manufacturing. A possible explanation for this is that as the CNC machine made the design of tools less complex, there was a change in which actors became more relevant. Presumably, the engineering department played a central role before the machine was introduced because they had the skills needed to deal with the complexity of the tool. As this complexity decreased, or was dealt with by the machine, their skill in this area, based on the existing technology, became less critical. At the same time people in the engineering department did not become familiar with the CNC machine because it was assigned to the toolroom. This enabled a different discourse, located in the toolroom, to assert itself.

It is not surprising therefore that this discourse is so technically oriented. It was the capabilities of the new machine that enabled the new discourse to take shape in this way.

TECHNICAL APPROACH	FACTOR I	SOCIAL APPROACH
TOOLROOM MACHINING MANAGER TOOLROOM MANAGER		QUALITY ASSURANCE MANAGER TECHNICAL DIRECTOR
CNC MACHINE IS: - a technologically advanced machine		CNC MACHINE IS: - an accurate machine
GUIDELINES IN THEIR INTRODUCTION: - Concerns with good engineering		GUIDELINES IN THEIR INTRODUCTION: - Improve workplace relations
WITH THEIR INTRODUCTION: -there were changes in control over too production and quality		WITH THEIR INTRODUCTION: - People had to be adapted to CNC operation - There were changes in the Company's commercial profile

Fig. 5.2. Second Level Analysis - Factor I.

At the other end of this factor one finds a different discourse, more concerned with people and the Company performance. The machine is described as a good tool to achieve results through people. Hence, a focus on workplace relations and the adaptation of people to CNC. It is interesting to find the Quality Assurance Manager at this end of the factor. A possible interpretation is that because he is not directly involved in operational matters, he can look in a more detached way to the conditions that enable quality, including technological and social dimensions. The factor can thus be described as opposing a technical to a social approach in the understanding of the CNC machine.

Factor II: Internal reference X External reference.

Item	2#F	Cos2	CTF	Percentage
SM	**-2032**	**413**	**180**	**Production Services Manager**
A4+	-1695	666	375	DEVELOPMENT OF INNOVATIVE PRACTICES COMPANY WIDE
O4-	-1393	268	85	INCREASE TOOLROOM PERFORMANCE
ZZ 3	-1257	282	69	[COST-EFFECTIVENESS (C1+); IMPROVE GENERAL ASPECTS OF COMPANY PERFORMANCE (O5+)]
TM	**-1162**	**354**	**235**	**Toolroom Manager**
CD	**-1049**	**401**	**239**	**Commercial Director**
C4-	-741	115	48	
A2+	-427	54	16	
O3-	-419	56	15	
A1-	-372	51	12	
C2+	-255	28	6	
QM	**-187**	**5**	**3**	
FD	**336**	**25**	**15**	
A3+	428	35	16	
MM	**463**	**59**	**37**	
O3+	526	82	24	
EM	**542**	**112**	**64**	
ZZ 2	555	43	13	
MD	**624**	**148**	**85**	Managing Director
ZZ 1	650	75	18	
C4+	651	156	37	TECHNOLOGICALLY ADVANCED MACHINE
ZZ 4	699	212	43	[ENABLES CHANGES AT DIFFERENT LEVELS (C3-); IMPROVE CUSTOMER SERVICE (O2-)]
O2+	742	144	48	
A3-	747	100	24	
O1+	758	672	100	IMPROVE COMPETITIVE POSITION
TD	**902**	**223**	**142**	**Technical Director**
ZZ 5	1081	161	51	

Table 5.21. Factorial Coordinates, Chi-square explained and contributions to Factor II (Second level analysis).

Factor II describes another kind of differentiation in the form CNC machine is made sense of. At the positive end of the factor one finds three actors sharing one label: "Development of innovative practices Company wide". Other labels are also present, if less well represented: the CNC machine is described as cost-effective, and the guidelines in its implementation have to do with improving general aspects of Company performance as well as the toolroom performance in particular. This discourse uses as its main referent internal aspects of the organization which are said to have changed with the introduction of the CNC machine.

INTERNAL REFERENCE	FACTOR II	EXTERNAL REFERENCE
PRODUCTION SERVICES MANAGER COMMERCIAL DIRECTOR TOOLROOM MANAGER		TECHNICAL DIRECTOR MANAGING DIRECTOR
CNC MACHINE is: - cost-effective		CNC MACHINE: - enables changes at different levels - is a technologically advanced machine
GUIDELINES IN THEIR INTRODUCTION: - increase toolroom performance - improve general aspects of Co. performance		GUIDELINES IN THEIR INTRODUCTION: - improve customer service - improve competitive position
WITH THEIR INTRODUCTION: - innovative practices were developed Company wide		

Fig. 5.3. Second Level Analysis - Factor II.

At the other end of the factor one finds an "outward looking" kind of view, shared by the Managing Director and the Technical Director. This view defines the machine as technologically advanced and is concerned mainly with the Company's competitive position and its relationship with customers.

Both these discourse differentiations are what one would expect from these actors, given their formal role definitions, except for the Commercial Director. He would be expected to be more "outward looking", given his position. Analyzing his production, he seems to be focused on the Company's cost structure and this brings him close to the operational level in his process of making sense of the situation created by the CNC machine introduction.

Factor III: Potential conflict approach X Consensus approach.

Item	3#F	Cos2	CTF	Percentage explained = 16%
ZZ 2	-1192	196	74	[ENABLES CONTINUITY (C3+); INCREASE GENERAL PERFORMANCE (O4+); DEVELOPMENT OF INNOVATIVE PRACTICES IN TOOL MANUFACTURING (A4-)]
QM	**-1093**	**165**	**125**	**Quality Assurance Manager**
C4+	-1013	378	107	TECHNOLOGICALLY ADVANCED MACHINE
MM	**-907**	**226**	**172**	**Toolroom Machining Manager**
C4-	-899	169	84	ACCURATE MACHINE
A3-	-834	124	36	
A3+	-765	113	61	
MD	**-634**	**153**	**105**	
C2+	-597	155	37	
ZZ 3	-361	23	7	
O3-	-353	40	13	
CD	**-275**	**28**	**20**	
O1+	-204	49	9	
ZZ 5	-94	1	0	
TD	**-71**	**1**	**1**	
A4+	99	2	2	
SM	**130**	**2**	**1**	
ZZ 4	234	24	6	
TM	**371**	**36**	**29**	
O4-	487	33	12	
A2+	712	149	53	
O2+	846	188	75	IMPROVE WORKPLACE RELATIONS
A1-	895	295	84	CHANGES IN CONTROL OVER TOOL PRODUCTION
EM	**991**	**374**	**257**	Production Engineering Manager
ZZ 1	1302	303	89	[RESTRICTED RELEVANCE (C2-); IMPROVE LOCALIZED ASPECTS OF COMPANY PERFORMANCE (O5-)]
FD	**1359**	**410**	**290**	**Financial Director**
O3+	1544	701	249	CONCERN WITH GOOD MANAGEMENT

Table 5.22. Factorial Coordinates, Chi-square explained and contributions to Factor III (Second level analysis).

The negative side of this factor identifies a discourse which defines the CNC machine both as an accurate machine and a technologically advanced machine (whereas in Factor I these two labels were separated) which does not trigger significant changes in the way the Company operates. The guidelines in their introduction are defined as increasing general performance and the account of its introduction describes the development of innovative techniques in tool manufacturing. This discourse looks at the process of CNC introduction as essentially circumscribed to the toolroom. The processes of change identified are not seen as a break with past practices but rather as a continuation of existing organizational logics. Interesting enough is the fact that the direct user of the CNC machine (the Toolroom Machining Manager) is found very close to this discourse. This suggests that direct interaction with the technological novelty is not in itself enough to the reconsideration of existing practices. Indeed the opposite may be true, the proximity to the technology may hide the wider range of possible courses of action it may open. Comparing this end of the factor to the opposite end helps understand the nature of the differentiation established in this factor.

POTENTIAL CONFLICT APPROACH (FACTOR III)	CONSENSUS APPROACH
TOOLROOM MACHINING MANAGER QUALITY ASSURANCE MANAGER	FINANCIAL DIRECTOR PRODUCTION ENGINEERING MANAGER
CNC MACHINE: - is a technologically advanced machine - is an accurate machine - enables continuity	CNC MACHINE - is of restricted relevance
GUIDELINES IN THEIR INTRODUCTION: - Increase general performance	GUIDELINES IN THEIR INTRODUCTION: - Concern with good management - Improve localized aspects of Company performance - Improve workplace relations
WITH THEIR INTRODUCTION: - Innovative practices in tool manufacturing Were developed	WITH THEIR INTRODUCTION: - There were changes in control over tool manufacturing

Fig. 5.4. Second Level Analysis - Factor III.

At the positive end, the machine is described as being mostly relevant to the toolroom. The guidelines for implementation concern improvements in localized aspects of Company performance, a special attention given to workplace relations and a concern with good management. Changes identified have to do with the alterations in the actors who are relevant in the control of tool production.

Comparing the two discourses, we find that what differentiates them essentially is wether or not attention is given to potential conflicts, and to the scope of possible negotiations. At the negative side, no awareness of these dimensions is present. The factor thus opposes a view of implementation where no awareness of potential conflict is present to a view where this awareness and the need for consensus are expressed.

Factor IV: Strategic possibilities X Details of implementation.

Item	4#F	Cos2	CTF	Percentage explained = 15%
A3-	-1262	284	87	ADAPTATION OF PRODUCTION SYSTEM TO CNC
C2+	-1218	645	162	GLOBAL RELEVANCE
ZZ 3	-1174	246	75	[COST-EFFECTIVENESS (C1+); IMPROVE GENERAL ASPECTS OF COMPANY PERFORMANCE (O5+)
MD	**-939**	**335**	**241**	Managing Director
CD	**-873**	**278**	**209**	Commercial Director
A2+	-799	188	70	CHANGES IN COMMERCIAL PROFILE
ZZ 4	-784	267	67	[ENABLES CHANGES AT DIFFERENT LEVELS (C3-); IMPROVE CUSTOMER SERVICE (O2-)]
O3+	-366	39	15	
C4+	-324	39	12	
FD	**-316**	**22**	**16**	
ZZ 1	-307	17	5	
EM	**-228**	**20**	**14**	
C4-	-186	7	4	
O1+	97	11	2	
A4+	129	4	3	
SM	**174**	**3**	**2**	
MM	**456**	**57**	**46**	
O2+	460	56	23	
A1-	511	96	29	
QM	**597**	**49**	**39**	
ZZ 2	614	52	21	
O3-	971	302	103	CONCERN WITH GOOD ENGINEERING
TM	**988**	**256**	**214**	**Toolroom Manager**
TD	**1000**	**275**	**219**	**Technical Director**
A3+	1074	222	126	ADAPTATION OF PEOPLE TO CNC OPERATION
O4-	1328	243	97	INCREASE TOOLROOM PERFORMANCE
ZZ 5	1345	249	99	[EFFECTIVENESS (C1-); CHANGES AT OPERATIONAL LEVEL (A2-)]

Table 5.23. Factorial Coordinates, Chi-square explained and contributions to Factor IV (Second level analysis).

Factor IV helps identify two other types of discourse. At its negative end, the CNC machine is described as having global relevance, as cost-effective and as enabling changes at different levels. The guidelines in its implementation have to do with improving customer service and general aspects of Company performance. The effects of its introduction were that the production system had to be adapted to CNC use and a change in the Company's commercial profile: both in terms of its cost structure and in the Company image as user of new technology. This is the "strategic discourse" being put forward by the Managing Director and the Commercial Director in the sense that it describes the innovation episode as an opportunity for wide ranging changes to take place, as a means to improve the Company's position.

STRATEGIC POSSIBILITIES	TOR IV DETAILS OF IMPLEMENTATION
MANAGING DIRECTOR COMMERCIAL DIRECTOR	TECHNICAL DIRECTOR TOOLROOM MANAGER
CNC MACHINE: - is of global relevance - is cost-effective - enables changes at different levels	CNC MACHINES: - effective
GUIDELINES IN THEIR INTRODUCTION: - improve customer service - improve general aspects of Company performance	GUIDELINES IN THEIR INTRODUCTION: - concern with good engineering - increase toolroom performance
WITH THEIR INTRODUCTION: - production system had to be adapted to CNC use - there were changes in Company's commercial profile	WITH THEIR INTRODUCTION: - there were changes at operational level - people had to adapt to CNC operation

Fig. 5.5. Second Level Analysis - Factor IV.

The Technical Director and the Toolroom Manager put forward a very different discourse, more focused on the fine details of machine implementation and use: the machine is described as effective, concerns with good engineering and toolroom performance were the guidelines for implementation and the changes described have to do with the operational level, with the adaptation of people to CNC use.

5.5. Discussion of Discourse Structure Analysis.

The central core of cryptic labels is constituted in this Company by one characteristic of the machine, "Controlled by programme", and one decision, "Run CNC machine alone", which are evoked by the majority of actors (See Figure. 5.6.) It is not hard to see how these two central themes come together as a perspective for action: the machine is controlled by computer, therefore it can be operated without human intervention. This seems to be the somewhat "hidden agenda" in CNC implementation. It corresponds clearly to the Managing Director's objectives of automating as much as possible, visible in his involvement in the fully automatic line for the fabrication of computer disk shutters and hub rings.

Around this core, appear the largest discourse differentiation, identified by the first factor, which is based on a technical versus social opposition in the approach to the CNC machine. As we have just seen, this factor is defined essentially by the productions of the Toolroom Machining Manager and the Toolroom Manager, on the "Technical" side, and the Technical Director and Quality Assurance Manager, on the "Social" side.

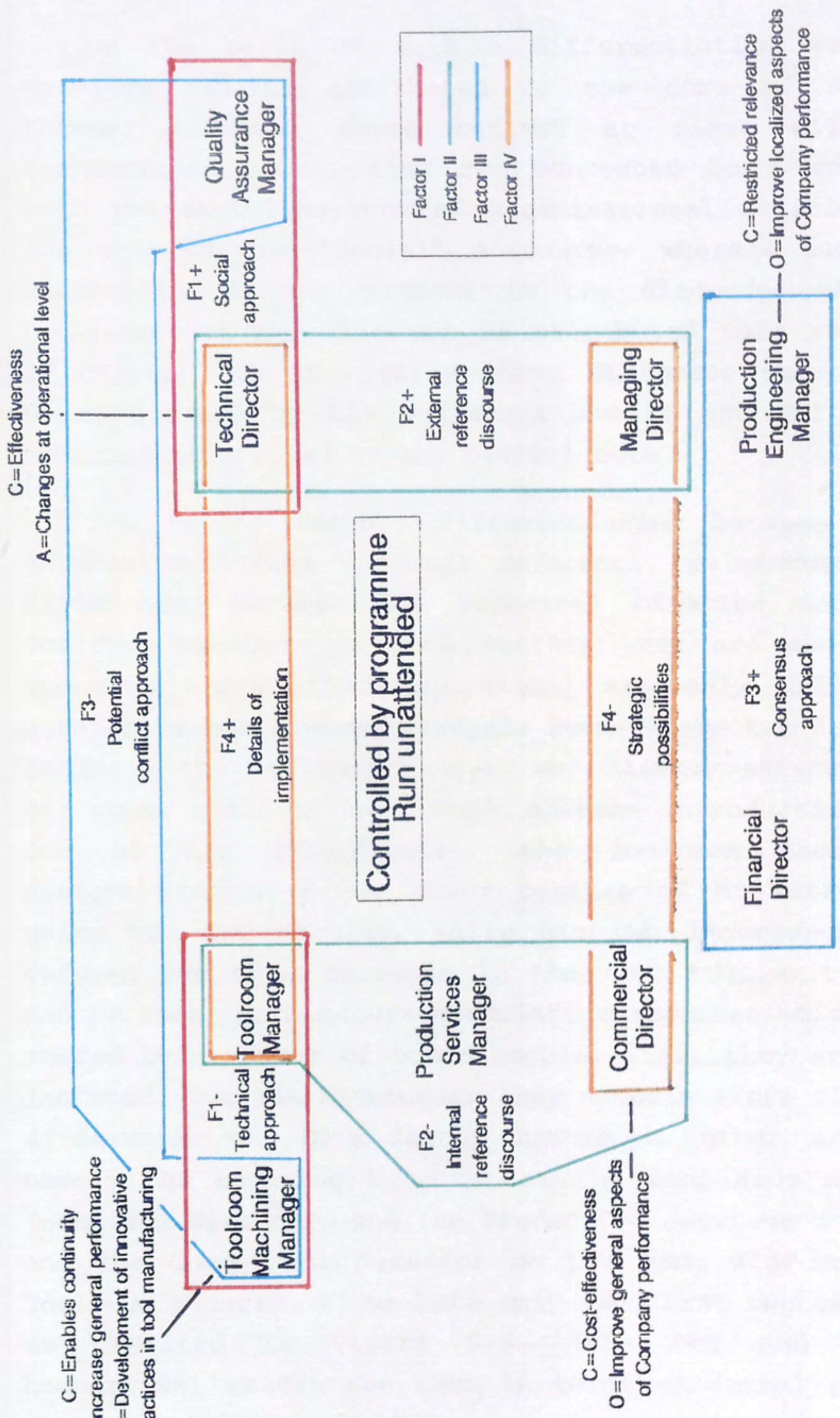

Fig. 5.6. Structure of discourses in Company 2

On the basis of such a differentiation several meanings can be attributed to the core of shared themes: although these reflect at first sight a technocratic slant, they are connected to a concern with the social aspects of organizational activity in the case of the "Social" discourse, whereas such an elaboration is not present in the discourse of the toolroom members. This can be attributed to a variety of causes, but it clearly shows different strategies being pursued by the different actors and different meanings attributed to the central core.

The second factor, differentiating between more external and more internal referents, reinforces the differences between the Technical Director and the Toolroom Manager: in both factors they are shown in opposite sides. This may signal not only different strategies but a power struggle between the two actors. In fact, the Toolroom Manager was clearly affected in his power position by the CNC machine introduction, as one of his subordinates, the Toolroom Machining Manager, became a key actor because of his skill in using the CNC machine, while his own importance was reduced due to a decrease in the tool complexity. As can be seen, both actors enunciate discourses which are shared by a number of other people, i.e., they are not isolated, but the discourses they enunciate are clearly differentiated. This factor brings in other actors, namely the Managing Director on the same side as the Technical Director, and the Production Services Manager and the Commercial Director on the same side as the Toolroom Manager. If we take only the first two factors as depicted in Figure 5.6. (the red and green boundaries) we can see that in terms of formal power, the "Social/External" discourses are much better served than the "Technical/Internal" discourses. This is not to say that the actors have more or less power, though. As we go on integrating other factors in this discussion, we can see that other links are defined, on the bases of other discourses.

With the third factor the Quality Assurance Manager and the Toolroom Machining Manager, who were on opposite sides in the first factor, appear together voicing the same type of approach to the CNC machine, which was labelled as potentially conflictual. Factor III thus describes a first bridge between the discourses identified by the two first factors. It also brings in two other actors, the Financial Director and the Production Engineering Manager, whose "Consensus" approach appears somewhat isolated in Figure 5.6. only because not all the factors are represented.

Finally, in the fourth factor, the Technical Director and the Toolroom Manager who were clearly differentiated in the first two factors, appear connected in their emphasis on the detailed description of the CNC machine implementation. This may be interpreted as they coming together in the way they refer to the CNC machine implementation. This similarity may reflect the fact that these details of implementation were not the object of a power struggle in themselves. This similarity between two actors who were clearly differentiated elsewhere may be taken, speculatively, as showing that some issues are not legitimate objects of disagreement in this Company, by reason of cultural assumptions or other political processes not revealed by this analysis. The Managing Director and the Commercial Director, who were separated in the second factor also appear closer in this factor, sharing the perception of the strategic possibilities of the CNC machine and establishing yet another link between actors who were apart in the first two factors.

In what concerns the individual clusters of discourses in this case, they reflect the re-definition of issues which are part of each role. In the case of the Technical Director his cluster reflects a clear definition of his role: to introduce a cost-efficient machine and take care of all the details of implementing this new technology at the operational level. This definition is not unexpected, given that the Technical Director came back to the Company in order to implement those changes. Yet, he needs to define his role in order to carry out those changes and his individual cluster reflects that concern.

The Toolroom Machining Manager's individual cluster also describes the machine as enabling the continuation of existing practices in production, only more efficiently. The key to his role re-definition is given by the possibility of developing innovative practices in tool manufacturing. This is clearly how he sees his relevance to the Company, the importance of his role, and the cluster reflects this position.

The Production Engineering Manager's cluster seems to define his role along more defensive lines, by describing the machine as something of restricted relevance and whose effects are to be felt essentially in the toolroom. This may reflect his strategy of not being involved in the conflict between the Technical Director and the Toolroom Manager, defining his role as essentially a user of the products of the toolroom.

