ORGANIZATIONAL KNOWLEDGE IN THE MAKING:

HISTORY, BREAKDOWNS AND NARRATIVES

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Abstract

The present study looks at the dynamics whereby organisational knowledge comes into existence and is eventually crystallised into stable structures of signification through processes of utilisation and institutionalisation. Recent years have seen an astounding explosion of writing about organisational knowledge. In different versions, organisational theorists have been paying increasing attention to the idea of the firm as a body of knowledge, stressing in turn the ability of firms to create, manage and transfer knowledge as a critical success factor. However, the current debate on the topic has highlighted the difficulty of documenting empirically the process of creation, accumulation and maintenance of knowledge in organisations. This, of course, begs the question: how is it possible to relate an empirical study to the theoretical debate on knowledge in organisations? More specifically, how does a particular knowledge system emerge and become stabilised? How does it evolve over time? In this study, we argue that the lack of attention to knowledge as an empirical phenomenon can be traced back to the assumptions underlying the mainstream knowledge-based theories of the firm, which emphasise the instrumental, functional character of knowledge in organisations. In contrast to the functionalist view of knowledge, we contend that mainstream assumptions need to be combined with those perspectives focusing on the social construction of knowledge and highlighting its contentious, provisional nature. Given the problems identified at both theoretical and methodological levels, the present study proposes a framework for studying knowledge as an empirical phenomenon based on three methodological lenses, which are echoed in the title of this work: history, breakdowns and narratives. The three lenses have to be seen as bringing into focus the tacit features of knowledge and organisation. The empirical core of the research is evidenced by three in-depth case studies conducted at Fiat Auto Italy. The findings of the study provide the backbone for constructing a theoretical model of knowledge in organisations. The model links the content, process, and context of knowledge-related phenomena in a coherent classificatory system. More generally, the empirical research highlights the systemic, institutionalised, and multi-faceted nature of knowledge in organisations.

INTRODUCTION

This study looks at the dynamics whereby organisational knowledge comes into existence and is eventually crystallised into stable structures of signification through processes of utilisation and institutionalisation. Specifically, this research sets out to achieve the following objectives:

- To study the dynamics of knowledge creation, utilisation, and institutionalisation in different organisational settings;

- To develop a methodology for studying knowledge as an empirical phenomenon;

- To develop a processual theory of knowledge in organisations able to link "modes of knowing" to "modes of organising";

- To describe the evolution and transformation of knowledge systems over time.

Knowledge has become increasingly relevant in organisations following a major shift in the dominant modes of industrial development and wealth creation in contemporary society. Peter Drucker (1993) has coined the term "knowledge society" to stress the importance of knowledge as the defining characteristic of the post-capitalist world. According to him, we have moved from an industrial economy based on the application of knowledge to tools, products and processes, to a globalised, information-driven economy where knowledge is being applied to knowledge itself. As a result of what Drucker calls the Productivity and Management Revolutions the post-industrial era will be increasingly populated by organisations while knowledge will displace capital as the motor of competitive performance. Within this scenario, knowledge-related factors will increasingly affect the current patterns of industrial and organisational change.

Following the wider debate about the emergence of the information age and the knowledge society, recent years have seen an astounding explosion of writing about organisational knowledge. In different versions, organisational theorists have been paying increasing attention to the idea of the firm as a body of knowledge, stressing in turn the ability of firms to create, manage and transfer knowledge as a critical success factor. Within the fields of strategic management and organisation theory the

recognition of knowledge as a source of competitive advantage has shifted the attention of scholars toward the so-called "intangible" assets of organisations. More generally, the significance of knowledge in organisations has been related to broader discussion about the organisation of work, the management of people, organisational learning and corporate memory, the management of core competencies, the management of knowledge-intensive firms, the value of intellectual capital and the management of R&D activities (Scarbrough *et al.*, 1999).