The Commercial Director's cluster is not as easy to interpret, in that his position in the whole process of implementation was apparently a minor one. However, his concerns with the effectiveness of the machine and with improving general aspects of Company effectiveness seem signal that he his attuned with the effort of innovating at the technological level, which may be relevant in other power processes not directly linked with the implementation of the CNC machine.

In summary, the image of Company 2 thus obtained shows how the different discourse differentiations are interwoven in a structure that, although expected to be dynamically changing, is very specific to this organization. Once again we find that this structure is not reducible to other dimensions, such as formal power, status or the formal organizational roles.

CHAPTER 6:
COMPANY 3

6.1. Brief description of Company 3.

Company 3 is a small Company located in the industrial area of a small town, near Birmingham, in the West Midlands. It produces submersible pumps, ranging from 6 to 26 inches., for use in water works, and petrol rigs (namely in the North Sea). This Company was the United Kingdom subsidiary of a German pump manufacturer, which was subsequently purchased by the Pump Division of a large American company. At the time of the study, the American company was reorganizing Company 3 and two other British pump manufacturers as its UK-based division, as a means to maintain a foothold in the European market for 1992. The three Companies had overlapping areas of activity and were being reorganized in order to deal separately with different segments of the market for pumps. Company 3 was to take charge of the offshore, water and waste treatment market, which had been its area of experience before these changes in ownership.

According to the Managing Director, such reorganization, as far as Company 3 was concerned, involved essentially the development of the ability to manufacture all the pumps components in addition to the assembly and installation of pumps, which was its traditional mode of operating. As we will see in the analysis of discourse, this was one of the main facts contributing to the sense-making process concerning the CNC machines.

The Company employed at the time of the study some 130 people, of which 70 in direct production, including people in the installation of pumps, and 50 in administrative, sales, after-sales, and design activities. The management structure was fairly flat, with the heads of different departments all reporting directly to the Managing Director.

Until the reorganization started, pumps were produced on the basis of designs provided by the parent Company in Germany. The goal of developing the manufacturing ability in this Company involved the acquisition of this know-how from the German company, which was being made at the time of the study.

6.2. Process of innovation.

The CNC machines included four lathes and one jig-borer. They were used to turn and bore castings which were bought from a foundry not belonging to the Company, and then turned to the shapes and tolerances required. No special emphasis was put by anyone interviewed as to the levels of accuracy to which these components were to be machined.

The first CNC machine had been purchased eight years ago, at a bargain price from a Company nearby which went out of business. This probably explains why no special emphasis was put in the pay-back period of this machine. When it was introduced, no one from the machine shop was very keen on learning how to use it. The explanation provided by the Works Foreman was that the workforce was middle age and afraid of novelty. However, in subsequent interviews with people from the machine shop it emerged that the issue must have been fairly controversial because of fears that the introduction of the machine would entail lay-offs among machinists. In the end, the machine was operated by the

Setter-Operator, who had no experience in machining but in welding. The Works Foreman justified this option saying that he had a computer at home, so it seemed a reasonable choice. The arrangement seemed to have worked mainly because having no experience in machining, the CNC operator was dependent upon machine shop skills for anything above the simplest tasks. In this way, the introduction of the CNC machine was defined as a minor event, and this may have served to attenuate fears in the machine shop that their skills and jobs would be taken over by a machine. Another reason for this dismissal of the CNC machines as not very important, was that the components machined in the machine shop were, according to the Head of Machine Shop, much more complex and expensive than the batches machined in the CNC machines. As we will see in the interviews, CNC machines are still very much played down and described as not threatening, although other contributions suggest that this is not the whole story.

Three years before the study, a second CNC machine was purchased and at the time of the study the fourth CNC machine had just been installed. Significantly, none of the CNC machines were located in the machine shop, where there existed however other lathes and borers. They were installed in a large pavilion, where assembly of larger pumps took place, as well as their testing, which was done in a large water tank. The CNC machine Setter-Operator did not appear to resent this segregation, although he was doubtless aware of it. He set the machines on the basis of a set of basic component programmes, which he modified as needed, on the basis of the drawings coming from the drawing office.

6.3. The actors.

The Works Foreman (**WF**) was the first person contacted, and the first to be interviewed. He reported to the Technical Director, and was responsible for coordinating the manufacturing side of the Company, including the machine shop and assembly, as well as testing and packaging. He defined his work, in essence, as making sure orders were completed in time.

The Head of Machine Shop (**HM**) was responsible for all the machining, and coordinated a group of 6 machinists in the machine shop. He stressed the levels of skill in their job and how work on CNC machines was not nearly as important as the work in the machine shop.

The CNC Setter-Operator (**SO**) had come from assembly and was previously a welder. He tended to present what he did as not very important and the improvements brought by the CNC machine as not dramatic. However unfamiliar with machining he could have been, he was quite relaxed about it, in the interview, speaking with certainty about his job and about the machines he used. He clearly did not want any hassles with the machine shop. He was in charge of one trainee, who was the second person operating the CNC machines.

The Managing Director (**MD**) and the Technical Director (**TD**) seemed to have a good working relationship and some overlapping of attributions, to the point of the Works Foreman reporting to one or the other, more or less indifferently. The Managing Director had been 13 years with the Company, the last 9.5 years as Managing Director.

The structure of Company 3, according to the Works Foreman, is depicted in Figure 6.1.

```
                        +----------------+            +---------+
                        |Managing Director+-----------+ Company |
                        +--------+-------+            |Secretary|
      +- ----------+-----------------+                +---------+
      |            |            +---------+--------+
      |            |            |Technical Director|
      |            |            +---------+--------+
      |            |                 +----+----+
  +---+------+  +-+-+-+       +---+---+    +---+---+
  |  Head    |  |Head |       | Works |    | Head  |
  |   of     |  | of  |       |Foreman|    |  of   |
  |Contracts |  |Sales|       +---+---+    |Design |
  +----------+  +-----+           |        +-------+
                            +-----+------+
                            | Head of    |
                            |Machine Shop|
                            +-----+------+
                          +-------+--------+
                          |Setter-Operator |
                          +----------------+
```

Fig. 6.1. Company 3 - Management Structure

6.4. Discourse Structure Analysis.

A. Characteristics.

The distribution of Characteristics is summarized in the following table.

Actors	WF	SO	TD	MD	HM	MEANING
NThemes	3	2	1	1	2	
OLAK	0	0	0	1	0	OVERCOMES LACK OF SKILLED WORKERS
INPL	0	0	1	0	0	COPES POORLY W/ VARIATIONS IN INPUTS
UNPR	0	1	0	0	0	UNPREDICTABLE
SPEE	1	0	0	0	1	SPEED
MAIN	1	1	0	0	0	MAINTENANCE DIFFICULT
ZZ 1	0	0	0	0	1	(ACCURACY; CONTROLLED BY COMPUTER; GIVES FALSE SENSE OF SECURITY; PROGRAMMABLE OFF-LINE; CAN REPLACE PEOPLE; OPTIMAL BATCH SIZE; PRODUCES MORE SCRAP)
ZZ 2	1	0	0	0	0	(COST OF REPAIRS; COST/TIME TO RESET)

Table 6.1. Distribution of Characteristics.

The analysis of this matrix yielded the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	1.00000	31.579	31.579
II	1.00000	31.579	63.158
III	.75000	23.684	86.842
IV	.41667	13.158	100.000

Table 6.2. Factors extracted: Characteristics.

Interpretation of factors

Factor I: CNC machine overcomes lack of skilled workers.

Item	1#F	Cos2	CTF	Percentage explained = 31.6%
ZZ 1	0	0	0	
INPL	0	0	0	
UNPR	0	0	0	
ZZ 2	0	0	0	
SPEE	0	0	0	
MAIN	0	0	0	
WF	**0**	**0**	**0**	
SO	**0**	**0**	**0**	
TD	0	0	0	
HM	**0**	**0**	**0**	
OLAK	3000	1125	1000	OVERCOMES LACK OF SKILLED WORKERS
MD	**3000**	**1125**	**1000**	**Managing Director**

Table 6.3. Factorial Coordinates, Chi-square explained and contributions to Factor I

Factor I isolates the Managing Director's production. The only characteristic he evokes is the CNC ability to overcome the lack of skilled workers. This, logically gives the label to this factor. This description of the machine is clearly in line with the Managing Director's concerns regarding the creation of a manufacturing plant, instead of just an assembling plant. His production in what concerns characteristics is isolated. If one takes the ability to influence others' discourse as an important means of political action, this pattern suggests the existence of a problem in the Managing Director's ability to achieve his goals.

Factor II: CNC machine copes poorly with variances in inputs.

Item	2#F	Cos2	CTF	Percentage explained = 31.6%
INPL	-3000	1125	1000	COPES POORLY W/ VARIATIONS IN INPUTS
TD	**-3000**	**1125**	**1000**	**Technical Director**
ZZ 1	0	0	0	
OLAK	0	0	0	
UNPR	0	0	0	
ZZ 2	0	0	0	
SPEE	0	0	0	
MAIN	0	0	0	
WF	**0**	**0**	**0**	
SO	**0**	**0**	**0**	
MD	**0**	**0**	**0**	
HM	**0**	**0**	**0**	

Table 6.4. Factorial Coordinates, Chi-square explained and contributions to Factor II.

The same can be said of the Technical Director. The characteristic he evokes concerns the tolerances within which the castings must fall if they are to be machined in the NC lathe. It is remarkable that the Managing Director's and the Toolroom Director's production appear so isolated and scarce. Together, they account for more than half the matrix chi-square, i.e., for the differences in descriptions of the machine. This may signal some lack of familiarity with or awareness of the problems and processes at the operational level, which are critical in the project of turning this plant into a manufacturing plant.

Factor III: Problematic to Integrate in Production Process X Difficult to Operate.

Item	3#F	Cos2	CTF	
ZZ 1	-1500	643	333	(ACCURACY; CONTROLLED BY COMPUTER; GIVES FALSE SENSE OF SECURITY; PROGRAMMABLE OFF-LINE; CAN REPLACE PEOPLE; OPTIMAL BATCH SIZE; PRODUCES MORE SCRAP)
HM	**-1299**	**711**	**500**	**Head of Machine Shop**
SPEE	-750	643	167	SPEED
OLAK	0	0	0	
INPL	0	0	0	
ZZ 2	0	0	0	
WF	**0**	**0**	**0**	
TD	**0**	**0**	**0**	
MD	**0**	**0**	**0**	
MAIN	750	643	167	MAINTENANCE DIFFICULT
SO	**1299**	**711**	**500**	**Setter-Operator**
UNPR	1500	643	333	UNPREDICTABLE

Table 6.5. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III distinguishes between the production of the Head of Machine and the Setter-Operator. The Head of Machine Shop evokes a cluster of characteristics which can be divided into objective descriptions of the machine (Accuracy; Controlled by computer; Programmable off-line; Speed; and Optimal batch size) and more evaluative descriptions of the machine (Gives false sense of security; Can replace people; produces more scrap).

The Setter-Operator evokes characteristics that describe the machine as difficult to operate: its unpredictability and the difficulties in its maintenance. The factor can thus be seen as differentiating a description of the machine as problematic to operate from its description as a novelty which is problematic to integrate in the production process.

We may consider this distinction against the actors' roles in the Company and against the process of introduction. The way the Head of Machine Shop describes the machine is consistent with the threat to jobs it may have presented at the time of introduction to the people in the machine shop, a threat which did not become real. Still, the resistance to its introduction was apparent in the location of the machine and in the fact that nobody from the machine shop came forward to learn how to use it. The Setter-Operator's production possibly reflects a social consensus about his lack of experience and skill, which is probably overestimated, and the fact that he had to learn by himself how to use the machine. It also tends to present the machine in a non-threatening way, more of a headache than a great help.

Factor IV: Complex/threatening Machine X Costly Machine.

Item	4#F	Cos2	CTF	
ZZ 1	-982	276	257	(ACCURACY; CONTROLLED BY COMPUTER; GIVES FALSE SENSE OF SECURITY; PROGRAMMABLE OFF-LINE; CAN REPLACE PEOPLE; OPTIMAL BATCH SIZE; PRODUCES MORE SCRAP)
UNPR	-982	276	257	UNPREDICTABLE
SO	**-634**	**169**	**214**	**Setter-Operator**
HM	**-634**	**169**	**214**	**Head of Machine Shop**
OLAK	0	0	0	
INPL	0	0	0	
TD	**0**	**0**	**0**	
MD	**0**	**0**	**0**	
SPEE	164	31	14	
MAIN	164	31	14	
WF	**845**	**714**	**571**	**Works Foreman**
ZZ 2	1309	857	457	(COST OF REPAIRS; COST/TIME TO RESET)

Table 6.6. Factorial Coordinates, Chi-square explained and contributions to Factor IV.

Factor IV groups the Setter-Operator and the Head of Machine Shop at the negative end of the factor, opposed to the Works Foreman at the positive end. The characteristics evoked by the two actors at the negative end have in common the description of the CNC machine as problematic in various senses related to its actual use. The Works Foreman's production stresses the costs involved in its operation and maintenance. All three actors are describing the machine as problematic, which is interesting, because it reflects a widespread discourse playing down the machine. Only the Managing Director, so far said something positive about it.

B. Objectives.

The distribution of Objectives is summarized in the following table.

ACTORS	WF	SO	TD	MD	HM	MEANING
NThemes	3	1	2	2	3	
KEEJ	0	1	0	0	1	KEEP JOBS
RLAC	1	0	0	0	0	REDUCE LABOUR COSTS
UTIL	1	0	0	0	1	INCREASE MACHINE UTILIZATION
IPRO	1	0	1	1	0	INCREASE PRODUCTION
ZZ 1	0	0	0	0	1	(ENHANCE COMPETITIVENESS; EFFICIENCY)
ZZ 2	0	0	0	1	0	(TRAIN MORE THAN ONE CNC OPERATOR; IMPROVE RETURN ON INVESTMENT; MACHINE MORE IN-HOUSE)
ZZ 3	0	0	1	0	0	(INCREASE BATCH SIZE FOR CNC; INCREASE SPEED)

Table 6.7. Distribution of Objectives.

The analysis of this matrix yielded the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	.86488	40.968	40.968
II	.50000	23.684	64.652
III	.50000	23.684	88.336
IV	.24624	11.664	100.000

Table 6.8. Factors extracted: Objectives.

Interpretation of Factors

Factor I: Develop Manufacturing Ability X Minimize Potential Management/Labour Conflict.

Item	I1	1#F	Cos2 CTF	Percentage explained = 41%
ZZ 2	-1080	259	123	(TRAIN MORE THAN ONE CNC OPERATOR; IMPROVE RETURN ON INVESTMENT; MACHINE MORE IN-HOUSE)
ZZ 3	-1080	259	123	(INCREASE BATCH SIZE FOR CNC; INCREASE SPEED)
TD	**-1004**	**378**	**212**	**Technical Director**
MD	**-1004**	**378**	**212**	**Managing Director**
IPRO	-788	986	196	INCREASE PRODUCTION
RLAC	-204	16	4	
WF	**-190**	**29**	**11**	
UTIL	462	256	45	
HM	**1049**	**763**	**347**	**Head of Machine Shop**
ZZ 1	1128	478	134	(ENHANCE COMPETITIVENESS; EFFICIENCY)
KEEJ	1337	671	376	KEEP JOBS
SO	**1438**	**460**	**217**	**Setter-Operator**

Table 6.9. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I groups the Technical Director and the Managing Director at its negative end, opposed to the Head of Machine Shop and the Setter-Operator at the positive end. The themes which the two managers evoke are clearly related to the strategic objectives of the Company's top management as referred in Company 3 description. The shift from assembly to manufacture is apparent in such objectives as "Machining more in-house" or "Increase production", while concerns with setting up favourable bases for this shift are apparent in themes like "Improve return on investment", "Train more than one CNC operator" and the appropriate and efficient use of the CNC machine.

At the other end of this factor we find concerns related with competitiveness and efficiency together with maintaining job levels. This conjunction of strategic and job security concerns suggests that this end of the factor describes the implicit agreement on which the CNC machines were accepted at the shopfloor: they are not to be opposed by the shopfloor, where the more visible management objectives are accepted but there will be no dismissals. The extremes of the factor can thus be respectively labelled as Development of Manufacturing Ability X Minimize Potential Labour/Management Conflict.

Factor II: Technical X Organizational Goals.

Item	I1	2#F	Cos2	CTF	Percentage explained = 23.7%
ZZ 3	-1701	643	526		(INCREASE BATCH SIZE FOR CNC; INCREASE SPEED)
TD	**-1203**	**542**	**526**		**Technical Director**
SO	**-64**	**1**	**1**		
KEEJ	-45	1	1		
ZZ 1	0	0	0		
IPRO	0	0	0		
HM	**0**	**0**	**0**		
UTIL	45	2	1		
WF	**64**	**3**	**2**		
RLAC	91	3	2		
MD	**1138**	**486**	**471**		**Managing Director**
ZZ 2	1610	576	471		(TRAIN MORE THAN ONE CNC OPERATOR; IMPROVE RETURN ON INVESTMENT; MACHINE MORE IN-HOUSE)

Table 6.10. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II differentiates between the Managing Director and the Technical Director. The Technical Director's production reveals concerns with machine utilization rates while the Managing Director's reveal concerns with more general organizational matters. The factor can thus be described as opposing a technical to an organizational orientation in CNC implementation.

Factor III: Job Security X Efficient Use of Resources.

Item	I1	3#F	Cos2 CTF	Percentage explained = 23.7%
SO	**-1047**	**244**	**199**	**Setter-Operator**
ZZ 2	-842	157	129	
KEEJ	-740	205	199	KEEP JOBS
ZZ 3	-639	91	74	
MD	**-595**	**133**	**129**	
TD	**-452**	**76**	**74**	
ZZ 1	0	0	0	
IPRO	0	0	0	
HM	**0**	**0**	**0**	
UTIL	740	658	199	INCREASE MACHINE UTILIZATION
WF	**1047**	**883**	**598**	**Works Foreman**
RLAC	1480	822	398	REDUCE LABOUR COSTS

Table 6.11. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III establishes a distinction similar to the one established in Factor I: it opposes the Setter-Operator to the Works Foreman and the opposition is again based on the concern with keeping jobs against other concerns with measures of efficiency in the Company. Whilst in Factor I this opposition involved the more senior managers opposed to the lower level managers, in this case it is the "middle man", the Works Foreman who appears voicing what can be seen as the translation at the operational level of the managerial strategic concerns. This factor can be described as opposing Job Security concerns to concerns with the Efficient Use of Resources.

Factor IV explains a small amount of the matrix information, so it will be left out of this interpretation.

C. Decisions and Actions.

The distribution of references to decisions and actions in the implementation of the CNC machines is summarized in the following table.

Actors	WF	SO	TD	MD	HM	MEANING
NThemes	4	2	3	4	1	
CARD	0	0	1	1	0	USE PRODUCTION CARDS TO CONTROL PROCESS
IRMC	0	0	1	0	0	INCREASE CONTROL OF CASTINGS
MMI*	1	1	1	1	0	INCREASED PRODUCTION IN-HOUSE
OFLP	0	0	0	0	1	PROGRAMME OFF-LINE
ROUT	1	1	0	0	0	GET REPAIRS FROM OUTSIDE
ZZ 1	0	0	0	1	0	GET DRAWINGS FROM PARENT COMPANY; USE UNSKILLED WORKERS IN CNC OPERATION; TRAIN CNC OPERATORS)
ZZ 2	1	0	0	0	0	(CREATE SETTER-OPERATOR TITLE; EMPLOY MORE PEOPLE TO REPLACE CNC OPERATOR; PLAN FOR BATCH PRODUCTION; STOP MACHINE UNTIL REPAIRED)
ZZ 3	1	0	0	1	0	(OPERATOR PROGRAMMES MACHINE; REORGANIZE PRODUCTION)

Table 6.12. Distribution of Decisions an Actions.

The analysis of this matrix yielded the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL %
I	1.00000	48.000	48.000
II	.55542	26.660	74.660
III	.35735	17.153	91.813
IV	.17057	8.187	100.000

Table 6.13. Factors extracted: Decisions and Actions.

Interpretation of Factors.

Factor I: Programming off-line.

Item	1#F	Cos2	CTF	Percentage explained = 48%
ZZ 1	0	0	0	
IRMC	0	0	0	
CARD	0	0	0	
ZZ 2	0	0	0	
ZZ 3	0	0	0	
ROUT	0	0	0	
MMI*	0	0	0	
WF	**0**	**0**	**0**	
SO	**0**	**0**	**0**	
TD	**0**	**0**	**0**	
MD	**0**	**0**	**0**	
PF	**0**	**0**	**0**	
OFLP	3742	1077	1000	PROGRAMME OFF-LINE
HM	**3742**	**1077**	**1000**	**Head of Machine Shop**

Table 6.14. Factorial Coordinates, Chi-square explained and contributions to Factor I.

Factor I isolates the Head of Machine Shop's contribution. In fact, he evokes only one theme which no one else shares. This factor thus receives a single label "Programming off-line".

Factor II: Changes in Operations X Changes in Production Process Control.

Item	2#F	Cos2	CTF	Percentage explained = 26.7%
ZZ 2	-1115	497	160	(CREATE SETTER-OPERATOR TITLE; EMPLOY MORE PEOPLE TO REPLACE CNC OPERATOR; PLAN FOR BATCH PRODUCTION; STOP MACHINE UNTIL REPAIRED)
ROUT	-1040	666	278	GET REPAIRS FROM OUTSIDE
WF	**-831**	**713**	**355**	**Works Foreman**
SO	**-719**	**318**	**133**	**Setter-Operator**
ZZ 3	-290	112	22	
MMI*	-32	6	1	
OFLP	0	0	0	
HM	**0**	**0**	**0**	
PF	**0**	**0**	**0**	
MD	**399**	**164**	**82**	
ZZ 1	535	115	37	
CARD	976	914	245	USE PRODUCTION CARDS TO CONTROL PROCESS
TD	**1056**	**647**	**430**	**Technical Director**
IRMC	1416	547	258	INCREASE CONTROL OF CASTINGS

Table 6.15. Factorial Coordinates, Chi-square explained and contributions to Factor II.

Factor II opposes two distinct descriptions of the implementation process: the Technical Director's, stressing matters of control over the production process, and a description of details of implementation which includes changes in production planning, maintenance and jobs, put forward by the Works Foreman and the Setter-Operator. It can be labelled as an opposition between a description based on changes in operations and one based on changes in control over the production process.

Factor III: Improvements in Production Core X Development of Manufacturing Ability.

Item	3#F	Cos2	CTF	Percentage explained = 17.1%
IRMC	-1182	381	279	INCREASE CONTROL OF CASTINGS
TD	**-707**	**290**	**299**	**Technical Director**
SO	**-586**	**211**	**137**	**Setter-Operator**
ROUT	-504	156	101	GET REPAIRS FROM OUTSIDE
MMI*	-196	231	31	INCREASED PRODUCTION IN-HOUSE
ZZ 2	-28	0	0	
WF	**-17**	**0**	**0**	
OFLP	0	0	0	
HM	**0**	**0**	**0**	
PF	**0**	**0**	**0**	
CARD	111	12	5	
ZZ 3	688	631	189	(OPERATOR PROGRAMMES MACHINE; REORGANIZE PRODUCTION)
MD	**839**	**727**	**563**	**Managing Director**
ZZ 1	1404	789	394	GET DRAWINGS FROM PARENT COMPANY; USE UNSKILLED WORKERS IN CNC OPERATION; TRAIN CNC OPERATORS)

Table 6.16. Factorial Coordinates, Chi-square explained and contributions to Factor III.

Factor III helps identify a further distinction in the account of changes associated with the introduction of the CNC machine. Both ends of the factor refer to the project of developing the manufacturing ability of the Company. However, the Technical Director and Setter-Operator concentrate on the improvements in the productive core while the Managing Director stresses more wide improvements in production organization, training and available skills and know-how in the Company. The factor can thus be labelled as differentiating between a description based on improvements in the productive core (negative end) and one based on developments of the Company's ability to manufacture the pumps, as opposed to just assembling and installing them.

D. Second Level Analysis.

Actors' positions in the factors just interpreted are summarized in Table 6.17. below.

ACTOR	WF	SO	TD	MD	HM	LABELS
NThemes	2	4	3	2	2	
A2-	1	1	0	0	0	CHANGES IN OPERATIONS
A3-	0	1	1	0	0	DEVELOPMENT OF PRODUCTION CORE
O1-	0	0	1	1	0	DEVELOPMENT OF MANUFACTURING ABILITY
ZZ 1	0	0	0	0	1	[PROBLEMATIC TO INTEGRATE IN PRODUCTION PROCESS (C3-); PROGRAMMING OFF-LINE (A1+)]
ZZ 2	0	0	0	1	0	[OVERCOMES LACK OF SKILLED WORK (C1+); ORGANIZATIONAL GOALS (O2+); DEVELOPMENT OF MANUFACTURING ABILITY (A3+)]
ZZ 3	0	0	1	0	0	[COPES POORLY WITH INPUT VARIANCES (C2-); TECHNICAL GOALS (O2-); CHANGES IN PRODUCTION PROCESS CONTROL (A2+)]
ZZ 4	0	1	0	0	0	[DIFFICULT TO OPERATE (C3+); JOB SECURITY (O3-)]
ZZ 5	0	1	0	0	1	[COMPLEX/THREATENING MACHINE (C4-); MINIMIZE POTENTIAL MANAGEMENT/LABOUR CONFLICT (O1+)]
ZZ 6	1	0	0	0	0	[COSTLY MACHINE (C4+); EFFICIENT USE OF RESOURCES (O3+)]

Table 6.17. Actor's factorial positions in first level analysis.

The analysis of this matrix yielded the following factors:

FACTOR	EIGEN VALUE	PERCENT	CUMUL. %
I	.88275	34.731	34.731
II	.75000	29.508	64.239
III	.54868	21.587	85.827
IV	.36024	14.173	100.000

Table 6.18. Factors extracted: Second Level Analysis

Interpretation of Factors

Factor I: Strategic discourse X "Defensive" discourse.

Item	1#F	Cos2	CTF	Percentage explained = 34.7%
ZZ 2	-1679	513	246	[OVERCOMES LACK OF SKILLED WORK (C1+); ORGANIZATIONAL GOALS (O2+); DEVELOPMENT OF MANUFACTURING ABILITY (A3+)]
MD	-1578	642	434	Managing Director
O1-	-1285	967	288	DEVELOPMENT OF MANUFACTURING ABILITY
ZZ 3	-892	238	69	
TD	-838	372	183	Technical Director
A3-	-184	38	6	
SO	491	234	84	
ZZ 4	523	122	24	
ZZ 5	754	396	99	[COMPLEX/THREATENING MACHINE (C4-); MINIMIZE POTENTIAL MANAGEMENT/LABOUR CONFLICT (O1+)]
A2-	754	396	99	CHANGES IN OPERATIONS
WF	926	221	149	Works Foreman
HM	926	221	149	Head of Machine Shop
ZZ 1	985	176	85	
ZZ 6	985	176	85	

Table 6.19. Factorial Coordinates, Chi-square explained and contributions to Factor I (Second Level Analysis).

Factor I differentiates between the strategic discourse put forward by the Managing Director and the Technical Director and what can be labelled as a defensive discourse, voiced by the other three actors. The reason for labelling the positive end of the Factor as "Defensive" is that it groups actors who have different positions but who share some concern regarding the changes that are being introduced as a consequence of the strategic objectives of senior management. In other words they are not very involved or committed to them, so they raise problems and voice difficulties. This differentiation, the largest in this group, shows a degree of estrangement between senior and lower level management, and this suggests that there are or will be some difficulties in the implementation of management's strategic objectives.

As will be seen in the following factors, this is not a clear cut divide, and further differences between the actors grouped by Factor I will be shown which help create a more dynamic image, blurring this first distinction.

STRATEGIC DISCOURSE	FACTOR I "DEFENSIVE" DISCOURSE
Managing Director Technical Director	Head of Machine Shop Works Foreman
CNC MACHINES: - Overcome lack of skilled work	CNC MACHINES ARE: - Complex/threatening - Problematic to integrate in production process
GUIDELINES IN THEIR INTRODUCTION: - Development of manufacturing ability - Organizational goals	GUIDELINES IN THEIR INTRODUCTION: - Minimize potential management/labour conflict
WITH THEIR INTRODUCTION: - The Company developed its manufacturing ability	WITH THEIR INTRODUCTION: - Some off-line programming was made

Fig. 6.2. Second Level Analysis: Factor I.

Factor II: Implementation at operational level X Resistance.

Item	2#F	Cos2	CTF	Percentage explained = 29.5%
ZZ 6	-1803	591	333	[COSTLY MACHINE (C4+); EFFICIENT USE OF RESOURCES (O3+)]
WF	-1561	629	500	Works Foreman
A2-	-901	565	167	CHANGES IN OPERATIONS
ZZ 2	0	0	0	
ZZ 3	0	0	0	
O1-	0	0	0	
ZZ 4	0	0	0	
A3-	0	0	0	
SO	0	0	0	
TD	0	0	0	
MD	0	0	0	
ZZ 5	901	565	167	[COMPLEX/THREATENING MACHINE (C4-); MINIMIZE POTENTIAL MANAGEMENT/LABOUR CONFLICT (O1+)]
HM	1561	629	500	Head of Machine Shop
ZZ 1	1803	591	333	[PROBLEMATIC TO INTEGRATE IN PRODUCTION PROCESS (C3-); PROGRAMMING OFF-LINE (A1+)]

Table 6.20. Factorial Coordinates, Chi-square explained and contributions to Factor II (Second Level Analysis)

Factor II Differentiates between two of the actors grouped together in Factor I, under the label "defensive" discourse. In this differentiation we can see that the Works Foreman in spite of his defensive position also puts forward a discourse where the strategic objectives of senior management and its implementation are accepted. The Head of Machine Shop appears as the one putting forward very clearly the discourse of resistance to changes. However, this resistance is not very radical, as this discourse also includes the concern with minimizing conflict. Simplifying a little, it can be seen as "negotiable resistance".

IMPLEMENTATION AT OPERATIONAL LEVEL FACTOR II	RESISTANCE
Works Foreman	Head of Machine Shop
CNC MACHINES ARE: - Costly	CNC MACHINES ARE: - Complex/threatening - Problematic to integrate in production process
GUIDELINES IN THEIR INTRODUCTION: - Efficient use of resources	GUIDELINES IN THEIR INTRODUCTION: - Minimize potential management/labour conflict
WITH THEIR INTRODUCTION: - There were changes in operations	WITH THEIR INTRODUCTION: - Some off-line programing was made

Fig. 6.3. Second Level Analysis: Factor II.

Factor III: Technocratic/technical discourse X Organizative discourse.

Item	3#F	Cos2	CTF	Percentage explained = 21.6%
ZZ 3	-1203	434	203	[COPES POORLY WITH INPUT VARIANCES (C2-); TECHNICAL GOALS (O2-); CHANGES IN PRODUCTION PROCESS CONTROL (A2+)]
A3-	-923	950	239	DEVELOPMENT OF PRODUCTION CORE
TD	-891	420	334	Technical Director
ZZ 4	-642	183	58	
SO	-476	219	127	Setter-Operator
ZZ 5	78	4	2	
A2-	78	4	2	
O1-	145	12	6	
WF	591	90	98	
HM	591	90	98	
ZZ 1	798	116	89	
ZZ 6	798	116	89	
MD	1107	316	343	Managing Director
ZZ 2	1494	406	313	[OVERCOMES LACK OF SKILLED WORK (C1+); ORGANIZATIONAL GOALS (O2+); DEVELOPMENT OF MANUFACTURING ABILITY (A3+)]

Table 6.21. Factorial Coordinates, Chi-square explained and contributions to Factor III (Second Level Analysis)

Factor III separates the Technical Manager from the Managing Director thus showing the articulation of different approaches to the Company strategy. The Technical Manager stresses the technical dimensions of the shift from assembly to manufacturing which have some relationship with the use of CNC machines, and the need for increased control of this process. The Managing Director evokes more general aspects of Company organization necessary for this shift. Interesting enough, the Setter-Operator is close to the Technical Director in this differentiation. This brings yet another understanding of the differentiation established by Factor I, where the Setter-Operator was close to the "Defensive" discourse. Here he appears close to the Technical discourse, which suggests that there is some ambiguity in his political position regarding the introduction of the CNC machines. While he does voice some aspects of the defensive discourse, thus coming closer to the Head of Machine Shop, it would appear that as user of the machine he is also committed to the strategic objectives put forward by the senior managers.

TECHNOCRATIC/TECHNICAL DISCOURSE	FACTOR III ORGANIZATIVE DISCOURSE
Technical Director Setter-Operator	Managing Director
CNC MACHINES: - Cope poorly with input variances	CNC MACHINES: - Overcome lack of skilled work
GUIDELINES IN THEIR INTRODUCTION: - Technical goals	GUIDELINES IN THEIR INTRODUCTION: - Organizational goals
WITH THEIR INTRODUCTION: - The production core was developed - There were changes in production process control	WITH THEIR INTRODUCTION: - The Company developed its manufacturing ability

Fig. 6.4. Second Level Analysis: Factor III.

Factor IV: Technical discourse X Resistance discourse.

Item	4#F	Cos2	CTF	Percentage explained = 14.2%
ZZ 3	-1045	327	233	[COPES POORLY WITH INPUT VARIANCES (C2-); TECHNICAL GOALS (O2-); CHANGES IN PRODUCTION PROCESS CONTROL (A2+)]
ZZ 1	-802	117	137	
ZZ 6	-802	117	137	
TD	-627	208	252	Technical Director
WF	-481	60	99	
HM	-481	60	99	
O1-	-187	21	15	
A3-	103	12	5	
ZZ 5	224	35	21	
A2-	224	35	21	
MD	402	42	69	
ZZ 2	670	82	96	
SO	751	546	481	Setter-Operator
ZZ 4	1251	695	334	[DIFFICULT TO OPERATE (C3+); JOB SECURITY (O3-)]

Table 6.22. Factorial Coordinates, Chi-square explained and contributions to Factor IV (Second Level Analysis).

Factor IV explains a fairly small amount of information in the matrix and would not be worth of inclusion except that it establishes a finer differentiation between the Technical Director and the

Setter-Operator which confirms the Technical Director in his proximity to a Technical discourse, and highlight some aspects of the Setter-Operator production which puts him close to the Resistance discourse. More specifically, it brings of his individual production, which concerns the difficulties in CNC machine use and the maintenance of job levels. These were components of what was labelled the resistance discourse, so it seems legitimate to include the information dealt with by this factor to define the Setter-Operator as close to the Resistance discourse.

6.5. Discussion of Discourse Structure Analysis.

This analysis shows how the discourse differentiations established by the different actors in the process of making sense out of a new fact can be related to political processes in the Company. At the centre of Figure 6.5. we find the two categories which are evoked by the majority of actors: Increase production and Machine more in-house. These two themes summarize clearly the strategic objectives of senior management, which in this Company are easier to identify than in the previous ones.

Around these two themes we find the discourse differentiations detected by the second level analysis. The more significant differentiation is a familiar one: the first factor reproduces clearly the hierarchical divide between senior management and the shopfloor, which is would be expected in processes of resistance to technical innovation or other strategic moves. However the discourse differentiations in this Company are not limited to this more visible division.

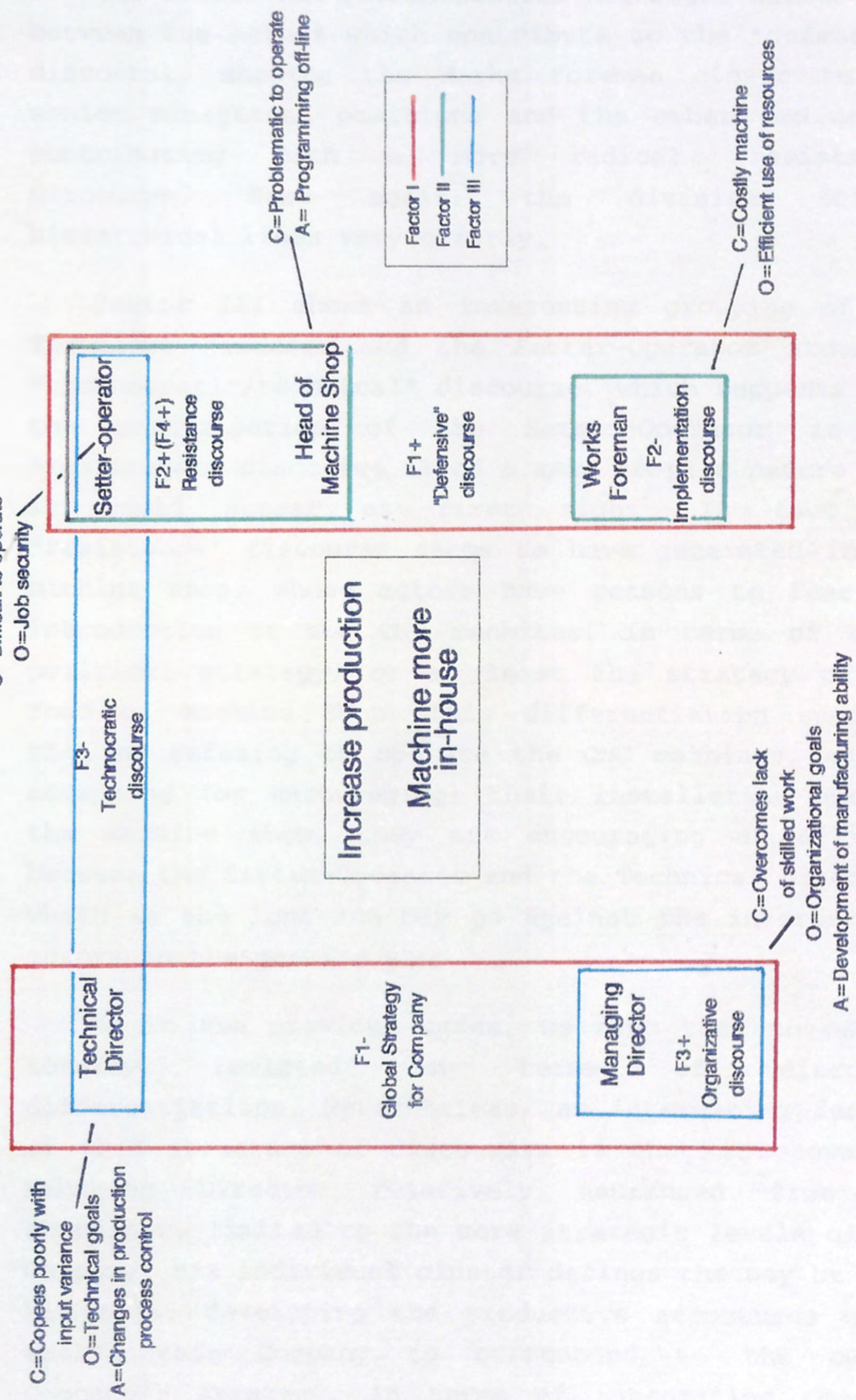

Fig. 6.5. Structure of discourses in Company 3

The second and fourth factors highlight differences between the actors which contribute to the "defensive" discourse, showing the Works Foreman closer to the senior management positions and the other two actors contributing with a more radical "resistance" discourse. Here again, the division follows hierarchical lines very clearly.

Factor III shows an interesting grouping of the Technical Director and the Setter-Operator around a "technocratic/technical" discourse, which suggests that the participation of the Setter-Operator in the "resistance" discourse is of a more complex nature than it would appear at first sight. In fact the "resistance" discourse seems to have generated in the machine shop, whose actors have reasons to fear the introduction of the CNC machines. In terms of their political strategy, or at least the strategy of the Head of Machine Shop, this differentiation suggests that by refusing to operate the CNC machines, and by accepting (or encouraging) their installation outside the machine shop, they are encouraging an alliance between the Setter-Operator and the Technical Director, which in the long run may go against the interests of actors in the machine shop.

As in the previous cases, we find that no one is totally isolated in terms of discourse differentiations. Nevertheless, an interesting feature of this structure of discourses is that it shows the Managing Director relatively estranged from the shopfloor, limited to the more strategic levels of the Company. His individual cluster defines the way he sees his role: developing the productive structures which enable this Company to correspond to the parent Company's strategy. In terms of integrating the CNC machines in this strategy the Managing Director's role definition makes the Technical Director a key actor because he appears as liaising between the senior managers and the shopfloor. The Technical Director's individual cluster reflects this role. He is concerned with the technical aspects of the CNC machines but also with the possibilities of control over the production process they may open.

However, this link is made solely via the Setter-Operator. Given the problems the Head of Machine Shop has with the CNC machines, there are two possibilities in what concerns the fate of senior management strategy: either the CNC machines will not be an essential part of their strategy, in which case this situation is fairly stable, or, if they are critical, this situation can develop into an open conflict, because the actors in the machine shop will be left behind by developments in the CNC sector and other technological innovations that may follow. In this last case the senior management's strategy can run into trouble.