The introduction of epistemology in organisations has forced scholars to dig into the nature of knowledge—sometimes even going back to the classical Greek philosophers—in order to build a more or less dynamic knowledge-based theory of the firm, more often than not within a prescriptive logic. As it is commonly accepted, the study of knowledge as a phenomenon in its own right entered the research agenda following the increasing success of Japanese firms throughout the 80s and the beginning of the 90s. The analysis of the superior performance of Japanese firms led research to identify knowledge as a key competitive factor. Nonaka and Takeuchi's (1995) analysis of knowledge creating companies provided a pathbreaking work within the literature. Interestingly, however, for at least one decade the debate within the literature on knowledge has remained at the theoretical level. Even more interestingly, this debate seems to have developed incrementally rather than through competing paradigms.

Despite the abundance of theoretical definitions of knowledge in organisations, current mainstream conceptualisations seem to be constructed on a reductionist argument. The reductionist view of knowledge can be articulated in a number of related issues. First, knowledge is seen as an objectified, transferable commodity that can be used instrumentally towards a firm's performance. Second, organisational knowledge processes are reconnectable to the dialectic between tacit and explicit knowledge. Under these circumstances, Nonaka and Takeuchi's neat model of knowledge creation through the conversion of tacit and explicit knowledge has been widely and uncritically accepted. Third, current debates on knowledge in organisations seem to suffer from a lack of interdisciplinarity. The strategic management perspective dominates the research agenda while the contributions coming from other streams of the literature are scarcely acknowledged. Fourth,

existing theories underestimate the systemic nature of knowledge-related phenomena. In particular creation dynamics are privileged over institutionalisation processes while knowledge is detached from the broader phenomenon of organising. Fifth, most existing knowledge theories are informed by a pervasive assumption of transmutability. Knowledge is seen as a-contextual, a-historical, and a-processual (Pettigrew, 1990, 1997).

Within the scenario depicted above, the current debate on the topic has highlighted the difficulty of documenting empirically the processes of creation, accumulation and maintenance of knowledge in organisations. The problem can be summarised as follows: while we have access to the explicit, formalised features of knowledge, it is not possible to get the same insight into the tacit, experience-related side of it. This, of course, begs the question: how is it possible to relate an empirical study to the theoretical debate on knowledge in organisations? More specifically, how does a particular knowledge system emerge and become stabilised? How does it evolve over time? The task is made particularly difficult by the fact that, as it has rightly been pointed out, explicit (visible) knowledge is just the tip of the iceberg while most of the knowledge organisations create and use remains at a tacit level.

This important omission is reflected in the lack of empirical studies on knowledge in organisations. So far, the few existing ones have been conducted within fields that are somewhat distant from the mainstream (e.g. cognitive anthropology, sociology of science and technology). However, the emphasis placed on knowledge-related phenomena in the last few years has promoted an increasing demand for empirical evidence to support the abundant theoretical literature in which those phenomena have been debated. Today, major research programmes on knowledge-related issues funded both by public bodies and corporations are being developed throughout the world, whilst knowledge management has become a hot topic among executives and doctoral students. In the next few years we will see the results of a research trend that has just started and the literature will probably be flooded by knowledge studies.

In this study, we argue that the lack of attention to knowledge as an empirical phenomenon can be traced back to the assumptions underlying the mainstream knowledge-based theories of the firm, which emphasise the instrumental, functional character of knowledge in organisations. In contrast to the functionalist view of

knowledge, we contend that mainstream assumptions need to be combined with those perspectives focusing on the social construction of knowledge and highlighting its contentious, provisional nature. Following Cooper (1990) we suggest that knowledge originates from those processes whereby organisations appropriate order out of disorder. Accordingly, the analysis of any social organisation or social action needs to be performed at the cleavage between organisation-disorganisation. Therefore, the epistemological argument of this study is grounded on an in-depth inquiry into the ontology of organisations aimed at disclosing the tacit assumptions informing the very concept of organising. Chapter 1, presents the main debates in the literature and reviews the main empirical studies in order to identify what is known and not known.

The need to study knowledge as an empirical phenomenon has critical methodological implications in so far as it points to the need for building effective tools. The major difficulty with existing studies is related to their treatment of knowledge as an independent variable affecting competitive performance. As will be argued in the next chapter, this conceptualisation poses problems of operationalisation. The present research proposes a framework for studying knowledge as an empirical phenomenon. The framework is based on three methodological lenses, which are echoed in the title of this work: history, breakdowns and narratives. The three lenses have to be seen as bringing into focus the tacit features of knowledge and organisation. Knowledge is evoked and revealed as an emergent phenomenon rather than defined *a priori*. Finally, the observational focus on shop floor dynamics reinforces the empirical focus of the study as well as constituting a main element of novelty with respect to existing studies. Chapter 2 explains in detail how each lens works.