Keeping with this conjecture, we find that the Works Foreman maintains links with the two other actors at this level, mainly through the "Defensive" discourse, but he also asserts his hierarchical position by putting forward what we labelled the implementation discourse.In terms of the latent conflict between the machine shop and the senior managers, he does not seem to be very involved, which is likely to give him plenty of choice if this conflict is aggravated. His individual cluster reflects a "rationalistic" approach to the process, stressing the cost of the CNC machines and the efficient use of resources. The introduction of these questions makes his role clearly more relevant to the objectives of senior managers.

In what concerns the Setter-Operator, his competence in CNC machining, and the proximity in terms of discourse with the Technical Director are likely to give him a strong political basis on which to act. His links with the Head of Machine Shop through the "resistance" discourse probably make him a critical actor in terms of strategy implementation in that he can be a mediator between senior managers and actors in the machine shop. His individual cluster reflects this balance between senior management and machine shop workers: on one hand he speaks of job security, the main concern at the shopfloor, and on the other hand he defines the CNC machine as difficult to operate, which may be interpreted as a positive evaluation of his role.

Finally the Head of Machine Shop defines his role clearly as opposed to the introduction of the CNC machine, both by stressing the difficulties with their integration in the manufacturing process and the possibility of programming the machine far from the shopfloor, a practice which is likely to undermine the importance of the machine shop in the Company.

In summary, in this Company we can see a situation which less stable than in the other two cases and where the potential for conflict is very clear. The analysis of discourses shows how this conflict is structured and the roles of each actor in it. This can be of significant help in a possible intervention, most of all because the conflict identified was not immediately apparent to an external observer.

CHAPTER 7: DISCUSSION AND CONCLUSIONS

The view developed in this research suggests that recommendations concerning the organizational changes associated with successful implementation of new technology have generally assumed too much linearity in planned organizational change. The levels of complexity identified in studies of strategic processes make it clear that such a linear view is not appropriate. Role changes, actual or potential, in technological innovation processes trigger attempts to re-define those roles. The result can be described as an interpretative process which takes place through the use of language, as discussed in chapter 2. Actors put forward different interpretations of what is happening, or what should happen with the introduction of a new technology.

This process is based on actors whose organizational roles are being changed. Therefore political processes involving attempts to exert influence over others become prominent. The structure which can possibly be found in this process is not the result of a plan being orderly carried out through a stabilized system of roles.

The method developed concentrated on the identification of the variety of discourses which are put forward in each organization, as a means of describing more clearly this interpretative process. The structures of discourse in the three companies show several interesting properties which reveal some of the dimensions and regularities of this process.

One striking feature of organizational discourse structures is the variety of discourses observed. In the cases analyzed very few discursive elements occupy a central place, i.e., very few are shared by the majority of actors. This variety in the discourses co-existing in the organization is consistent with the definition of strategy making examined in chapter 2, as a complex and ambiguous problem which fosters a variety of interpretations. This variety reinforces the idea that strategic processes can be approached through the examination of how people speak about them.

The examination of these discourse structures reveals some characteristics which are worth exploring. In fact, the diversity found is not chaotic and its structure can be explored in order to understand the relationships between discourse structures and strategic processes.

One of the characteristics observed is the fact that actors always share some discursive elements with other actors. In this sense there are no isolated actors. This feature of discursive structures is in line with the notion of discourse as essentially a social process. It also suggests why discourse differentiations do not occur at random. They take place in a space where other discourses are being voiced and to which the contributions of individual actors have to relate in some way.

Individual actors will participate or not in the discourses put forward by other actors, thus defining three areas in a discourse structure: an area of discourses which are not shared, i.e., which are voiced by a single actor; an area of discourses which are partly shared, i.e., of discourses which are shared, but only by a few actors; and an area of discourses shared by all or the majority of actors. Each of these areas, and their contribution to understanding the interpretative processes in strategic organizational changes will be discussed in the following sections.

7.1. Isolated discourses.

In the diagrams which represent the discourse structures of the three companies studied (Figs. 4.6., 5.6. and 6.5.) this area corresponds to the peripheral clusters of discourse labels which are not shared by other actors. These clusters are related to the definition of the individual role in the organization, of an individual domain. In what concerns the discourse structure of a company, this area can be seen as one of its sources of novelty. Each individual actor is exposed to a set of different discourses, both external and internal to the organization, which may result in individuals bringing to the organization different ideas, thus generating a discourse differentiation. This introduction of new elements in a discourse structure is not random. If we take a look at the individual clusters, they can be related in every case with the definition of individual roles. It follows that from all the discourses individual actors are exposed to in their experience, they are going to select those which they feel are relevant for the definition of their role and their specific domain of activity.

Education, social contacts, hobbies, etc., form a network of discourses where the actor lives. Of these discourses in which the actor participates, some become relevant for his or her interpretation of organizational processes and for the articulation of his or her role in them. Some of these discourse networks can be highly relevant for action in the organization. For example, the notion of "industry recipe" (Spender 1989) can be seen as a particular type of discourse produced along industry-based networks which is not directly influenced by the existence of a particular organization but which provides means of interpreting experiences and "ready made" discourse differentiations for some actors.

Another example can be seen in Newell and Clark (1990) who make the point that some individual actors link into external networks in order to keep up-to-date with innovations and new best-practice methodologies, which the organization can then learn and appropriate. They suggest, citing Hage (1980), that the probability of the organization profiting from these contacts depends on the ability of these individuals to disseminate such information internally "through having some influence within the organization's power structure" (Newell and Clark, 1990:200). This influence should be seen, in terms of discourse analysis, as the ability to link these contributions to the overall discourse structure. By voicing them internally, actors assume a new role in the organization, and possibly direct the attention of other actors to this information as relevant for their role definition. If this happens new actors start to participate in this discourse. A new shared discourse and new role definitions come into existence.

For example, in Company 1 the Production Services Director introduces the problem of optimizing the utilization of CNC machines. These are concerns which are widely available in the management literature and in management education courses. Because this was a new issue in this Company, it was neither the object of conversations nor linked to a specific role. In this form the Production Services Director introduces a discourse differentiation which will eventually include in his role definition the issue of optimizing CNC use. If this discourse is accepted, i.e. if other people recognize it as relevant, his role will be re-defined to include questions of optimization, thus opening for him new areas of acceptable discourses, as well as new possibilities to interact in a power position with others.

Still another example is given by the Head of Machine Shop in Company 3 who mentions in the interview the contacts with engineers in other companies. These contacts made him aware of the CNC machines potential for making redundant the type of skills he and the other actors in the machine shop controlled. In this case, the participation in other discourses, external to the organization, prompts his participation in the "resistance discourse" identified in this company.

This view of the process by which discursive elements become relevant for particular actors enables a re-interpretation of the "garbage can" model of the organization (Cohen et al., 1972) which describes the association between problems, solutions and problem-solvers as a non-rational, almost random process. The point is that discourses become relevant for particular actors by almost any reason but their introduction in the organization should be seen as an attempt to participate in a deliberate way in the organizational discourse structure with a view to maintain or reformulate a role definition.

In what concerns the fate of planned organizational changes that strategic moves entail, the suggestion is that because they change at least some role definitions, actors are bound to respond by introducing new elements in the discourse structure, which may or may not be consistent with the objectives of those changes. At any rate, this change in the discourse structure creates a new situation which did not exist at the time the strategic objectives were stated. The statement of strategic objectives probably triggers changes in the situation because it becomes an element in the discourse structure which will be met by other contributions coming from different actors in the effort to secure, or change, their role definitions. This description of the process explains why organizational changes which go as planned are the exception rather than the rule.

In the case of Company 3, the existence of an explicit strategic plan at the group headquarters is a good example of this type of process. The changes in roles which can be detected from the interviews are related with the use of CNC machines and affect more visibly the Setter-Operator, who takes on a new role, and the Head of Machine Shop whose job relevance is threatened. Indirectly they affect the other actors because they modify the kind of issues they have to deal with. Each actor voices a different cluster of discursive elements which reflects a problematic implementation of CNC machines. The problem appeared to be that the re-definition of roles did not tend to be a stable one. Although the Setter-operator appeared satisfied with the present situation, his position reflected a difficult balance between the resistance to CNC implementation at the machine shop, and the pressures from senior management in the sense of developing the ability to machine in the Company all the components needed to manufacture the pumps. In fact there had been several problems with this objective to the point that the production of some components was eventually given up.

It could be tempting in this case to attribute this failure to resistance to innovation at the shopfloor.

An alternative interpretation is that there was a lack of "interpretative resources" or a lack of discourses which would enable the shopfloor to become involved in an active re-definition of their roles. This re-definition would certainly entail a degree of conflict, but possibly not the entrenched, wordless conflict which appeared to exist.

It becomes therefore pointless to attribute the blame to this or that actor or group. This lack of discourse possibilities is a characteristic of the discourse structure as a whole. Company 3 is a case which could be described as strategically over-directed (Newell et al., 1989). One of the reasons why over-directed strategic changes may go wrong is because pressures from outside the Company may not leave enough time and/or may not provide the discursive possibilities which would enable actors to build a new understanding of the situation and of their roles in it.

7.2. Partly shared discourses.

The area of partly shared discourses is clearly connected with processes of a political nature, in the more conventional sense. Discourse differentiations at this level indicate the alliances and oppositions between groups of actors. However, the analysis of discourses shows that the alliances identified do not constitute mutually exclusive groups. This distinction is important because traditionally the notion of alliance suggests a compromise between actors which holds at all levels. The way discourses are structured in the three cases, linking different actors at several levels suggests a more complex notion of alliance with several levels which end up linking actors who apparently had very little in common. There is a clear example of this in Company 2, where the Technical

Director and the Toolroom Manager are on opposite sides in the two first factors but contribute to a common discourse focused on the "details of implementation" (Factor IV). This suggests that in spite of the opposition which the two first factors identify there are areas of agreement in what concerns the actual practices of CNC implementation.

The analysis of this area of discourse structures shows the existence of multiple layers of discourse in organizational politics which link all the actors involved. This suggests how the notions of power and discourse can be connected. On one hand the introduction of a new discourse can be instrumental in the re-definition of organizational roles and consequently in the definition of a domain of influence. On the other hand the participation in shared discourses also contributes to one's own role definition, while reinforcing discursive differentiations introduced by others. This reinforcement may contribute to make those discursive differentiations more visible or relevant in a company. Participation therefore, is instrumental too in the ability to influence interpretations of what happens. It follows that an actor's power can be seen as related both with the discourse differentiations he or she introduces in the discourse structure and with the participation in and maintenance of existing discourses.

In Company 1, the case of the Quality Director is illustrative of the relationship between discourse differentiation, participation in existing discourses and the ability to influence. The absence of any new discourse in the Quality Director's production suggests that although he participates in a number of discourses, his ability to influence other actors is reduced, at least in what concerns the CNC machines. In fact, of all the actors interviewed he seemed the less involved in the process of CNC implementation and the general effort to innovate technologically.

In the same Company, the Toolroom Director although sharing some discourses with the Technical and the Design Directors, is less "connected" than the other four actors, who are all linked between them by several discourses. This can be related to the difficulties the Toolroom Director had in coping with the novelty the CNC machines constituted. These two example in Company 1 show how both differentiation and participation in existing discourses are dimensions of an actor's ability to intervene and influence what is happening.

In Company 2, the Technical Director, who appeared as the "technology champion" in what concerned the introduction of the CNC machine contributes with several discursive elements which are not shared by other people. However he also participates in a number of other discourses. In fact he appears as one of the actors more "connected" in the group, connected referring here to the number of discourses in which he participates. Interestingly enough, he is as "connected" as the Toolroom Manager and om opposite sides of the same factors. But he shares discursive elements with the Managing Director which, speculatively, might give him the upper hand in a conflict with the Toolroom Manager.

Another example in the case of Company 2, are the Financial Director and the Engineering Manager who appear relatively isolated from all the other actors (in fact they relate at other levels described by factors which were not interpretable). If in the case of the Financial Director his role may explain to some extent his relative isolation, in the case of the Engineering Manager this isolation seems to correspond to a withdrawal from the conflict which is going on between the Toolroom Manager and the Technical Director, which polarizes the discourse structure to a significant extent.

7.3. Shared discourses.

The area of shared discourses, in the centre of the discourse structure diagrams indicates the discursive elements which at a given point in time are not objects of debate. The more relevant feature in the three cases is that this central area of discursive elements is always in line with the objectives, or the understanding of the situation by senior managements.

In Company 1, the central element is the definition of the CNC machine as accurate. This is clearly in line with the orientations coming from at least one of the more important customers of this Company, which were put forward through their supplier development programme and brought in by the directors who went to these courses. In Company 2, the two central elements are the description of the CNC machine as controlled by computer and the possibility of running it without the assistance of the operator. This kind of concern can be traced clearly to the Managing Director whose involvement in the automated production line attests his resolution to automate whenever possible. Finally, in Company 3 the two central elements are a summary of the strategic objectives defined by the group headquarters which the Managing Director is expected to implement.

The process by which these elements become central can be described as a circular process in which some elements of the discourse of powerful actors are taken by other actors in their own production and this appropriation is reinforced in some way by these powerful actors. A possible recommendation here is that for an actor to increase the probability of influencing the discourse of others s/he must be attentive to the echoes of her or his own discourse in the discourse of others and use whatever means to reinforce those who take elements of their discourse. A note of caution should be made here, in that clearly not all elements of the discourse of powerful actors take this central position.

This suggests that the process by which certain elements become central may not be as easy to control as this recommendation would suggest. A more likely image is that these elements would be acceptable anyway but because they are invested with the formal authority of powerful actors they become very visible and help structure around them all the other discursive differentiations described in the other areas. In other words, they help to legitimate individual contributions to the discourse structure: if these elements become visible, as symbols which are manipulated by everyone, individual actors can legitimate their personal contributions by demonstrating that they contribute to the strategic concept they represent. In terms of role definitions this demonstration may be the key process. The central area could thus be described as the fixed point around which orbit the other discursive elements which are only partly shared or individual.

In summary we have seen how the ability to introduce new discourses is instrumental from the actor's perspective in the definition of organizational roles and how the ability to participate in existing discourses is instrumental in keeping the actor connected to the discourse structure of a group. A fundamental dimension of these processes appears to be the legitimation of different discourses by relating them to the discursive elements in the central area.

7.4. Conclusions and recommendations.

This description of organizational discourse structures is interesting in several ways. As we have seen in Part I, the main weakness of recommendations concerning organizational changes in technological innovation processes is the assumption that their implementation is not problematic. The view of the strategic process as in fact distributed among organizational actors, coupled with the political processes by which these same actors re-define their roles in technological innovation processes suggests that the process is highly unpredictable. The cases analyzed demonstrate that this process shows a certain degree of order, although not enough to suggest that the recommendations concerning organizational changes might be implemented without alterations and re-definitions.

The order which can be seen in these processes is related with (i) the existence of a narrow area of shared discourses which can be related to the objectives of powerful actors and (ii) the fact that in the structure of discourses there are no isolated actors.

These two findings suggest that even though new technologies introduce a discontinuity in role definitions, the subsequent political process is not chaotic. There are relatively stable rules of the game which have to do with the maintenance of a connected discourse structure. In fact, although actors may introduce discursive differentiations which are not connected with the discourse structure of the company, they will always participate to some extent in other discourses which are shared by other actors. This means that they will always participate in the interpretative processes, even if some of their contributions occupy a relatively marginal position. Marginal should not be taken as irrelevant: probably any new discourse will start by being in marginal positions.

From this description, a model of the interpretative processes involved in organizational change can be derived. This model describes two opposite movements of discourses along the organizational discourse structure:

1. The actions which constitute organizational changes associated with technological innovation are the consequences of interpretations made by actors in their effort to re-define roles. Interpretations of organizational reality take place as discourses put forward in the network of exchanges between organizational actors. New discourses, representing different interpretations of novelties like new technology are formed by the activity of actors who bring to the organization new discursive elements. These discursive elements are related to the maintenance or change of definitions of organizational roles in a way which makes them relevant to other actors. When new discursive elements are introduced, they occupy a peripheral position, because they are not yet relevant for other actors. Some of these discursive elements are taken by other actors, thus moving to the partly shared area and defining agreements between actors concerning specific issues. Finally, a few discursive elements become central in the discourse structure, defining common ground between actors. This can be described as a centripetal movement from the periphery of a discourse structure to its centre. It is through this movement that new discursive elements become socially relevant as constituents of new interpretations.

2. At the same time, a centrifugal movement may be seen in the influence of the central area in determining the criteria by which discursive elements will be judged as relevant by actors. The central area of discourses provides the referents which can be used to legitimate divergent discourses in the partly shared area which also become referents for individual actors to introduced new discursive elements from discourse networks external to the organization. Through this movement, discourses are consolidated and provide momentum, or stability to a discourse structure.

It follows from this description that recommendations concerning organizational change may become relevant for actors, depending on how this process takes place in their organizations. The recommendations that organizations should adopt a more integrated structure, constitute discursive elements. They are relevant as part of the process by which specific networks of discourses, like scientific communities, interpret the specific phenomena of strategic organizational change and try to define a role in them. The probability of these discourses becoming relevant for organizational actors depends on the several processes by which discourse structures are changed and maintained.

Firstly, this probability depends on the extent to which these actors may participate in such discourses. This may happen for example through books, specialized publications, training and education, consultancy interventions, informal contacts, etc. Secondly, on the extent to which these recommendations may become relevant for these actors' maintenance or change of a role definition in view of the specific changes experienced or expected. Thirdly, this probability depends on the extent to which the role re-definitions which actors may derive from those recommendations are likely to be perceived as relevant by other actors. This will be determined by the discourses which are shared by the majority of actors in their organizations, and by the partly shared discourses in which those "innovative" actors participate.

7.5. Suggestions for future research.

The acknowledgement of a certain degree of structure raises the issue of whether organizational discourse structures can be intentionally influenced. Although this is a question which can be addressed empirically, at this point the suggestion is that direct influence, in the sense of rational re-design, is not possible because it is a structure which results from the autonomous activity of several actors. However, the fact that this structure is not directly re-designable, does not mean it is impervious to influence. In fact every single actor influences it. In terms of its deliberate influence by a single actor, what the analysis suggests is that there is some scope for influence. The fact that, as we have seen in all three cases, the central area in the discourse structure is related to strategies of powerful actors indicates this possibility.

The recommendation which it is possible to make at this stage is basically that the existence of processes at this level and the fact that they are only in part amenable to direct influence has to be taken into account when recommending specific organizational changes. Moreover, the recommendations made would benefit from the recognition that they constitute only part of the set of discourses to which organizational actors are exposed. In consequence, they "compete" for relevance with other discourses which are not thoroughly mapped. Nevertheless, the knowledge that the interpretations which become relevant are the ones which enable the actors' involvement in their role redefinition suggests that recommendations for organizational change would benefit from a diagnosis of the discourse structure of an organization. This would enable the identification of problem areas and a more accurate intervention.

Specific recommendations will require (i) a more complete understanding of how discourse structures evolve over time and episodes of change, and (ii) a more detailed description of the discourses organizational actors are exposed to. Although the complete description may be overwhelmingly complex probably some order may be found in these influences. Spender (1989) and Newell and Clark (1990) are two examples of these type of description but they tend to analyze only those sources of discourses which are obviously relevant for organizational actors. A more thorough approach would take individual organizations as the focus and trace the influences from there. Only this can give a clear idea of the "competition" faced by recommendations issued from academic settings.

Nevertheless, a first use of this method can be conceived as the monitoring of change processes in order to assess to what extent the existing structure of discourses reflects the appropriation of discourses which are deemed relevant.

The usefulness of this method for exploring interpretative processes would benefit from some developments at the methodological level.

In what concerns the validity problems identified in chapter 3 more research is needed concerning particularly the method of collection and the size of discourse samples which one can take with some certainty as representative in order to explore the structure of discourses. Another problem which is worth exploring concerns the categories and method used in coding the text of the interviews. The categories used in this research are justifiable theoretically as relevant for the type of text under analysis. In practical terms, they have yielded intelligible results. However, this does not mean that empirically derived categories would not have yielded clearer results showing in addition other dimensions of discourse structures. Given the evolution in the field of automatic text analysis this can be a promising line of research in itself.

At a different level, the methodology would benefit from making it simpler to use in "real" interventions, as cognitive maps sometimes are. The possibility of creating a computer programme to carry out the calculations and the generation of diagrams of discourse structures would be straightforward if the problems of coding and interpretation of factors did not exist. As it is, it is unlikely that such a solution can be realistically considered, unless the collection of samples of discourses could be formalized. An example that comes to mind is the Self-Q technique developed by Bougon (1983), as a formalized procedure for the exploration of causal attributions, in order to build cognitive maps. The advantages would be the possibility of using representations of discourse structures interactively. The risk in developing the methodology along these lines is the loss of the "spontaneity" of the texts on which the representation of discourse structures is based. Nevertheless, considering that an interview is not precisely a natural context, research could possibly help to reach an acceptable balance between the advantages of a formalized procedure and the validity of the use of natural discourse.

In spite of the methodological problems identified this approach to organizational change processes opens very interesting possibilities for research and intervention in organizations. Some questions which can be addressed by this approach are:

1. The evolution of the three areas in a discourse structure over time and episodes of change is at the moment a central question. Work along this line will show in a more clear way the relationships between discourse structures and organizational change.

2. Feeding back a discourse structure to organizational actors can be a very powerful way of making changes happen by making them aware of the full variety of perspectives existing in the organization. more cautious view suggests that this feedback can also have the effect of reducing the variety of discourses. Research along these lines should also address the practical and ethical issues involved in making public an image which can conceivably be used to identify and suppress "deviant" points of view.

3. A question following from the previous one is what relationships can be identified between discourse structures and the effectiveness of organizational processes. In this research, variety and connectedness in discourse structures have been valued as important dimensions concerning effectiveness. This assumption follows from what is known about complex organizational processes and from my own values. It can and should be tested, nevertheless. Other dimensions can be identified, and different views can be developed

In summary, several developments can be conceived in the methodological, the theoretical and the application spheres. The point which hopefully is clear is that this approach to the analysis of discourse structures provides valuable insights concerning the more processual dimensions of organizational change.

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Appendix 1: Interview guide.

Interview guide

I am doing a research on the way small and medium companies introduce CNC machines and other technologies and how they cope with the changes that these machines sometimes bring.

If it is alright with you, I would like to ask you some questions about your job and how you felt the introduction of the [specific machines] in this Company.

A

Tell me a little about yourself and your job with this Company.

What is your present position?
What are your major responsibilities?
How long have you held this position?
With whom do you work more closely?
[role set: frequency of interaction, weekly].

B

Now as I said, I am particularly interested in the introduction of [the specific machines] and in all the changes, big or small, that they brought.

(If needed, prompt) I find that sometimes when this type of machines is introduced, there are a number of little problems that go unnoticed because someone notices them and solves them on the spot, so they don't become real problems.

What was your position in this company when [the specific machines] were introduced?
(So) Were you involved in the introduction of [the specific machines]?
What did you do precisely? (According to position, prompt for actions concerning organization and nature of work).
Who (else) was involved in this introduction?
What did they do precisely?

From the time the machines were introduced, what changes have you felt in your job, for instance the way you do things, the decisions you have to make or the problems you have to solve?

What are some of the problems you have to deal with in your position, presently?
Are they somehow related with the use of [the specific machines]?
What can you do about those problems? (Why?)

C

How would you describe the goals of this Company?
What do you see as your contribution towards these goals?
What do you particularly enjoy about your job?

Appendix 2: Chi-square, Weight and Moment of items.

COMPANY 1

Characteristics				*** Objectives**				*** Decisions/Actions**				*** 2nd level analys.**			
Item	Chi2	Wgt	Mom	**Item**	Chi2	Wgt	Mom	**Item**	Chi2	Wgt	Mom	**Item**	Chi2	Wgt	Mom
ZZ 1	1000	77	173	**EFFI**	978	91	144	**MMIN**	1100	91	303	**ZZ 1**	1000	63	87
ZZ 2	1000	77	173	**COOP**	962	91	86	**ZZ 1**	1305	91	81	**ZZ 2**	1000	63	202
ZZ 3	1000	77	285	**INTG**	963	91	86	**ZZ 2**	1305	91	81	**A2+**	1000	63	125
ZZ 4	1000	77	117	**CIMA**	923	182	83	**OFFP**	1977	182	51	**O2+**	1000	125	77
DIFF	1000	154	93	**CEXP**	880	182	53	**ZZ 3**	167	91	303	**ZZ 3**	1000	63	125
GEOL	1000	154	93	**OUTI**	978	91	144	**ZZ 4**	1305	91	81	**O3+**	1000	125	96
ACC*	1000	385	67	**ZZ 1**	923	182	83	**SADO**	1977	182	51	**ZZ 4**	1000	63	87
TD	1000	308	163	**ZZ 2**	1100	91	321	**MPRO**	1977	182	51	**ZZ 5**	1000	125	58
PD	1000	154	301	**TD**	1100	91	321	**TD**	1563	273	131	**A1-***	1000	188	67
TD	1000	231	226	**PD**	968	182	201	**PD**	167	91	303	**O2-**	1000	125	77
DD	1000	231	226	**TD**	931	273	139	**TD**	1563	273	131	**DD**	1000	250	154
MH	1000	77	83	**DD**	931	273	139	**DD**	1563	273	131	**PD**	1000	188	221
				MH	968	182	201	**MH**	1100	91	303	**QD**	1000	188	221
												TD	1000	125	250
												TE	1000	250	154

Table A.1. Company 1 - Chi-square, Weight and Moment of items.

Appendix 2: Chi-square, Weight and Moment of items.

COMPANY 2

Characteristics				* **Objectives**				* **Decisions/actions**				* **2nd level analys.**			
Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom
SPCL	1000	63	158	**ZZ 1**	1231	31	47	**CFPG**	1000	33	104	**ZZ 1**	1000	30	46
SPEE	1000	63	109	**ZZ 2**	0	31	339	**ZZ 1**	1000	33	38	**ZZ 2**	1000	30	59
LEAR	1000	125	97	**ALOO**	1280	31	39	**SHOW**	1000	33	75	**O3+**	1000	61	56
STWI	1000	63	158	**CDEL**	1467	63	47	**REDM**	1000	67	45	**ZZ 3**	1000	30	46
ACCU	1000	250	158	**CIMA**	1460	94	71	**RPGR**	1000	100	126	**A2+**	1000	61	56
ZZ 1	1000	63	255	**ZZ 3**	1391	31	28	**CDZN**	1000	67	207	**C4-**	1000	61	78
CPR*	1000	375	65	**IPRO**	1818	63	27	**ZZ 2**	1000	33	75	**O4-**	1000	30	59
TD	1000	125	267	**ISET**	2141	94	29	**ROPG**	1000	100	49	**A1-**	1000	61	44
MD	1000	188	166	**ILMR**	1127	63	172	**ZZ 3**	1000	33	46	**O3-**	1000	61	51
TM	0	0	0	**QUAT**	1257	63	85	**EXPR**	1000	67	30	**A4+**	1000	91	106
QM	1000	125	49	**CPTV**	2263	94	26	**TRAI**	1000	67	63	**A3-**	1000	30	46
SM	1000	63	61	**ACCO**	3018	94	16	**ZZ 4**	1000	100	39	**ZZ 4**	1000	61	38
CD	1000	63	109	**RLAC**	2189	125	37	**ELOP**	1000	67	49	**C4+**	1000	61	44
FD	0	0	0	**ITOO**	2189	125	37	**ALO***	1000	200	54	**C2+**	1000	61	38
MM	1000	250	134	**TD**	2723	281	57	**TD**	1000	200	104	**ZZ 5**	1000	30	59
EM	1000	188	215	**MD**	2043	219	73	**MD**	1000	133	127	**O2+**	1000	61	62
				TM	1200	63	109	**TM**	1000	33	161	**A3+**	1000	61	85
				QM	0	31	339	**QM**	1000	100	81	**O1+**	1000	121	28
				SM	0	0	0	**SM**	1000	33	46	**TD**	1000	121	119
				CD	1273	63	80	**CD**	1000	133	127	**MD**	1000	152	107
				FD	1067	31	164	**FD**	1000	33	104	**TM**	1000	121	125
				MM	1730	188	90	**MM**	1000	233	76	**QM**	1000	61	118
				EM	1500	125	87	**EM**	1000	100	176	**SM**	1000	30	82
												CD	1000	152	112
												FD	1000	91	110
												MM	1000	121	119
												EM	1000	152	107

Table A.2. Company 2 - Chi-square, Weight and Moment of items.

Appendix 2: Chi-square, Weight and Moment of items.

COMPANY 3

Characteristics				**Objectives**				**Decisions/actions**				**2nd level ana.**			
Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom	Item	Chi2	Wgt	Mom
ZZ 1	918	111	123	**ZZ 1**	1000	91	115	**OFLP**	1077	71	446	**ZZ 1**	1000	77	166
OLAK	1125	111	281	**ZZ 2**	1000	91	194	**ZZ 1**	969	71	86	**ZZ 2**	1000	77	166
INPL	1125	111	281	**ZZ 3**	1000	91	194	**IRMC**	979	71	126	**ZZ 3**	1000	77	101
UNPR	918	111	123	**KEEJ**	1000	182	230	**CARD**	926	143	71	**O1-**	1000	154	103
ZZ 2	857	111	70	**RLAC**	1000	91	115	**ZZ 2**	969	71	86	**ZZ 4**	1000	77	68
SPEE	673	222	61	**UTIL**	1000	182	72	**ZZ 3**	897	143	51	**ZZ 5**	1000	154	87
MAIN	673	222	61	**IPRO**	1000	273	81	**ROUT**	953	143	111	**A3-**	1000	154	54
DG	714	333	105	**DG**	1000	273	160	**MMI***	538	286	23	**ZZ 6**	1000	77	166
DH	880	222	167	**DH**	1000	91	194	**DG**	921	286	133	**A2-**	1000	154	87
JM	1125	111	281	**JM**	1000	182	230	**DH**	953	143	111	**WF**	1000	154	235
DN	1125	111	281	**DN**	1000	182	230	**JM**	955	214	177	**FF**	1000	308	125
MP	880	222	167	**MP**	1000	273	187	**DN**	921	286	133	**TD**	1000	231	172
PF	0	0	0	**PF**	0	0	0	**MP**	1077	71	446	**MD**	1000	154	235
								PF	0	0	0	**HM**	1000	154	235

Table A.3. Company 3 - Chi-square, Weight and Moment of items.

Appendix 3: Interview Coding

Conventions

The type of characters indicates which of the first level categories were applied (Characteristics, Objectives, Decisions and Actions.) Between square brackets [] appear the initials of the first level category (C/O/D) and the subcategory defined.

Characteristics = **Bold characters.**
Objectives= Underlined characters.
Decisions and Actions = SMALL CAPITAL CHARS

A. COMPANY 1.

Quality Director

We found ourselves pretty worked out, so we decided, IF WE BUY ONE OF THESE WE CAN DO IT [TOOLS] OURSELVES IN-HOUSE [D/Machine more in-house].

There's no effect of the CNC [on the quality]. They are all in the toolroom, really. When you show the customer around they will see everything and they are impressed with it [O/Impress customer].

The toolroom became more efficient [with the introduction of CNC] [O/Efficiency]. But **the actual dimensions of the moulding they were still accurate before the machines came in [C/Accuracy].**

Technical Director.

[DECISION TO GO BACK INTO THE MOTOR TRADE] IS A LARGE COMMITMENT.[D/Concentrate on motor trade] And hence our commitment to NC and CAD/CAM, because to stay in the motor trade today you've gotta be in that sort of [set up?].

The LEARNING CURVE [FOR CNC] WAS ABOUT TWELVE MONTHS [C/Learning curve] I suppose but it was soon obvious after that that... they were tackling work as we couldn't even dream of tackling before, not the same **accuracy** [C/Accuracy] and the same **speed** [C/Speed].

Appendix 3: Coding.

YOU'RE NOT AFRAID TO TACKLE NOW COMPLICATED THREE-DIMENSIONAL WORK [D/Accept orders for complex 3D work]. The manufacturers used to supply schemes of the original master models. With NC now the information comes on computer tape [D/Accept orders on computer tape]. **We transcribe that into the CAD system and there you are** [Compatibility with CAD].

Another major thing was of course that most of the customers want now a very quick response. They want it for today or yesterday, not in three weeks time [O/Good customer relations]. SINCE YOU'VE GOT CONTROL OVER YOUR DESTINY AS IT WERE, WHEN IT COMES TO MACHINES, COMPLEX SHAPES,ETC, [WE CAN TAKE THOSE ORDERS] [D/ Accept urgent orders].

You just go in [into designing new components with CAD\CAM] with complete freedom because you know that PROVIDED YOU WORK WITHIN ACCEPTED GEOMETRICAL SHAPES, [D/ Design within CNC geometrical parameters] **the machine is gonna cope with it** [D/Produces a finite set of geometrical shapes].

Provided it's recognized geometrical arcs and curbs, then the machine will cope. [C/Produces a finite set of geometrical shapes] It's function then of the operator's ability to **input that data within the parameters of the machine** [C/ Geometrical parameters].

The chaps down there [toolroom] have got sufficient experience on the CNC 's and they've got sufficient honesty to realize their limitations vis-a-vis **the lengthy calculation needed.** [C/Needs lengthy calculations to be programmed]

WHAT THEY [TOOLMAKERS] DO NOW, THEY COME DOWN HERE WITH THE TRIG WE CAN DO IT IN A FEW MINUTES ON THE CAD, WE JUST PLOT THE POINTS ON THE CAD [D/ Use CAD to help operators with calculations] and then we can alter the dimensions. [...] SO IN EFFECT WE STILL HAVE THE HUMAN LINK AS WELL AS THE WIRE [BETWEEN CAD SYSTEM AND CNC MACHINES] [D/ Keep people involved with CNC programming/ Use CAD to programme CNC directly].

We've gotta close the loop [in quality control by integrating CAD with manufacturing, with the control of the manufactured tool and control of the moulding] [O/ Integrate production process]. **You can feed back the data at each stage and then change the programmes** [C/ Compatibility with other equipment]. This will be expected of us. We don't have any option. [O/ Satisfy customer expectations regarding technology]

We had not basically got along and said 'oh, it's about time we had CNC, it's about time we do this. It's been dictated to us by our major customer, who ultimately is Ford [O/ Satisfy customer expectations regarding technology].

Appendix 3: Coding.

Design Director

Toolroom director is the one that pushes for new technology. The managing director is the cautious one. The toolroom director doesn't like to spend money but at the same time he still likes the new technology. The technical director initially said we had to go for it. He convinced the MD and even though the toolroom director was the one in charge of the toolroom, he took even more convincing than the managing director did.

[explains toolroom director's resistance to new technology] It's human nature, if you run any area in a certain way, **if new technology comes along,** [C/ Novelty] it interferes with what you are doing. And the older you get the more you do tend to feel that way. **You can become frightened of it.** [C/]

WITH NEW TECHNOLOGY YOU TEND TO HAVE PEOPLE GOING OUT FOR TRAINING [D/], and then they come back reasonably conversant with it. JOHN ISN'T THAT CONVERSANT WITH IT. **SO HE HAS TO TAKE TO A CERTAIN DEGREE THEIR WORD TO WHAT'S GOING ON.** [D/ Trust Operators; C/ Makes control of operators more difficult]

THERE'S A LOT OF TRUST INVOLVED [IN THE USE OF CNC] [D/ Trust operators]. <u>Trusting the people will give you an honest assessment in what concerns the time required.</u> [O/ Control operators] **rather than thinking they will spend half an hour machining and then spend the next hour sitting there.** [C/ Makes control of operators more difficult]

The idea is that MOST OF THE PROGRAMMING [FOR THE CNC'S] WILL BE DONE FROM THE CAD [D/ Programme CNC from CAD]. Unless it's something simple.

[CNC] is something we knew we had to start using. IT'S SOMETHING THAT WE KNOW EVENTUALLY WE'LL TAKE OVER IN WRITING THE PROGRAMME IN THERE [CAD] [D/ Programme CNC from CAD]. But we are not rushing our way to doing that. WE'RE TAKING THINGS STEP BY STEP [D/ adopt incrementally]. **If you rush into it too much you tend to undo what you started** [C/ Difficult to adapt to].

To me one of the great benefits [of CNC] should be that you can programme the machine and then you can leave it there to run its programme [C/ Controlled by programme]. <u>We don't do that, but we should do</u> [O/ Reduce man/machine ratio].

We still treat it [CNC] in a way like an ordinary milling machine, where you've got to stand there. To me, once you set one up to the start of the programme, you shouldn't need to stand there [C/ Controlled by programme]. You can get on with something else [O/ Reduce man/machine ratio].

I think it's probably because we don't push enough on it [CNC utilization] [O/ Increase utilization]. There's a difference between a contract toolroom and an in-house toolroom. Contract toolroom does nothing but make tools, so that's the only profits they get. Our biggest profits are from the mouldings, the tools are more of a means though we still make money out of it.

We like a lot of middle size companies have realized, we've gotta have it [new technologies] otherwise our larger customers turn round and say 'well if you haven't got the latest technology I'm not interested' [O/ Satisfy customer expectation regarding technology] even though the people you are talking to probably don't even know what the thing does anyway.

With the CNC machines you can rely on the **quality and the accuracy** [C/ Accuracy] of the part that has been machined. SO YOU TEND TO MACHINE A LOT MORE BEFORE HEAT TREATMENT THAN WE USED TO [D/ machine more before heat treatment].

Toolroom Director

There's also another aspect which prompts you [to introduce CNC] in that most young men reasonably ambitious, if you haven't got CNC machinery... [are not interested in working for Co]

WE CAME TO IT SLOWLY INITIALLY [D/ Adopt slowly], in that we doubted the flexibility of **CNC with respect to budgets** [O/ Keep good financial situation; C/ Cost]. [...] We had problems in the early eighties [...] we invested heavily into buildings, if you like, with a view to filling it with machinery, which was a bad time to do it in the sense that in the early eighties we had our turnover declining.

Having put that behind [bad times in the early eighties] we became increasingly aware of the need to get CNC machinery in the toolroom to remain competitive [O/ Remain competitive]. It was a question of not going into debt [O/Keep good financial situation].

Also, increasingly it's getting difficult to get hold of the right sort of men to do it in conventional machines. So we obviously have a great deal more of efficiency with the CNC machine [C/ Overcomes lack of skilled workers].

Once you put in a part of the machinery [CNC] you tend to give rise to another imbalance [C/Unbalances work flow]. It's up to the management to see that they're introduced effectively and efficiently because they still got to relate with machinery that isn't CNC controlled [O/ Harmonize CNC and traditional machines] WHICH MEANS THAT YOU STILL HAVE SOMETHING THAT NEEDS VARYING SKILLS [D/Keep traditional skills].

I KEEP PULLING THE ONE OFF TO DO OTHER WORK, SO IT VARIES BETWEEN TWO AND THREE PEOPLE FOR THE FOUR [CNC] MACHINES [...] I SUPPOSE BY AND LARGE YOU MIGHT GET TWO AND A HALF PEOPLE [D/ Reduce man/machine ratio].

[OPERATORS] ARE INVOLVED IN PROGRAMMING [CNC's] . NOT SO COMMON IN THE CAD/CAM SITUATION, YET, BUT AT THE SAME TIME I'M KEEPING THEM INVOLVED [D/involve operators in programming], **in other words they feel part of it, they're not threatened** [C/Threatening]. And also it means that their skills are disseminated [O/Disseminate new skills throughout toolroom].

To some degree, WE ARE EDUCATING THEM [CNC OPERATORS IN THE TOOLROOM] IN THAT DESIGN OFFICE AS MUCH AS IN THE TOOLROOM [D/involve operators in programming]. **There's no problem when the design is for a geometrical shape. Our problems come when we go for totally non-geometrical shapes** [C/Produces a finite set of geometrical shapes].

[Operators programme CNC's because] You need operators' interest, don't you? [O/Motivate operators to work with CNC] It's a part of the process where, if they have any pride at all, the solutions would be efficient.

[CNC machines brought] a lot more accuracy [C/Accuracy] Certainly more efficiency] WE DO A LOT MORE THROUGHPUT THAN BEFORE [D/Increase throughput].

Production Services Director

Compared with other machines that we had [...] if I have a problem with a CNC machine and it's an electronic problem having to do with the microprocessor, there is nothing I can do whatsoever. And the only way that can be rectified is the manufacturer coming in and replacing the board [C/Difficult to repair]. And those are going at about £3,000 a piece. [C/Cost of repairs]

[Repairing the CNC machines] is a very expensive deal [C/Cost of repairs].

We are talking about German machines [C/Foreign origin]. I personally think that the facility should be made available in this country. THEY ARE SENT TO GERMANY AND THEN MONTHS BEFORE WE HEAR ABOUT THEM [D/Send machines to Germany for repairs].

I can understand a CNC machine being required for something which has got an extremely fast cycle [C/Optimal cycle length/Optimal batch size] [...] where if the manufacturer can save a tenth of a second of the cycle time, it would be worth then re-invest in new tooling completely [O/Increase utilization].

In other areas it's been marvellous [the CNC machines]. Really YOU HAVE TO MAKE SURE THAT THE JOB THAT REQUIRES DOING REQUIRES A CNC MACHINE [D/Make sure job requires CNC machine], because so much of it really is technical bullshit [O/ (re.complete sentence) Optimize utilization].