The empirical core of the research is provided by three in-depth case studies conducted at Fiat Auto Italy. The choice of the automotive sector for a study on organisational knowledge was dictated by distinctive features of the competitive environment in which car manufacturers operate. More than fifty years ago, Peter Drucker (1946) defined car manufacturing as "the industry of industries" and today, the car market is still the one in which competition is most fierce. In the last decade, the industry of industries has undergone a major transition from Fordist mass production systems to new organisational models derived from Toyotism (Womack *et al.* 1990). As a result of this critical transition, avant-garde organisational concepts

such as lean production, total quality management, just in time, teamwork, along with the adoption of cutting edge technologies, have been pioneered in car manufacturing in response to competitive market forces. The above characteristics of the sector bear critical consequences for knowledge creation, change and innovation.

The case studies focus on knowledge creation, utilisation and institutionalisation processes occurring on the shop floor of two of Fiat's most renowned plants: Fiat SATA assembly plant in Melfi and the Mirafiori Pressing plant in Turin. Beyond the specific business operations, the selected plants can be seen as productive units characterised by distinctive combinations of product, production process, and work organisation (Abernathy, 1978; Whipp and Clark, 1986). In this respect they are characterised as knowledge systems in their own right. The two plants offer a stark contrast as far as the institutional setting is concerned. Melfi is an avant-garde assembly plant, located in the South of Italy, built as a green field site in 1993 and opened officially in 1994. The plant is characterised by a novice work force and holds one of the best productivity records in the world. Mirafiori is a brown field set up in the 50s and characterised by an experienced work force. The two plants share the same organisational model, known as the "integrated factory", introduced by Fiat at the beginning of the 90s as a result of a major re-engineering process accompanying a radical shift from mass production systems to a Post-Fordist paradigm. However, while Melfi has been designed as an integrated factory, in Mirafiori the model has been superimposed on to the existing organisation. The two factories also differ in terms of technology since Melfi is a final assembly plant relying on an assembly line, whilst Mirafiori produces car parts and accordingly is organised as a batch production system. The distinct settings of two plants characterised by different stages of maturity constitute critical context variations in the study. These variations offer alternative perspectives for the observation of organisational knowledge processes. The three case studies are presented in chapters 4, 5 and 6 and are preceded by a brief profile of the company in chapter 3.

The empirical findings of the study provide the backbone for constructing a theoretical model of knowledge in organisations. The model links the content, process, and context of knowledge-related phenomena in a coherent classificatory system. Knowledge in organisations results from the dynamic interaction of the three

processes of creation, utilisation and institutionalisation leading to the production of generic knowledge outcomes conceptualised as black boxes. Specifically, the case studies highlight three main knowledge contents, which we label *blueprints*, *routines*, and *common sense*. Finally, by juxtaposing the case studies in a sort of "photo-montage" we introduce a time dimension (which was already present in the research design) that allows the researcher to follow a hypothetical knowledge trajectory. This trajectory identifies three main types of knowledge - foundational, procedural and experiential - corresponding to the knowledge contents mentioned above. The trajectory defines a possible evolutionary trend of knowledge in organisations. At the overarching metalevel, the typology mentioned above is informed by a distinctive definition of organisation, based on the ontological categories of being and becoming, and highlighting the tension between controversies and steady states. The ontological argument portrays organisation as confronted by the equivocality of action and exposed to major challenges for sensemaking. It looks at how organisations frame the equivocality of action by means of primary sensemaking devices such as the division of labour, routines and standard operating procedures, workflow and production systems, and so on. Accordingly, organisation originates from those processes of appropriation of order out of disorder. Likewise, knowledge springs from the tension inherent in the dichotomies organisation/disorganisation, being/becoming, order/disorder, routines/breakdowns. The theoretical interpretations of the study are presented in chapter 7.

The conclusions of the study summarise the main theoretical, methodological, and empirical contributions achieved by this research. In contrast to the reductionist assumptions informing the mainstream literature the study highlights the systemic, institutionalised, and multi-faceted nature of knowledge in organisations.