They [CNC] are very easy to run [C/Easy to run].

They [CNC] are a lot easier to set [C/easy to set].

The other difference of course is it's [CNC] similar to the robots as well.

[We went for the CNC option] to see what difference it made, to see what the difference was.

we are thinking about buying more CNC machines now. **There are certain jobs that require them, others that don't. To sum it up, you don't buy a Rolls Royce to deliver bread** [C/Optimal type of work; O/ Optimize utilization].

If you are producing a job that doesn't require tight tolerances then you use a standard machine. Whereas if you've got to achieve those tolerances you go for CNC. Because you have to remember that the machine has got a five year payback [C/ Optimal type of work/ Payback time]. If it doesn't get a five year payback then you're wasting the extra money that goes into a CNC [O/Optimize utilization].

...you must remember that we didn't realize in the first twelve to eighteen months the costs that were involved [C/Operating costs].

What we were putting down to teething problems, were heavier. **Though the companies were very quick to react to come out, to get the spares to get the [CNC] machine sorted out, because they were under warranty.. it's only when the warranty expires and you have to pay for it... bloody hell! this is costing a lot of money** [C/Cost of repairs].

There are certain things which I don't think it's right in the toolroom, I don't see why they can't have one person operating three CNC machines running through the night [O/Increase utilization]. Really, just in case it breaks down or what have you [...] it's a complete waste of time.

...you've gotta try and make sure that you almost wear those [CNC] machines out within two to three years. And you're not gonna do that with the time that we are working at the moment [O/Increase utilization].

PROBABLY THE BIGGEST THING [CHANGE BROUGHT BY CNC] IN THE TOOLROOM WAS **THE FACILITY TO REPRODUCE ACCURATELY [THE TOOLS]** [C/Accuracy]. IN A MULTI-IMPRESSION TOOL THAT'S AN ABSOLUTE MUST [D/ Produce multi-impression tools]. We have noticed differences in tooling which comes downstairs [to the presses].

SOME OF THE TOOLING WHICH REALLY WOULDN'T HAVE BEEN THOUGHT ABOUT FIVE OR TEN YEARS AGO WHICH WE'VE BEEN ABLE TO PRODUCE NOW [BECAUSE CNC WAS INTRODUCED IN THE TOOLROOM] [D/ produce different types of tools].

It's not just the introduction of CNC that happened over the last five to ten years, it's the all introduction of new technologies, the computers, the control, SPC, machine capabilities, all this sort of thing has come altogether, at once, and you have to have the one to make the other. It's all linked together.

B. COMPANY 2

Technical Director

So [I looked at] how long did it took us to grind, how long did it took us to check the components. How long it took the toolmakers to assembly them into a tool, and also to check them and then to check the [output]...

And the times were quite exorbitant but the reason was for that was we were looking for a [very high] degree of accuracy. Then the tool gets a good chance of performing, assuming the design is O.K [O/Accuracy].

...if we do manufacturing technically or not, or are we fast enough in the manufacturing to be competitive, because our product cost depends on how long we take to manufacture it [O/Speed up process/ Competitiveness]. So composing all the figures, it was obvious that we couldn't improve the speed, because the skills that we've got were very, very good. To improve the speed meant we'd got to change the method and to change the method meant we've to find the machines that were capable of giving us the accuracy and speed [O/Accuracy/Speed].

So the soft machining we decided that is gonna stay as it is, but what we now want to do is to reduce the number of parts per tool [O/Simplify design]. [...] we were splitting and grinding in half the shapes and then putting it together. **With wire work (on the CNC machine) all you need is the design to start and the machine will do the job** [C/Controlled by programme]. SO WE STARTED DOING INVESTIGATIONS [D/Monitoring of production system efficiency].

[CAD] MADE THE GAINS ON THE DESIGN SIDE BECAUSE THE CALCULATIONS INSTEAD OF DOING IN THE OLD WAYS WE DID IT WITH THE CALCULATOR, IT WAS ALL DONE BY THE COMPUTER, ANYWAY [D/Design on CAD]. SO ALL ANGLES AND VARIATIONS OF THINGS COULD BE WORKED THERE IMMEDIATELY, RATHER THAN SOMEBODY CHECK IT AS WELL [D/Eliminate calculations check]. So we could improve the design facilities, we could improve the presentation of the drawings, the clarity of the drawings, the consistency of the drawings where we were not relying on a man on the board, the machine was doing it. So everything would begin to come together.

WE HAD QUITE AN EXTENSIVE PERIOD OF TRAINING WHERE THE PERSONNEL OFFICER WAS INVOLVED [D/Training] and so were SELECTED PEOPLE OF THE SHOPFLOOR TO RUN THE MACHINE, AND ALL SORTS OF PROGRAMMES OF THE MACHINE [D/Select people for CNC operation]. THIS WAS ASSISTED BY AN EEC GRANT FOR NEW TECHNOLOGY AND THEY HELP US IN ALL THIS [D/Get EEC grant for training] [...] And the Company is investing in new technology that will help with the training, not with the costs of the machine, but with training of personnel involved.

the objective is to try to upgrade the training of everyone in engineering, so they [EEC] offer the granting system. [...] So it helped us too, to make sure we still prepare these people.

AT THE MOMENT WE PRODUCE THE TAPES OFF A LITTLE COMPUTER, OFF THE COMPUTER THAT CAME WITH THE WIRE ERODER [C/Includes small computer; D/programme on CNC machine]. But now, we will make that redundant to produce tapes off the CAD, with the NC facility on the software. So we, will take in that by stages, so we solve each problem as we go [O/Programme from CAD]. And eventually we will modify our wire eroder so that we can put disks in there, that is the next step [O/Put disk drives in wire eroder].

But because we are a small Company, because we work to order, then we prove each step as we go. We are cautious, but nevertheless we are making in roads into new technology. And there is no doubt that if the CAD by itself helped enormously, the wire erosion has in fact reduced the costs of tooling. I would think about 15%, 18%. On some tools we could make something a 50% reduction, depends on the nature and the complexity of the tool [O/Reduce tooling costs]. **The more complex the more the gains can be** [C/More efficient with more complex tools].

The other advantage with the wire eroder is, in theory, it will run for 80 hours on one man operation [C/controlled by computer]. [...] WE CAN PRODUCE A TAPE AND IF IT IS A JOB THAT WE ESTIMATED GOT TO 20 HOURS OF WIRE EROSION, WE CAN PUT IT ON FRIDAY AFTERNOON AND MADE IT RUN TROUGH THE WEEKEND. AND ON MONDAY WHEN WE COME BACK IT IS FINISHED [D/Run CNC unattended].

WE SET A SHIFT SYSTEM WHERE THE OPERATOR IF HE'S GOT TO COMPLETE, IF HE GOT A JOB ON WHICH MIGHT FINISH IN THE MIDDLE OF THE NIGHT OR EARLY IN THE MORNING, WE'VE GOT A SYSTEM WHERE HE COMES BACK AT 10 OR 11 AT NIGHT, AND PUT ANOTHER JOB ON, OR CHECK IF THE ONE THAT IS RUNNING IS O.K. [D/set shift system] And in that way we can ensure the continuity of the machine and we can ensure that we are getting on [O/increase CNC utilization].

WELL, I'VE DONE REALLY ALL THE STUDIES AND SET UP THE SHEETS WHERE WE COULD WRITE THE ESTIMATED TIMES TO PRODUCE THE PART AND THE ACTUAL TIMES AND THE DRAWING OFFICE WOULD FOLLOW THAT UP [D/introduce control sheets]. On each detail that we drew on the tool sheet we put a stamp asking the operator to put down the times he takes to run the detail, and so on.[...] If the estimated times started to..., the practical times were far exceeding the estimated times we have to go down and watch the machine and who is doing the job, and ask him why is it taking so long [O/increase control of operators]. [...] if you are saying to a man drawing that and I want to know how long it takes, that man might not always work as fast as he could do because you are watching him. So you have to be very cautious how you deal with people, that has to be very tactical [O/Keep good relations with workforce].

WE FIRST OF ALL SENT A LOT OF PEOPLE AWAY, IN THIS CASE WITH THE WIRE ERODER. SO WE SENT THE TOOLMAKER AND THE MACHINIST TO AGIE FOR 5 DAYS FOR A TRAINING COURSE, PRIOR TO HAVING THE MACHINES HERE [D/training before implementation].

We only do the tools needed to produce the components. We do occasionally make tools only, for other people. But very rare. And if we make a tool we make sure it is not for a competitor.

WE TRIED TO GET INTO THE NEW TECHNOLOGY ON THE ELECTRONIC COMPONENTS WHICH IS THE CLOSEST CONNECTED [TO WHAT WE DO NOW] [D/try to enter new markets; O/Enter new markets].

Instead of doing trial work, because we didn't have the time we went straight into producing new tools [...] and that was reasonably successful for us, we didn't lose any parts. [...] WE ALSO FOUND THAT **A LOT OF THE PARTS THAT WE HAD TO BUY FROM AGIE [FOR MAINTENANCE]** WE COULD IN FACT MACHINE OURSELVES MORE CHEAPLY [C/ Cost of maintenance; O/ Reduce costs of CNC maintenance; D/machine parts for the CNC machine].

AND THEN, AFTER THE GUARANTEE PERIOD WE THEN BEGAN TO LOOK FOR OTHER PEOPLE'S WIRE [D/Look for wire other than Agie's] **that was cheaper** [C/cost of wire for CNC] and we had no problems so we continue to use it [O/Reduce running costs].

WE SENT TWO OPERATORS AND A SUPERVISOR [TO TRAINING]. THAT WAS ON THE WIRE ERODER [D/Training for CNC operation]. WE SENT ONE MEN FROM THE OFFICE ON THE PROGRAMMING OF THE MACHINE [D/Training for programming].

...machine shop supervisor went on the machinists course, as a wire eroder, so we could supervise the machine in this operation. AND HE IN FACT WILL SET THE MACHINE AND OPERATE IT IF WE HAD A PROBLEM WITH THE OPERATOR BEING AWAY. SO WE USE HIM AS A BACKUP ON THE MACHINE [D/replicate CNC skills].

the chief designer does training on the wire eroder programming. THERE ARE TWO DISTINCT FUNCTIONS: PROGRAMMING FOR THE TAPE AND THE MACHINE OPERATION ITSELF. AND WE STILL KEEP THEM SEPARATED [D/ separate programming from operation]. ALTHOUGH WE HAVE TAKEN THE MACHINIST TO BE USED TO PROGRAMME [...] BUT VERY SLOW AT THE MOMENT [D/some training on programming for operators]. [...] But in an emergency yes [he could programme] [O/Have backup skills]

One of the disadvantages with the new machine and new technologies is that you train people and then they go somewhere else and get more money. Because their experience now is too valuable for a small company.

I ALSO IMPLEMENTED AN INTENSIVE APPRENTICESHIP TRAINING SYSTEM [D/implement training system], because you could see what is going to happen to us. So what do you do? YOU EITHER GO OUT FOR MORE MONEY, WHICH CREATES PROBLEMS TO THE COMPANY OR YOU'VE GOT TO START TRAINING PEOPLE FOR THE EVENTUALITY OF THEY LEAVING. WE DECIDED TO START TRAINING MORE APPRENTICES SO THAT WAS SOMETHING AGAIN I STARTED [D/replicate CNC skills].

WE TRAIN THEM IN-HOUSE NOW. IT IS BRIAN, AND IN THIS CASE ON THE WIRE ERODER IT WILL BE THE MACHINISTS THAT WE'VE GOT TO SPEAK TO. SO WE USE THE MAN WHO IS OPERATING EVERYDAY, WE ALSO USE THE SUPERVISOR [D/use skilled operators to train apprentices]. WE HAVE A TRAINING OFFICER WHICH COMES INTO US ONCE A WEEK, TO ENSURE THAT THE TRAINING IS

DONE CORRECTLY FOR THE APPRENTICES [D/Contract out training officer].

and HE COMES AND MAKES SURE ALL THE TRAINING IS DONE CORRECTLY, ALL THE PROCEDURES ARE BEING FOLLOWED. BECAUSE WE ALSO SEND APPRENTICES TO COLLEGE, THEY ARE ONE DAY AT LEAST AT COLLEGE TO GO ON FOR CERTIFICATES [D/contract out training officer]. [...] At the moment we have two apprentices in the shop, we've just lost one again for more money, he's going to another Company. WE HAVE TWO COMING THROUGH AND ONE IS GOING TO BE RAINED IN THE DRAWING OFFICE. SO HE WILL BE GOING THROUGH THE TOOLROOM MORE QUICKLY THAN NORMAL. AND HE WILL GO THROUGH THE ESTIMATING, THE FINANCE DEPARTMENT, THE DRAWING OFFICE, HE WILL GO TO THE SALES OFFICE, AND SO ON [D/give some apprentices wide range of skills].

The other advantage with the wire eroder is that because most of our product runs into millions [...] gives us the speed. ALSO, GIVES US THE FACILITY TO MAKE SPARES [D/machine more spare tools]. So we can now put spares on the shelf and if a tool breaks for any reason and it needs a lot of work, you know, you might just put a new spare, take the old one out and then work on the old. IT ALSO GIVES US THE ADVANTAGE WHERE WE CAN MAKE PROTOTYPE COMPONENTS VERY QUICKLY [D/make more prototype components]. [...] WE ALSO OFFER A CONTRACT SERVICE TO THE PEOPLE ON WIRE EROSION, WHICH WE COULDN'T DO BEFORE [D/Offer contract service re wire erosion], <u>and we now look for the wire erosion machine to earn us something in the order of four to five thousand pounds a year in contract work. So when the machine is idle we can do work for other people, and we have done work for example to India, where we wire eroded polycrystalline diamond</u> [O/increase machine utilization].

AND WE ALSO OFFER TO OUR CUSTOMERS WIRE ERODER SERVICE FOR THEM, ON THEIR TOOLS. IF THEY SEND US DRAWINGS WE WILL MAKE THE PARTS FOR THEM. WE ALSO OFFER BECAUSE OF THE WIRE ERODER A SERVICE TO JAPANESE COMPANIES, LIKE MAXWELL, WHO USE CARBIDE CUTTERS TO CUT UP SERIES OF COMPONENTS FOR ASSEMBLY. WE MAY CUT THIS FOR THEM. AT THE MOMENT WE ARE GOING TO MAKE TWENTY CUTTERS FOR THEM [D/Offer contract service re wire erosion].

The unexpected problems we had with the wire eroder was when we were cutting carbide, to get the finish that we wanted, with the limited experience that we had was quite dramatic. WE HAD TO DEVELOP OUR OWN TECHNOLOGY AND WHILE THAT WE HAD TO DEVELOP A NUMBER OF CUTS [D/develop new processes]. Depending on the number of cuts, and how much you would take out at each cut, can give you improvements on the accuracy and the finish of the part.

WE BUY [CARBIDE] FROM THE COMPANIES THAT MAKE IT, AND WE SEND THEM A DETAIL FORM, AND THEY WILL SEND US BLOCKS, CLOSE TO THE SHAPE AND THEY STILL LEAVE A LOT OF MATERIAL TO BE REMOVED. AND USED TO BE ALL DISTORTED AND TWISTED AND IN SOME CASES JUST SCRAP. NOW WE CAN BUY A BLOCK [D/buy carbide in larger blocks], <u>and wire erode</u>

pieces out of the block, so it's another knock on the costs of carbide that we used by buying a big block [O/Reduce costs in carbide for tools].

There were various aspects to look at for savings, one is manpower savings [O/reduce labour costs], time on the design for the wire eroder [O/reduce time in design], time for the operator to set up and produce components [O/reduce time for machine set up]. Time on for the toolmaker, that now gets least pieces to check and take to the grinding machine [O/Reduce time in assembly]. Cost of material, that was the other area we've looked at, and the only saving we can do on the cost material was instead of buying individual components in carbide, we buy a block and cut out the components, so we did cover that as well [O/reduce costs in carbide for tools].

[THE WORK FORCE] WEREN'T SURE WHETHER WE COULD GET THE ACCURACY THAT THEY LIKE TO SEE COMING FROM THE OPG WORK (OPTICAL PROFILE GRINDING), FROM SURFACE GRINDING. SO WE HAD A LOT OF RETICENCES FROM THE GRINDING AREA, FROM THE BENCH AREA. AND IT HAD TO BE PROVED TO THEM THAT WE COULD DO THE JOB AND GIVE IT TO THEM AS THEY WANTED [D/reassure workforce of quality of wire eroded parts].

At the time we were very busy and I don't think people felt the implementation of this machine as an adverse technology. If you put the machine in lime that when you are very quiet, then they might think you want to get rid of people [O/keep good relations with workforce]. BUT IT WAS EXPLAINED TO THE WORKFORCE, I HAD A MEETING WITH ALL THE TOOLMAKERS AND THE ENGINEERING SIDE, TO TELL THEM WHAT WE WERE DOING, AND I EXPLAINED, AS FAR AS THE MANAGEMENT OF THE COMPANY WAS CONCERNED, IT WILL ONLY HELP TO ENHANCE THE THROUGHPUT OF THE JOB AND THEREFORE GIVE US THE CAPACITY TO TAKE EVEN MORE WORK [D/explain workforce Company plans]. And that is the genuine...

Most of the skilled men that we've got had been with us for a great number of years, some as much as twenty years. And as such, they've grown with the accuracy of component tools, and they really are excellent people, and our problem is just make sure we can hold them to us [O/retain skilled workers]. And we are a close knit company and departments do get on well together. I, we like to think that everybody is hoping for the bonus, which is production related, so everybody makes an effort.

So the objective of the company, through my point of view as technical director is to we design around the latest equipment to the best of our experience and knowledge to produce a tool that can produce millions. So my objective is to put into that press the best possible tool that we can design and manufacture to run the best possible component at the best possible speed [O/produce high-performance tools].

Managing Director

the original machines required an operator to be with them all the time and insofar as ... they were good and they were accurate and they had this limitation actually that you couldn't programme them and leave them to run all night or the weekend [O/run machines unattended]. **And so when Agie brought out the new 100 which was self-threading and much more accurate than the biggest ones** [C/Accuracy/Self-threading] we decided that in spite of the cost which was quite considerable for a firm of this size it would be advantageous to install it. It was a board decision really, the technical director came up with one or two costings of punch and dye assemblies done on the Agie and how we did them originally, which was splitting and grinding, the final grinding which was made on the optical profile grinding... although these machines are quite accurate [O/Accuracy] **they haven't got the automatic repeatability of the CNC wire eroder** [C/Repeatability] nor can you leave them running without an operator [O/run machine unattended]. SO WE ALWAYS HAVE A BIG FORWARD LOAD. WE'VE GOT THREE OPTICAL GRINDING MACHINES AND THEY WERE ALWAYS OVERLOADED [D/reduce bottleneck in OPG]. Punches and dyes still have to be picked out for final adjustment but whereas **with the wire eroder we hardly ever have to do any final adjustment** [C/accuracy]. They come straight off the machine finished.[33]

THE LONGEST PROGRAMME WE HAD WAS THIRTY-FOUR AND A HALF HOURS CONTINUOUS SPARK EROSION. WE LEFT IT ON A FRIDAY EVENING, CAME BACK MONDAY MORNING AND IT HAD COMPLETED THE PROGRAMME [D/run machine unattended]. The man concerned, the operator did come from time to time to have a look and see if it was behaving itself but he didn't touch it. But it meant that we were doing... if we had done it by grinding it would probably had taken something like in between three hundred and fifty to four hundred and fifty hours. **So although the investment was big the actual later savings and the fact that the machine will run when there's nobody here. And that is the big bonus** [C/Controlled by programme; O/ Run machine unattended].[53]

...most of the tools we make are progression tools and we have to have a series of very accurate tracking pilots to register the material. We put a round hole right at the very beginning and these holes have to be accurately placed according to the pitch of the tool [O/Accuracy]. [...] We used to put those in the soft state using milling machine and after dyes had been hardened they would then have to be finished off on a jig grinder. WE NOW JIG DRILL THE HOLES IN THE SOFT STAGE ON A MILLING MACHINE, A MUCH SMALLER HOLE, AND THEN WE AFTER HARDENING WE

THEN PUT THEM ON THE AGIE, INSTEAD OF A JIG GRINDER, AND THE AGIE MAKE PERFECT ROUND HOLES ALL THE WAY DOWN THE PROGRESSION TOOL [D/make more operations after heat treatment]. **And on a ten inch square it's accurate to two microns** [C/accuracy]. [89]

SO FROM THE POINT OF VIEW OF DECISION MAKING WE SOLD THE JIG GRINDER AS SUPERFLUOUS [D/SELL REDUNDANT MACHINES] AND ALSO WE SAVED THE JIG GRINDER OPERATOR, WHICH WAS EXPENSIVE [D/ELIMINATE ONE POSITION]. WE COULD IN ACTUAL FACT, HONESTLY SAYING, WE COULD SAVE UP TO THREE OR FOUR MEN WHEN WE PUT THAT MACHINE IN [O/REDUCE LABOUR COSTS]. WE DIDN'T ACTUALLY DISMISS ANYBODY, IT WAS REALLY A QUESTION OF... IF TODAY WE HADN'T GOT A WIRE ERODER WE HAD RELY ON OLD FASHIONED METHODS. WE'D HAVE FOUR MORE EXTRA MEN. NOT SUCH A GOOD SERVICE, ARE THEY?[116]

We were getting very worried about whether we were competitive or not [O/Competitiveness]. BECAUSE THE OLD METHOD OF GRINDING IS VERY, VERY TIME CONSUMING. AND... IT'S QUITE ACCURATE BUT ... SOME TOOLS MAY HAVE UP TO A HUNDRED PROGRESSIONS [...]. TO MAKE THAT BY GRINDING WOULD BE EXTREMELY DIFFICULT [D/substitute grinding by wire erosion]. The final debugging of the tool would take a long long time, because we are looking at a few tenths here and there [O/Reduce times producing tools]. **Whereas we were able to wire erode big sections on the basis that they were within two microns of each other so the in-built accuracy of the machine produced the end result without a great deal of debugging** [C/accuracy].[176]

If you didn't have CAD and CNC wire erosion making dyes and punches I doubt very much that you'd get this long running business which we have. They [continental and international companies] wouldn't deal who haven't invested in that type of plant because they would show a lack of management efficiency, that'd show a lack of wise investment, and it would probably show that you weren't making the sort of profits which they would look at [O/Be perceived as an efficient company].[386]

I'd say that it [CNC] makes it easier to run the company because delivery dates are more reliable . If somebody telephones and says 'can you delivery a tool or components' and you know that that tool is right we know that the components and the tool are right you have a more reliable operation [O/INcrease reliability in delivery times]. In the old days you couldn't always be sure that the toolmakers would finish that tool or maintain it for that particular day.[410]

Toolroom Manager

...there is no doubt that the wire eroder has up to a point revolutionized our thinking about the way we go around making a tool. WE DON'T HAVE SO MANY SPLIT SECTIONS IN A TOOL AS WE HAD BEFORE [D/simplify tool design]. [256]

[my job] has changed, because there's not so many sections in the tool. Which simplifies the checking. We've saved time from the checking point of view. We save time with the build-up of the dye or the stripper. We may have had twenty, thirty, forty or more split sections in an average build-up. Now we may have only two or three plates [O/reduce time checking tools]. It's more simple than it was before. Nevertheless I'm still looking for the total accuracy of build-up that we had to have before. Because that's the only way that we get the performance that we are after [O/accuracy of tool].[333]

Quality Assurance Manager

[155] I CAN'T THINK OF A PROBLEM [CONCERNED WITH THE INTRODUCTION OF CNC] EXCEPT FOR THE AMOUNTS OF TRAINING THAT WAS REQUIRED [D/training operators] and... when you train a person up to that level of technology it makes them more marketable to competitors. AND YOU HAVE TO CHOOSE PEOPLE WITH PROVEN LOYALTY [D/ Choose loyal people for training]. Because whenever there is a new field of technology open to industry, normally the experts get in on the ground floor and are very quickly elevated to the higher salary levels.[...] **The other thing I think is that it has an increased effect on the amount of control the designer has over the making of the tool. He can express quite clearly to the machine himself what he wants rather than leave it to the... just leave it to the handworking skill of the hands-on traditional grinding [C/controlled by computer; O/ increase designer control over machining]. Also of course there is the repeatability that gives better product conformance because once the programme is written for the machine you know that you can repeat that block of metal for that tool over and over again [C/repeatability]. There's gonna be no difference between grinders and grinding machines... It narrows down the variability of the tool pieces themselves [C/accuracy]. I think you see a greater consistency in the output from the tool [O/accuracy of final product].[188]**

[191] **And because you can just put the same tape and get a replacement part that is exactly the same as the previous one** [C/repeatability] then not only is the manufacture of the part simplified but you ... consistency of the product is also improved because you haven't got to rely on the ability of different grinders and so on [O/increase designer control over machining]. At one time there was a case where only one

grinder could do one particular difficult job. So unless he was able to do it, the tools couldn't function. So we got away from that syndrome now [O/decrease relevance of traditional skills]. **We've got a machine that thinks for itself and can interpret the tape** [C/controlled by computer] and produce the part and [has] the necessary skill of the grinder.[201]

[204] AND YOU CAN ALSO HAVE PIECES AND SPARES ON THE SHELF MORE EASILY BECAUSE YOU CAN DEVOTE A MACHINE'S TIME MORE EASILY THEN THE HUMAN BEING THAT YOU NEED [D/machine more spares]. OVERNIGHT, THROUGH THE LUNCH HOUR, WHATEVER [D/run machine unattended].[208]

[232] **I think [with CNC] you get a bit more confident in the repeatability of the tool** [C/repeatability]. For instance IF YOU KNOW A TOOL IS WORN YOU DON'T THINK TOO DEEPLY IN THE AMOUNT OF WORK YOU'RE GONNA INTRODUCE IN THE ENGINEERING DEPARTMENT. YOU KNOW THAT THEY'VE GOT THE FACILITY TO GIVE YOU AN IMMEDIATE BACKUP, SPARE PART OR WHATEVER [D/machine more spares]. You think rather than risk the quality of the production you can quite easily get that tool repaired more quickly than in the traditional way [O/accuracy of final product].[240]

[248] I think it's good for morale in the department, for them to see new technology being brought into the company. They don't feel as though the company is being left behind. [253]

[262] When a member of the company can see new technology being installed, in the way of computer-aided design, wire erosion, laser measurements, automatic packaging, and investing pouring into business rather than drifting out through the other channels, I think it gives them more of a satisfying feeling that they are working for the right sort of company.[269]

Production Engineering Manager

[288] I'VE SEEN CHANGES DUE TO ITS INTRODUCTION: THE NATURE OF THE TOOL HAS CHANGED, THE DESIGN OLD THE TOOL IS CHANGED [D/change tool design]. [...] It sometimes makes the running of the tool a little more difficult. [...] I can see changes in the way the work load is in the toolroom. I can remember to be a bottleneck in one area, now that's gone. YOU'RE ALWAYS WAITING FOR SOMETHING TO BE DONE IN THE OPG (OPTICAL PROFILE GRINDING) GRINDERS, THERE WAS ALWAYS A BOTTLENECK THERE. NOW THE WIRE ERODER HAS TAKEN OUT SO MUCH WORK FROM THAT AREA THAT YOU'RE NEVER WAITING FOR ANYTHING NOW [D/reduce bottleneck in OPG]. It makes my job easier because if a tool comes out with a problem or if we break something we can be back in circulation a lot quicker [O/reduce downtime in presses]. [307]

[320] The OPG grinder wouldn't actually made the block. From the wire eroder they get a completely finished block, with all the forms finished and holes put in... [325]

342 **I think everybody is impressed by the technology [the CNC] by what it's supposed to be able to do. But it takes probably six to twelve months to get it accepted. So they feel comfortable with it, they may take finished work off this and use it and feel happy about it. I think it takes that sort of time** [C/learning curve] [348]

367] the problem is we were trying to duplicate what was coming off the grinders... it's a different process, isn't it? We weren't saying 'this is a wire eroded part' and accepting it, we would say 'Well it's always been grind finish, grind part' I mean it's exactly how we wanted it BECAUSE WE KNOW HOW WE WANTED IT, WE WERE IN CONTROL OF THE GRINDING. BUT WE ARE NOT REALLY IN CONTROL OF THE WIRE ERODING [D/less control from engineering department]. **That's the idea of it... it runs itself!** [C/controlled by computer] You look at what comes off. That's the grey area.. getting over that period. If you're having, starting apprentices now, where that's a functional machine, they wouldn't know any difference, that's the part they would see and that's acceptable. In a way that's like a miracle to toolmaking, wire erosion, it's made a massive difference.[385]

[388] I think that [bottleneck in toolmaking] was the major reason [for investing in CNC]. <u>But I think it was really to be competitive, to be seen to be competitive</u> [O/competitiveness/ Be perceived as efficient Company]. To be competitive in the market by being able to react quickly to changes, dye form, use a lot more carbide, it's more difficult to [@393?] it's no longer really on the wire eroder, they can change the quality of the tool quickly... and safely and accurately. I think it was needed generally. THAT TECHNOLOGY WAS REQUIRED REALLY SO YOU COULD SIMPLIFY YOUR TOOL DESIGN [D/simplify tool design], SIMPLIFY YOUR TOOL MANUFACTURING AND [D/simplify tool manufacturing] <u>shorten the time, delivery time</u> [O/reduce delivery time].[400]

[581] We have used the CNC machine to help people making parts, you know, making the line [new diskette shutter line with automatic cleaning and packaging] we have used their capacity and skill. So it does help where we can on that line. **It's very, very specialized a CNC machine it's really... it'll really only help the toolroom in the short run** [C/specialized machine]. But in the long run it will help the press shop. It's not directly related to anything that goes on in the press shop. We can benefit from extra tooling, in the end of the day, quicker faster tooling. [594]

Production Services Manager

[67] WITH THE WIRE ERODER YOU MAKE A MUCH FASTER TURNOVER WHEREAS BEFORE, YOU KNOW, OPTICAL GRINDING, PROFILE GRINDING, A LOT OF STUFF IS DONE ON THE WIRE ERODER THAT CAN BE SET ABOUT THE NIGHT, THAT PASSED IT WILL BE THERE WAITING THE NEXT MORNING AND THE TOOL CAN BE ASSEMBLED [D/run machine unattended]. So obviously it does help enormously maintenance of tools.[72]

[74] **Whereas before you had an operator on an optical grinder doing it by hand if you like, it now can be set up on the wire eroder, programmed [C/controlled by computer] and machined overnight [D/run machine unattended]. [...] It's speeding up the maintenance and it's giving us the opportunity to do other work [...?]**

Commercial director

[142] I SHOW A LOT OF CUSTOMERS OR POTENTIAL CUSTOMERS OF THE COMPANY [D/show machine to customers] whenever they see that equipment they always... I regard this as a sale value, in the same way that the technical director is. If the customer has got the time to go around the factory with the technical director than that's a big part of the sale [O/impress customer]. A difficulty we have in generating new business is we have to persuade the customer to put a third down, normally if the tool is gonna cost thirty thousand we want ten thousand pounds with his order. And he's not gonna see anything for about six weeks, not even the drawings... and you've gotta have some good arguments. And this sort of thing, the input of the Agie and CAD, on a good day the presses all running, and a technical person like the technical director to talk to, it's a good sale value [O/impress customer].[157]

[163] FIRSTLY, WE USED TO HAVE FOUR MEN ON OPTICAL PROFILE GRINDING. I THINK WE NOW MAY HAVE TWO, ONE OF THEM DOUBLES ON THE AGIE [D/reduce OPG operators]. SO, IT'S SAVED MANPOWER [D/reduce man/machine ratio; O/ Reduce labour costs]. **It's also very accurate** [C/accuracy]. [...] THE OTHER THING IS IT CAN BE OPERATED WITHOUT A MAN. WITH THE RIGHT JOB, WE CAN SET UP ON A FRIDAY AND WITH VERY LITTLE ATTENTION ON MONDAY A BIG COMPLEX JOB WHICH WOULD HAVE TAKEN VERY MUCH LONGER IN THE TRADITIONAL WAY WILL BE READY. NO SWEAT [D/run machine unattended].[177]

Financial Director

[113] FROM MY VIEWPOINT WE DEFINITELY SEEM TO BE GETTING BY WITH FEWER PEOPLE IN THE TOOLROOM, PARTICULARLY IN THE MACHINING SIDE [D/reduce

people in toolroom], but I've never quantified it [...] because the work loads vary so much... the amount of work particularly on making new tools in the company just varies enormously from one month to the next, from one year to the next, we are not like a toolmaking company who survives on the amount of tools it makes. Our prime business is making presswork, a secondary side is making the tools to make that presswork. Most of the time saved on the wire eroder machine is on new tooling, making new blocks of metal.[127]

[153] Any sort of new machinery it really gives a boost to the workforce because we all work in a very old, inefficient building and when the workforce sees that sort of investment going in I think it stops them believing they could get pushed into... stops them believing that we really are old fashioned and a little backwards a company that all the world is passing us by... it makes them proud that they are living in the twentieth century, we are looking at the future [O/be perceived by workforce as efficient company]...[164]

Toolroom Machining Manager

[@9] [THE CNC WIRE ERODER] IT ALLOWS US TO DO THAT [SPARE PARTS FOR TOOLS] AND IT ALLOWS US TO DO THAT VERY QUICKLY [D/machine more spares]. To replace conventionally a broken dye, we have to surface grind it, probably optical profile grind it, fit it,... so there is an element of gain due that someone will make a mistake somewhere on the line and therefore you can only make that part in the number of hours that you've got in the working day, i. e. we do eight hours a day. So unless the guys work over we're stuck with those eight hours. **Where the wire eroder is concerned, we can wire erode 24 hours a day [C/controlled by programme]. So we can actually put a part at two or three o'clock during the day come in the next morning and it's finished [D/run machine unattended]. And ready to go straight into the tool and back into the press shop [O/reduce downtime in presses].[@22]**

[@198] The changes everybody noticed, and certainly from my point of view, **within the normal learning curve for the new CNC machine, that will be probably six months** [C/learning curve for CNC], we were able to produce very intricate parts very quickly. WE HAD FOUR OPTICAL GRINDERS, THAT'S A VERY SKILLED JOB IN THE TOOLROOM, SO WE HAD FOUR OPERATORS. WE WORK NOW WITH ONE FULL TIME OPERATOR AND A PART-TIME OPERATOR [D/REDUCE OPG GRINDERS/ REDUCE MAN/MACHINE RATIO]. So, VIRTUALLY, WE CUT THAT AREA DOWN TO ONE AND A HALF PERSONNEL INSTEAD OF FOUR. SO THERE'S VAST SAVINGS FROM THAT POINT OF VIEW [O/REDUCE LABOUR COSTS]. THERE WERE NO REDUNDANCIES BECAUSE WE USE THAT LABOUR ELSEWHERE AND NATURAL WASTAGE [D/RETAIN OPG GRINDERS].[@215]

[@226] WE STILL RETAIN SOME OF THE OPTICAL GRINDERS. BECAUSE WE STILL HAVE TO USE THEM. THE WIRE ERODER HASN'T COMPLETELY REPLACED ALL THE JOBS. IT'S REPLACED PROBABLY 70% OF THEM fci[D/retain OPG grinders]. **It's the speed of the machine which is so useful to us** [C/speed].[@229]

[241] In the larger companies there is some bad feelings about innovations. But I think within this company we were in the position where we could have either employed more people, i.e. we could have employed a couple of optical profile grinders or we spent money in the wire erode. AND I THINK EVERYBODY REALIZES THAT IN THOSE AREAS, PARTICULARLY THE OPTICAL PROFILE GRINDING AREA WE WERE NEVER ON TOP OF THE JOB, WE WERE ALWAYS STRUGGLING TO PRODUCE THE PARTS. SO WITH THE ADVENT OF THE WIRE ERODE, EVERYBODY COULD SEE THAT WE WERE MAKING PARTS QUICKER [D/REDUCE BOTTLENECK IN OPG] AND IN RETURN WE DO HAVE A PROFIT SHARE SCHEME AND IT DID HELP WITH THE PROFIT SHARE BECAUSE WE WERE DOING THE PARTS QUICKER, REPLACE THEM QUICKER AND TO GIVEN DIMENSIONS [O/INCREASE PROFITS TO BE SHARED; C/SPEED/ ACCURACY].[260]

[275] ...AND THIS IS ONE OF THE TOOLS [FOR THE NEW PRESS SHOP] WE NEED TO HAVE QUITE A NUMBER OF SPARE PARTS FOR. AND WE CAN MAKE THEM TO THE DRAWING. VIRTUALLY EVERYTHING IS MADE ON THE CNC MACHINE, AND WE CAN TURN THEM ROUND VERY QUICKLY fci[D/machine more spares].[279]

[286]I could virtually name all the parts in most of the tools, how many have we got, have we got any spares... I'll have to answer you, and I normally can, directly. That's where the wire erode is really [289?]. There was no problems with the workforce, as I said, because we didn't make anyone redundant [295].

[298] [Profit sharing scheme] WHEN I FIRST STARTED IN THE COMPANY IT WAS VERY LOW, OCCASIONALLY: 10%, NOTHING, ONE OR TWO PERCENT NEXT MONTH, THEN NOTHING... AND THEN IT STARTED TO CLIMB. PROBABLY TWO OR THREE YEARS AGO WE PROBABLY WERE GETTING FIFTY, TWENTY PERCENT WHICH IS WELL WORTH HAVING, ISN'T IT? fci[D/increased profits were shared] and the company, you can imagine, the company is doing very well. And part of that was due to the wire eroder [O/increase profits to be shared], **a machine that is able to able to replace parts very quickly, very accurately [C/Speed/Accuracy]**

[428] We had one or two problems with the machine, it was a new machine on the market, I think we had the second machine which came into Britain. So it was a very new machine and we had one or two teething problems, so within certainly four to five months we were up and running, we were producing the parts that were required but all the time you learn. YOU LEARN FROM YOU KNOW THE TECHNIQUES AND INTRODUCE YOUR OWN IDEAS TO THE MACHINE, FROM THE POINT OF VIEW OF PROGRAMMING IT AND OPERATING IT [D/EXPERIMENT WITH THE MACHINE], THAT OTHER COMPANIES MAY NOT USE. BUT ONLY BECAUSE

WE REQUIRE THE ACCURACY THAT OTHER COMPANIES MAY NOT REQUIRE [O/ACCURACY].[444]

[499] I myself went there [CNC manufacturer's course]. WE CHOSE INITIALLY ONE OF THE BENCH HANDS WHO WAS APPROXIMATELY 32 YEARS OF AGE, HE'D GOT A VAST AMOUNT OF EXPERIENCE IN THE TOOLMAKING SIDE, AND WE THOUGHT HE'D BE THE IDEAL TRAINEE [D/choose experienced bench hand for CNC]. So we both went onto the course, then when we arrived back he left within a few weeks of coming back. [...] We now have a full time operator, a back-up operator and myself. I discuss the wire eroding with the technical director.[526]

[553] **Our operator isn't employed 100% of his time on the CNC machine. Because it's a CNC machine it will work on its own** [C/controlled by programme]. AND SO THEREFORE, WHILE IT IS ACTUALLY RUNNING WE WILL PUT HIM ON ANOTHER MACHINE, SURFACE GRINDING OR PROFILE GRINDING AGAIN [D/reduce man/machine ratio]...we will find him another work to do while that machine is working automatically. <u>So there's a great saving there, virtually getting two jobs for one</u> [O/reduce labour costs]. Now not a lot of companies would do that, certainly some of the bigger companies wouldn't do that, but we do, because we have to. <u>We have to be very cost-effective in our use of our labour</u> [O/use labour cost-effectively].[561]

[702] when I say I'll have to make some decision of where we're gonna make a part because of the CNC machine, it makes it easier for me to decide. And we can save a lot of machining hours. It's very easy now to decide

[27] <u>We bought the wire eroder because we knew it would speed up the production of parts</u> [O/speed up production of parts]. AND WE ARE LOOKING AT OTHER AREAS NOW TO DO THE SAME. WE HAVE SENT OUT PARTS FOR [?30] BUT WE MUST MAKE SURE THAT THEY CAN DO THEM QUICKER SO THAT WE WILL MAKE MORE MONEY AND THE PARTS QUICKER [D/look for other improvements in technology]. [33]

[35] because we only make one offs, that's our really problem... when I say one offs, where the wire eroder is concerned we make more than one we also make spares for the tools. <u>WHEN WE MAKE ONE NEW TOOLS, SO THEREFORE FROM THE SOFT MACHINING AREA, WE ONLY MAKE ONE PART ONCE AND WE NEVER NEED TO REPLACE THAT PART. BUT WE HAVE LOOKED TO SEE IF WE CAN MAKE THAT PART QUICKER ON THE CNC</u> [O/Speed up soft machining; D/ Experiment with CNC]. We find that we can make it quicker on the CNC but it's not significant enough to purchase that machine [43].