CHAPTER 1: LITERATURE REVIEW

1.1 Introduction

A definition of organisational knowledge is implied by each of the various conceptualisations of organisation that we find in the literature. Admittedly, organisational theories reflect our knowledge about what an organisation is. However, only recently has knowledge in organisations been put explicitly under scrutiny as a phenomenon in its own right. The theme has become so popular that today we are witnessing a shift from organisation theories to knowledge theories of organisations.

Existing theories of organisational knowledge are indebted to a wide spectrum of theoretical traditions. Knowledge is a multifaceted phenomenon which has been debated in a variety of disciplinary contexts: from philosophy and sociology, to social psychology and cognitive science; from economics to management and organisational analysis. The breadth and depth of the subject under investigation makes it difficult to set the focus of a literature review.

For Spender and Grant (1996) the beginning of the knowledge-based paradigm can be traced back to Simon's (1947) notion of bounded rationality. Interestingly, the work of Simon epitomises the encounter of two epistemological traditions: one derived from economics and emphasising issues of individual self interest and rational decision-making, the other related to psychology, focusing on the link between cognition and action and its behavioural consequences. It is this mix of tangible and intangible, technology and human skills, hard and soft concepts, that we find in most of today's knowledge-based theories of the firm.

Likewise, Brian Pentland (1992) contends that the existing theories of organisational knowledge can be traced back to two distinctive roots. One approach—which derives from the conceptualisation of the firm as an information processing device (Galbraith, 1977) and is related to cognitive science—has been to look at knowledge as a cognitive phenomenon that can be equated to abstract representation. The alternative approach has focused on organisational structures such as routines (Nelson and Winter, 1982). The structural view offers the insight that the capacity of the

organisation to act depends on things that are often tacit or taken for granted, apart from any explicit representation. This dichotomy is neatly captured by what Ryle (1949) called "the dogma of the Ghost in the Machine". The cognitive approach directs our attention to the ghost: perception, belief and sensemaking. The structural approach focuses on the machine: structures, objects and routines.

Historically, the advent of knowledge to the forefront of organisational analysis can be dated back to the end of the 70s, with the appearance of organisational learning theories (Argyris and Schön, 1978) and the conceptualisation of organisations as cognitive artefacts. The cognitive approach draws on the metaphor of organisations as brains (Morgan, 1997) and builds on the concepts of "bounded rationality" (Simon, 1947), cybernetics (Ashby, 1952; Wiener, 1961), the definition of organisation as information processing devices (Galbraith, 1977) and interpretation systems (Daft and Weick, 1984). Organisational knowledge is represented and stored in cognitive structures such as maps, frames, scripts (Sims and Gioia, 1986) which account for how organisations make sense of their activity and perform in the face of environmental changes. Learning is defined as a cognitive process and seen as a source of change and/or inertia. A fundamental dichotomy within the cognitive approach is between cognition and action. The prosperity of organisational learning theories was also promoted by the increasing influence of the cognitive approach in emerging disciplines such as artificial intelligence and information systems.

On the practitioner's side, the increasing success of Japanese firms during the 80s and the relative competitive decline of American companies boosted the attention to knowledge-oriented factors. The emergence of new production systems, total quality management, and teamwork shifted the focus of analysis towards the role of human skills and intangible assets. Interest in benchmarking, best practice transfer and knowledge audits involved recognition that it was not so much firms' tangible assets that mattered as the way they were being used and combined with individual and organisational knowledge (Spender and Grant, 1996). The above developments gradually brought the theme of organisational knowledge to the attention of the strategic management literature, which ultimately ensured the success of knowledge-based theories.

Drawing on the work of organisational economists such as Arrow (1962), Penrose

(1959), Nelson and Winter (1982), the resource-based approach defined knowledge as an asset or commodity. This conceptualisation resulted in a new theory of the firm - emphasising firm-specific, difficult to imitate resources as a source of competitive advantage - and somewhat displaced mainstream market-centred approaches to strategy (e.g. Porter, 1980). The analytical cornerstones of such a theory include: resources (Wernerfelt, 1984); (Barney, 1991); core competencies (Prahalad and Hamel, 1990); and core capabilities (Leonard-Barton, 1992a).