[78] What would I like to achieve? Well... What I would like to achieve is obviously... it's a difficult thing to do because of labour. This company has shrunk over a period of time, mainly maybe due to the wire eroder, it's replaced certainly three or four people. <u>What I</u>

would like to achieve is to build new tools within a shorter period of time [O/reduce times to produce tools]. That's gonna be my objective, that instead of three months we can make them in two months or six weeks, really.[87]

[118] I'm sure we need to expand, and by expand I don't mean that we take more staff, that seems to be what everybody is doing, expand the product but trying to keep the staff [?120] small numbers. That's where the CNC machinery helps [O/increase production /reduce manpower].[122]

C. COMPANY 3

Works Foreman

[90] THE CNC MACHINE IS STOPPED NOW, UNTIL WE CAN SORT IT OUT [D/Stop machine until repaired]. It's a problem but we don't take the risk of running it through. [If someone] ploughs the tool into the chuck and what are you gonna do? **That's gonna cost you a fortune** [C/High cost of repairs].[92]

[154] **Productionwise definitely increased [due to the CNC]** [C/High capacity]. IT'S INCREASED IN GENERAL BUT WE HAVE TO ORGANIZE IT DIFFERENTLY [D/ Reorganize production]. WHEREAS BEFORE WE BUILT ONE OF THOSE, ONE OF THOSE, ONE OF THOSE,... AND WE PUT IT TOGETHER AND MADE A PUMP, WE HAVE TO GO MORE INTO FORMAL PLANNING AND PLAN SIX OF THOSE WITH SIX OF THOSE AND ORGANIZE THE TIME SCALE DIFFERENT WITH USING THE MACHINE [D/Plan for batch production], because obviously you don't want to use the CNC to turn one off. You don't want to turn one, then break it down, put something else... so we needed to organize that we needed to increase our..., WE ACTUALLY INCREASED OUR ORDERS TO THE FOUNDRY, TO THE CASTINGS, TO MAKE IT WORTHWHILE [D/Increase orders to foundry]. AND WE CHANGED THE FABRICATION SHOP TO.. INSTEAD OF BUYING FLANGES WE STARTED TO MAKE THEM OURSELVES [D/Machine more in-house]. But actually that was a little bit of a mistake because we put that much work on the CNC that we lost the production of the pumps and we went back again to buy flanges. But it was a thought to use it to its full capacity [O/Increase utilization]. [172]

[181] WHEREAS BEFORE [BUYING THE CNC MACHINE] WE WOULD ACCEPT AN ORDER FOR VIRTUALLY ANY MODEL OF PUMP AND SAY 'IN SIX WEEKS YOU CAN HAVE IT' WE HAD TO THINK MORE IN TERMS OF 'WE ARE ALREADY BUILDING ONE OF THOSE WE CAN FIT ANOTHER ONE IN ALONGSIDE IT' [O/Increase utilization] SO SOME PRODUCTION SCHEDULES CAME DOWN FROM SIX WEEKS TO FOUR WEEKS AND SOME WENT FROM SIX WEEKS TO EIGHT WEEKS [D/plan for batch production], if it was a job that was not... if there was not another one running through at the same time. It became more organized in respect of that. Less

flexible but it did speed up the majority of our standard orders [O/Speed up utilization]. It didn't help with the bigger pumps but the smaller pumps it did help.[195]

[200] It needs a bit more planning now because you've got to think you've got to eliminate **the change-over time, the time changing from one to the other** [C/Change-over time]. A little bit more conscious about that. When we first had it we... 'just break it down will do it'. NOW WE THINK A BIT MORE OF A 'WELL I'VE GOT SOME MORE COMING UP ON THAT ONE, IT MAY PAY TO LEAVE THAT AND I'VE GOT SOME MORE CASTINGS COMING IN TOMORROW THEN I CAN CHANGE THE PROGRAMME AFTER [D/Fit order into batch schedule]. Not necessarily wasting time by changing the programme, more a case of... even if necessary leave the machine to stand [O/Machine utilization]. **It was cheaper than breaking the machine down and setting it up again** [C/cost of re-setting machine]. [210]

[239] THE SETTER-OPERATOR DIDN'T EXIST BEFORE. THEY WERE ALL MACHINISTS, THEY ALL HAD THE SAME TITLE. NOW WE'VE GOT MACHINISTS, ONE OPERATOR AND ONE OPERATOR-SETTER. BUT THE OPERATOR WE'VE GOT ACTUALLY IS CAPABLE OF SETTING IT [D/ Operator programmes machine]. So really you could say we've got machinists and two operator- setters. [...] the one runs the section, which involves the three machines plus the jig borer. He's been there longer so he gets a bit more. [251]

[265] WE DIDN'T GO THAT WAY [MAKING THE CNC OPERATOR'S JOB AN UNSKILLED ONE] BECAUSE WE FOUND THAT IT WAS BETTER TO HAVE A SETTER-OPERATORS [D/Create setter-operator job title]. We are not long term production. We can change that machine down... I've known that machine to be changed two or three times a day. If we were setting that machine up to turn out fifty-thousand then yes, it would make sense. [...] I should imagine about one or two days is the maximum that we run one particular sequence, then we would change it. We would need to change it because we would have sufficient parts of that particular type. So we was better to have the setter-operator because the operator on his own would have nothing to do while we changed the setting over, so... we went for this [O/Human resource utilization] [285]

[300] **Problems arise when the machine packs up. If there is trouble with the machine then it's a panic** [C/Maintenance difficult] TO GET SOMEBODY OUT AND GET THEM WORKING ON IT STRAIGHT AWAY [D/Get repairs from outside]. More than on the ordinary lathes. The ordinary lathes it doesn't really matter so much but that one... we have a good relationship with the maintenance people in Birmingham, who actually maintain several machine for the parent... the other group in Nottingham. [310]

[344] [CNC breaking down} is not a regular thing. But when it does happen, because we are geared into production, it's the same as if the operator is ill... we swing the second setter- operator up to run it... you cannot afford to let the machine stand for a long time... and we don't use it as much as we should do, really. They should be run twenty-four hours a day, shouldn't they. Really, to make them pay to make their money [O/Machine utilization]. But our sort of way we cannot run twenty-four hours a day. It's too varied. But as it is we run it ten hours a day, with two people. At present they are running two CNC's and the jig borer.Well, three, three! Eventually there will be two people running four machines. Or there could even be another operator brought in. We are thinking in terms of another one, another apprentice we've got, well a young man. So that will make three. [371]

[432] WE ACTUALLY EMPLOYED TWO MORE PEOPLE WHEN WE BOUGHT THE CNC [D/employ more people to replace CNC operators]. We had operators not specifically employed for the CNC. We've had people from in the company, move them to CNC. But we bought people in to replace them. So really we have increased buying the CNC. But then production has increased and everything else, so it's been an on-going situation.

Managing Director

[49] the other incentive [alongside with government paying up to a third of the machine] was we were trying to manufacture more. Previously we just bought from Germany and assembled. We were trying very hard to manufacture more [O/Machine more in-house]. One of the ways I saw we could improve our return on investment, particularly on bronze castings [O/Improve return on investment]. So we looked at various machines at the time and we settled on the Smith & Grace. We actually sent drawings to the company and they gave some indications of the times which would be taken by those machines to produce a component. We did an investment analysis and showed it was a worthwhile investment to do. [57]

[61] The problem is you can't find skilled machinists. So if you can't find skilled machinists you have to automate the process [C/overcomes lack of skilled work]. We were trying to increase our production. [O/Increase production] we couldn't get skilled machinists so we went to automatic method of production.[64]

[70] THE FIRST CHANGE WAS WE TOOK SOMEONE FROM THE WELDING SHOP. HE WAS FOREMAN OF THE WELDING SHOP. WE SENT HIM ON TRAINING COURSES

[D/Train operator]. So there is a very big culture change in terms of production. [...] We had machinists, but WE TOOK SOMEONE FROM THE WELDING SHOP, WE SAW HIM AS A BRIGHT PERSON TO BE ABLE TO TAKE THIS ON. WE COULDN'T ACTUALLY SPARE SKILLED MACHINISTS [D/Use someone other than skilled machinists]. And he had done some machining on the old NC machine.[76]

[78] But it was a big change. Also, it's much easier to order things from Hamburg. TO MACHINE WE THEN HAD TO ENSURE THAT WE HAD THE DRAWINGS [D/get drawings from parent Company], WE HAD THE PRODUCTION ROUTINE CARDS [D/get production routine cards]. SO THERE WAS QUITE A LOT OF SYSTEMS WHICH HAD TO FOLLOW IN ON TOP OF THE INTRODUCTION OF THE MACHINE [D/implement production system]. [82]

[96] Their's [company from where the second hand CNC lathe was purchased] was a typical example where they were too reliant upon one man to work the machine. When that man left that machine wasn't properly used at that company. Which is why we always tried to train two or three people to use the machines [O/Have more than one person trained in CNC].[100]

[110] BASICALLY, ALL WE HAVE DONE IS THE SAME PERSON WHO PROGRAMMES IT OPERATES IT. BECAUSE WE ONLY HAVE A FEW MACHINES. SO BASICALLY THEY ARE PAID A SKILLED MACHINIST'S RATE [D/Keep programming and operation together].[114]

[118] BASICALLY THE CHANGE WAS THAT WE BECAME A PRODUCTION UNIT AND NOT AN ASSEMBLY UNIT [D/more production than assembling]. So that was a dramatic change. [120]

Setter Operator.

[102] They [CNC] bring a heck of a lot of changes but they didn't bring what we expected. We thought when the computers came in that we would get rid of a lot of turners. A lot of people would be made redundant. This was the general feeling. When the first came in there was a lot of talk in that shop particularly, you know, which one of us is gonna go. Because it gonna turn out five times more than any of us can do in the day. Probably more, ten times... and that's lot. [...] And they thought 'with the amount of work that we've got who's going out?' But it didn't happen [O/Keep jobs]. Production went up, sales went up, demand went up. So we were back to were we started, working seven days a week and still not having time. With two machines, two of those. [116]

[120] [introduction of CNC] it didn't seem to alter really. I THINK WE BOUGHT IN LESS COMPONENTS THAN WE USED TO [D/Buy less components out]. WE USED TO BUY AN AWFUL LOT, DIDN'T WE?

READY MACHINED COMPONENTS WHICH WE COULDN'T THEN DO OURSELVES. WE DO A LOT MORE NOW THAN WE DID THEN, OBVIOUSLY [D/machine more in-house]. [124]

[138] **you get a lot of down time [for repairs]. [...] If it's electric with the state of the electrics as they are now, we have no one to actually put it right, so we have to call someone in** [C/Repairs, maintenance difficult]. [143]

[147] **[It] can run perfectly through a month or more and then suddenly one day it'll just lock off, stop, and you press all the keys and nothing happens, you think 'why is it stuck?'. You can't move it, it won't budge neither way, anyway. So you shut it down, go back to zero, start again then it will go past that point and no problem. But suddenly it'll lock for no reason. It's just a problem with the computers** [C/unpredictable].

Head of machine shop

[115] It's like everything else... an unknown factor you have mixed feelings. **You know in the back of your mind that it may do you out of work, you may finish up having no work at all** [C/can replace people]. In fact it does happens but I do think in most places... of course you hear things along the line, you make friends in engineering and you keep informed... and I have found, and most would agree with what I think, it increases the work [O/Keep jobs]. Because the factory as a whole can have a bigger turnover of work and you get the offspin of the parts that can't go in the CNC. Or not work done on the CNC, you know, [?@125] if the job is not sufficient, or the numbers are not sufficient to [grant?] go into CNC. So you increase work. Even now, I work on the lathes, I don't want the CNC's but we all [stacked out?] the work, don't we? And I would say it's in the direct relationship with the CNC's... That's right, it's a pleasant surprise because you become more competitive with the CNC's. It's improved the job. [135]

[140] because you see if you turn out more work, and the people who are in charge of selling you to have a ... the neck grows wider to your customers [O/enhance competitiveness]. [...] It all becomes part and parcel of the complete job lot, isn't it? [145]

[149] I was surprised.. you haven't got to say, you have no idea what a CNC can do the first time you see one. **The machine is just a machine, all you know is like instead of a hands work it's doing computer work. It's not until you actually see work that you realize**

how fast the CNC can work [C/Speed]. **Of course the big problem is that it can produce scrap just as fast** [C/produces more scrap]. [...] **A CNC tends to relax you into a false sense of security. You put the job in, press the button and stand back. It kind of relaxes you into... you are not aware or your concentration starts to fail, because all this work is just coming up on the CNC and you get a pile of scrap on the floor, you know [C/Gives false sense of security]. [...] Off a center lathe you can have say one scrap or two scrap but the CNC's like, you know, ten! [165]**

[171] **It's working by itself, it's carrying on through but it has no mind to think, it has a computer telling which way operations should be carried out** [C/controlled by computer], what sort of tool, but the tool starts to wear... the machines, I don't know the latest machines, with self-checking... ways of doing it. But in the end if the tool wear the job becomes big, and it's wrong. [178]

[221] We only have a maximum amount of eight [pieces turned in center lathes]. Eight would be acceptable to the CNC because you've got the process and the time of setting up [O/Machine utilization]. **I would say the optimal is about five. If you've got more than five castings it wouldn't pay yet to do it in the CNC because although the CNC turns it quicker there's a lot more time spent in setting up. I think five would be an optimum** [C/optimal batch size].[226]

[372] our work is repetitive, so we don't actually do a lot of new programme as such. A lot of the work on the CNC's are held at the back of the machine, Derek put a cupboard, he keep the boxes with the tapes in. So just a case of... this jobs comes in, goes at the back, takes the tape, puts the tape in [...] and there we go. We don't do a lot of new programming. [380]

[386] **All the CNC's we've got have the facility to be programmed off the machine and taped in, you could even put a telephone connection** [C/programmable off-line]. In many CAD/CAM systems you can have machines at the drawing office where as they actually programme, the machine is processing and feed down through the wire into the machine so you just switch the machine on.[393]

[435] If you used to make a die or a mould, a plastic mold, on a lathe, which I have done in plastic, jobs I've done before, it took months to do that particular mold it was... the size had to be right, the finish had to be right, a complicated shape [...] this may take two or three days to programme, to write a programme out for CNC, but you press the button and it may take two days to do it, that's four days. **A CNC, if you**

programme it perfectly will produce perfectly [C/accuracy]. See, the other thing that I noticed, I went to the course, two year course ... CNC's will work... I always thought it was black and white, they'd either work or don't work. CNC's will work in shades of grey. They will work to a certain degree with not enough information... but they won't produce exactly right. **If you give the exact information the book tells you it needs, then it gives you everything, it will produce a perfect job** [C/accuracy]. [456]

[551] Ordinary straightforward lathe you work with your hands. I mean, you have got dials on, but you could get away without, you can work much... as much for a... visual as what you can by actual mechanical measurements as you move around. [...] **In a CNC you press the button press the button and that's it** [C/controlled by computer]. And when you open the door, there it is, it's either right or wrong. You can work block to block where the machine does one block, one operation and stops. And then you can have a look, shut up, carry on from there. <u>But it's not a very practical way of working. It's not a very profitable way of working neither</u> [O/Efficiency]. [575]

[680] When you programme you work in a different part of the computer [in the old CNC computer]. [...] once you press that into run/load, that computer runs the machine and switches up all the programming. So you cannot programme as you run. **This new computer you can programme as you run** [C/programmable off-line]. SO YOU CAN PRESS SAY TO GO INTO AUTOMATIC AND IT WILL BE DOING A JOB. WHILE IT'S DOING THAT JOB YOU COULD BE PROGRAMMING ANOTHER JOB. SO AT THE END OF THAT YOU CAN TAKE THAT JOB OUT, PUT ANOTHER JOB IN, PRESS THE BUTTON AND GET ON WITH THAT ONE [D/programme off-line]. That's how good a computer it is but it's sometimes an overkill. [698]

Technical Director

[14] The function has changed over the years and the emphasis today with myself is more on contracts [...] and as a consequence of that I see very little of the CNC operation, although I was involved in the selection of the machinery and the decision to go into it.[19]

[110] <u>THE MAIN CHANGE WAS WHAT INTENDED, WHICH WAS TO INCREASE THE THROUGHPUT OF COMPONENTS</u> [D/increase throughput of components; O/Increase throughput of components]. As a small company we really do anything in the way of... large companies suffer from demarcation and the reluctance to accept change. [115]

[142] We are doing nothing new, just the same thing faster [O/Speed up production][143]

[150] I don't think there was anything we were not expecting [with the introduction of CNC]. WHAT WE DID HAVE TO DO WAS TO MAKE THE STANDARD OF CASTINGS WHICH WE WERE BUYING MORE CONSISTENT AND OF A BETTER QUALITY [D/Control quality and dimensions of castings]. **Particularly from the size point of view, if the casts came in various sizes then they are not really suitable for the CNC machine** [C/Copes poorly with variety in inputs]. It was a matter of liaising with the castings [...] to ensure that they went back to standard.[158]

[163] The changes that took place to a large extent were in the buying of the castings and the flow of quantity, although we still manufacture in relatively small quantities those quantities have increased since we have the CNC machine. We do try to put larger batches through [O/Increase batch size]... it doesn't always work that way because the needs of the building of pumps... require the need to do short batches. The intention is to do as large a batch as possible [O/Increase batch size].[170]

[172] WE DON'T HAVE PUMPS IN STOCK BUT A LOT OF THE COMPONENTS THAT WE ARE MACHINING ARE FOR PARTICULAR ORDERS AND THIS QUALITY IS ALSO A MATTER OF TRACEABILITY [D/trace quality of components to process]. [176]

Appendix 4: Analysis of Correspondence.

Analysis of correspondence is a statistical technique developed in France in the seventies (Cornejo, 1988). The mathematical exposition and justification of the method is beyond the scope of this thesis, but it can be found in Benzecri (1976). Correspondence analysis is useful as a means of dealing with two-way tables containing data measured at the nominal level of measurement and when one wants to explore the relationships between values of these variables.

If we take a table where the rows correspond to individuals and the columns correspond to the different states of a nominal level variable, each individual will be described by a profile of values. In this research, for example, each actor is described by the presence or absence of discourse categories. Between these profiles there will be similarities and differences which can be used to calculate distances between them: the more similar the profiles the closer they are and vice versa. To define these distances, the values found in each cell of the matrix are compared with the values which would be expected if no association between different states of the two variables existed, in much the same way as the chi-square test is carried out (in the case of the matrixes used in this research, which cross-tabulate actors X discourse categories, a lack of association would mean that all actors talked alike). The greater the difference, the higher this value will be. The distances between profiles define a cloud of points which, as the number of cases and variables increase, can only be accommodated in a space with more than the two or three dimensions we are familiar with. The factors extracted by correspondence analysis describe the dimensions of this space and the position of each actor or category in it.

Each row (or column) will contribute a certain amount to the total chi-square of the matrix. If we add the contribution of all rows (or columns) we obtain the total chi-square (note that the sum of all rows equals the sum of all columns). The factors extracted explain all the chi-square contained in the matrix analyzed. They do this, however, in an economical way. The factors needed to explain all the information in the matrix are always less than the variables in the matrix. More precisely, the maximum number of factors which may be needed is always equal to the number of column or rows, whichever is less, minus one. Besides, the algorithm for factor extraction tries to maximize the amount of chi-square explained by each successive factor. The first factor will explain more chi-square than the second, and so on. This means we need to deal with less information when analyzing the matrix. This "compression" of information is the objective of any factor analysis.

The distinctive characteristic of correspondence analysis, however, is the fact that in order to define the differences between profiles it uses a specific metric. The chi-square metric, introduced by Benzecri, (not to be confused with the chi-square test) enables the study of contingency tables without regard for the actual magnitude of frequency counts. Therefore, what is used to describe similarities and differences across profiles is the structure of the values which constitute a profile, not the values themselves (Bouroche and Saporta, 1980:92; Cibois, 1991; Cornejo, 1988:112). The fact that the analysis of correspondence operates on the basis of the structure of values means that profiles of very low values will not be masked by profiles of high values. Whatever the absolute values in a profile, it is their structure which will be important in determining distances between points. This makes the method very relevant for this research, because individuals are defined by a profile of binary values (0 or 1), denoting the absence or presence of a discursive category in one actor's verbal production.

Being based on the structure of values, identical profiles, i.e. profiles with the same structure, can be aggregated and treated as one, without influence on the structure of the matrix. In other words, if we aggregate two rows which show the same profile, the distances between columns will not change (Bouroche and Saporta, 1980:93). In this research, the software used aggregates similar rows as clusters which are numbered (ZZ1 to ZZn).

The fact that correspondence analysis is based on the chi-square metric enables the representation of row and column profiles can be described in a similar space (Cornejo, 1988:113). In this research, this means that we can define a space where actors will appear close to the discursive categories they use. This useful possibility does not exist in other methods of factor analysis. It is therefore possible to define the positions of the different values of column variables (in this case the different actors) and of row variables (in this case the different discourse categories) in the same space and, within certain limits, interpret the proximity between values of these variables as associations between them.