Within the strategic management literature, learning assumed once again a central role, accounting for the acquisition of firm-specific competencies and capabilities and the development of path-dependency. The ability of a firm to learn became somewhat infused with value as the emergence of the Learning Organisation concept (Senge, 1990) as one of the fads of the early 90s demonstrates. Accordingly, the interconnected processes of learning and knowledge acquisition were causally linked to organisational performance - with a specific focus on the dynamics of innovation and change - and assumed a quasi-ideological significance. Finally, the conceptualisation of knowledge as a strategic factor of production found application in some of the best selling management books of the 90s documenting the increasing success of Japanese firms. The latter emphasised the notion of product development performance (Clark and Fujimoto, 1991), the conceptualisation of production systems as knowledge systems (Womack *et al.*, 1990), and the knowledge-creating company (Nonaka and Takeuchi, 1995). More generally, knowledge creation was assimilated to the production process and the organisation was defined by using such metaphors as "knowledge refinery" (Nonaka and Takeuchi, 1995) and "learning laboratory" (Leonard Barton, 1992b).

The move towards the commodification of knowledge did not leave out the cognitive element as the terms competence and capability indicate. Rather the ghost was somewhat incorporated in the machine. The tension between the soft cognitive element and the hard structural one was well reflected in the definition of knowledge as an "intangible" asset. Furthermore, the influence of social psychology was still visible in the recognition of the duality of knowledge, which was articulated in the distinction between explicit and tacit knowledge (Polanyi, 1966). The latter informs the most recent knowledge-based theories of the firm.

The theories of knowledge analysed above account for the vast majority of the literature that has been produced on the subject. The third strand analysed in the present chapter is referred to as the organisational perspective (Scarbrough, 1998). Two major bodies of literature emerge within this strand. The first includes situated theories of knowledge and is characterised by a distinctive focus on organisational practices. It directs our attention to that body of organisational literature that has stressed the importance of the "details of practice" (Brown and Duguid, 1991), situated action (Lave and Wenger, 1991; Suchman, 1987) and methodological situationalism (Knorr-Cetina, 1988). A second distinctive body of literature within the organisational perspective refers to those studies that have emphasised the institutional dimension of knowledge focusing on the concepts of action, context and time (e.g. Whipp and Clark, 1986, Pettigrew, 1987), formative contexts (Unger, 1987; Blackler, 1992 Ciborra and Lanzara, 1994), and structuration (Giddens, 1984; Barley, 1986; Barley and Tolbert, 1997).

Finally, the fourth strand considered in this chapter can be labelled the "techno-science" approach (Latour and Woolgar, 1979; Knorr-Cetina, 1981; Latour, 1987; Bijker *et al.*, 1989). Its roots are in the sociology of science and sociological studies of technology. The body of literature belonging to this strand emerges from the rejection of the traditional mind-body opposition and the recognition of the socially constructed nature of knowledge. The techno-science approach is primarily empirical in its focus. The laboratory serves as a metaphor underlying most of the empirical work in this strand, emphasising the processes of knowledge production and transformation.

In the following sections we review the four main perspectives on organisational knowledge presented in the introduction in order to identify the gaps in the literature and derive the main research questions of the study.

1.2 Knowledge as representation: the cognitive approach

The "cognitive turn" in organisation studies was conceived as a way of bringing in the concepts of mind, intentionality and sensemaking into the realm of organisational behaviour (Boland and Tenkasi, 1993). Drawing mainly on developments in cognitive

psychology and artificial intelligence, organisational knowledge is seen to reside in mental structures such as frames, scripts, cognitive maps and interpretative schemes, which account for the sensemaking processes of organisational members. The latter include the members' perceptions of both their internal and external environments, their learning and unlearning, change and resistance to change, and appropriate and inappropriate actions in the face of altered environmental conditions (Boland and Tenkasi, *ibid.*).

In its most paradigmatic formulation, the cognitive framework is characterised by two fundamental dichotomies: one between thought and action; the other between individual and organisation. In exploring the cognition-action linkages a fundamental hypothesis is that action always possesses a cognitive basis which is reflected in the above mentioned knowledge structures. But how do mental structures operate? According to Newell and Simon (1972) the human mind can be conceived as a computational engine whose functioning is based on the manipulation of symbols after the fashion of digital computers. As Norman (1993) has pointed out, the caricature of the traditional symbolic approach to human cognition is that it focuses entirely upon the processing structures of the brain and the symbolic representations of the mind. All action is inside the head, yielding a natural distinction between the reality out there and the processes taking place inside here.

Planning and representation are central to symbolic theories since human behaviour is always oriented towards a goal. The planning model in cognitive science treats a plan as a sequence of actions designed to accomplish some preconceived end. The model posits that action is a form of problem solving, where the actor's problem is to find a path from some initial state to a desired goal state, given certain conditions along the way (Newell and Simon, 1972 cited in Suchman, 1987: 28). Under these circumstances, internal representations act as filters mediating between goal and situation. Representation is information about a situation, which is stored in human memory as a result of previous experience and learning. As for a computer program, representations contain a set of instructions on how to respond to a given situation. Accordingly, effective behavioural performance depends on the degree of accuracy in the representation of a problem: it is a matter of matching action with representations; it is the outcome of a cognitive coupling between the individual and his image of the

world.

Within cognitive theory, organisations are seen as an extension of the "computer model of the mind". In recent years they have been variously defined as brains (Morgan, 1997) information processing devices (Galbraith, 1977), or thinking systems (Sims and Gioia, 1986). In the classical Simonian view, organisations are considered as devices for accomplishing complex tasks that may exceed the bounded rationality of individuals. In this respect, human limitations are institutionalised in the structure and modes of functioning of our organisations. Hierarchy, for example, provides a powerful mechanism of simplification, capable to break a complex task down to its smallest components. Likewise, organisational routines and standard operating procedures act as programs for action. More generally, organisations are viewed as decision-making mechanisms (March and Simon, 1958), conveying a simplified image of reality and thereby helping individuals to take rational decisions. In sum, Simon's theory of decision-making leads us to understand organisations as kind of institutionalised brains that fragment, routinise and bound the decision-making process to make it manageable (Morgan, 1997). Furthermore, the conceptualisation of knowledge as symbolic representation, related to problem solving, bears important implications for organisational learning. According to Simon *et al.* (1992) a primary task for researchers on organisational learning is to understand how people acquire new problem representations for dealing with new problems. New problems need new problem representations because existing problem solving procedures are based on selective searches through a problem space defined by a particular problem representation. Changes in problem representations imply fundamental change in organisational knowledge and skills.

1.2.1 Organisational learning

Organisational learning has been brought to the forefront of management by Argyris and Schön (1978). Their aim was to explore the relationship between action and cognition in organisations in order to develop an action-oriented theory of organisational learning. In line with the brain metaphor they see organisations as cognitive artefacts. Central to their framework is the notion of theories of action, conceived as cognitive structures underlying all deliberate human behaviour. A theory

of action is a set of norms, strategies and assumptions informing human conduct. It contains hypotheses about the world aimed at realising a correspondence between situations, intentions and behavioural outcomes. Typically, a theory of action consists of a set of interconnected propositions having an "if... then" form. Theories of action are inferential (causal) structures, characterised by an instrumental quality: in situation S, if you want to achieve consequence C, under assumptions *a*... *n*, do A... (Argyris and Schön, *ibid.*: 11)

For Argyris and Schön a crucial problem in effective action is that theories of action which people actually use may differ from theories of action they espouse. This potential split has important organisational consequences since it can lead to learning inefficiencies. There are various reasons why the two theories may not collide, which can be reconnected to the tacit nature of theory in use. Theory in use may remain tacit because its incongruity with espoused theory is undiscussable. In fact, theory in use reflects a set of assumptions, strategies and norms which have sedimented over time and have come to be taken for granted. We act without being aware of the premises that govern our behaviour. Or it may remain tacit because people know more than they can tell (Polanyi, 1966), since the theory in use is inaccessible to them. In this case, tacitness is related to the opacity of human behaviour and to the bounded rationality of individuals. A theory of action contains a huge number of instructions which it is impossible to codify or to describe. A further source of incongruence between espoused theory and theory in use is that people may deliberately hide the theories underlying their behaviour for opportunistic reasons.

Just as individual theories of action may be inferred from individual behaviour, so organisational theories of action may be inferred from patterns of organisational action. More specifically, a firm's theory of action is a set of shared norms, strategies and assumptions informing organisational practice and directed to the achievement of corporate objectives. Furthermore, as individuals have espoused theories which may be incongruent with their (often tacit) theories in use, so with organisations. At the organisational level, espoused theory is reflected in formal corporate documents such as organisational charts, policy statements and job descriptions while the organisation's theory in use needs to be inferred from the observation of actual behaviour. According to Argyris and Schön the largely tacit theory in use accounts for

organisational identity and continuity. Organisational knowledge resides in the organisation's theory in use. Consequently, theory in use constitute the focus of any inquiry on organisational learning dynamics.

Organisational theory in use is encoded in private images and public maps of the organisation. The latter are defined as shared descriptions which individuals jointly construct to guide their behaviour. Maps offer a simplified picture of reality, thus allowing for cognitive economies and providing guides to future action. In this regard, maps are both descriptive and prescriptive. Having introduced the notion of theory of action as a guide to individual behaviour in organisations, Argyris and Schön analyse how these theories are formed, how they come to change, and in what senses they may be considered adequate or inadequate. This analysis leads to a theory of organisational learning. Human action and human learning are placed in the larger context of knowing and defined as the construction, testing and restructuring of a certain kind of knowledge. Likewise, organisational learning can be defined as a stable modification of behaviour. It occurs as a result of modifications of individual's maps and images of the organisation, which in turn, may produce changes in organisational theory in use. Argyris and Schön distinguish between two types of learning. Single loop learning is based on a simple feedback mechanism that links expected outcomes of action to the theory informing them in order to keep organisational performance within the range set by organisational norms (keep the organisation "on course"). The norms themselves remain unchanged. In this situation organisational members respond to changes in the internal and external environments of the organisations by detecting errors and correcting them within the existing theory in use. Single loop learning is effective for most of the day-to-day problems that organisations have to face. A typical example would be the modification of an organisational routine in response to a certain type of systematic disruption. The modification occurs within a constant framework of norms for performance. Double loop learning refers to situations of organisational change where complex issues cannot be tackled by means of existing cognitive and institutional resources. It implies changing existing norms and premises in order to solve the problem at hand. The authors also highlight the difficulties in succeeding in double loop learning. These difficulties are related to the tendency of organisations to resist change by enacting defensive routines (Argyris, 1990). Hence, a crucial dilemma for

organisations is the balance between control and innovation, between static and dynamic efficiency. In both cases, organisational learning, defined as a stable modification of behaviour, implies testing and restructuring the existing theory in use. Put another way, learning does not take place if the modifications in strategies, norms and assumptions are not embedded in organisational memory by means of encoding in organisational maps. Organisational learning is the result of a collective inquiry into the strategies, norms and assumptions underlying organisational practice.

1.2.2 The situated cognition perspective

More recent developments in cognitive and learning theories have attempted to move away from the disembodied view of knowledge suggested by symbolic cognition in order to stress the social, situated nature of representations. In particular, situated cognition goes beyond the traditional dichotomies between thought-action and individual-organisation by reconceptualising the "world of social activity" in relational terms (Chaicklin and Lave, 1993). Central to the situated approach is the problem of the context in which human action and interaction takes place. The context is described as a fabric of interrelated meanings rather than a sheer container of activity divorced from everyday practice. Most of the contributions within this perspective derive from psychology and cognitive anthropology and are characterised by a distinctive empirical focus on knowledge. They have in common a view of learning and knowing as predominantly social activities which take place through participation within a "community of practice" (Lave and Wenger, 1991).

From such an epistemological stance, knowledge is not the property of the individual but is distributed across a social system. Hutchins' (1993, 1996) ethnographic study of the work practices of a navigation team represents one of the best empirical inquiries into situated cognition. The study considers navigation as an activity system providing a distinctive context for thinking and learning. The routine activity on a naval vessel is centred around the task of devising fixes at regular intervals in order to establish the position of the ship. This task setting requires complex computations that exceed the capabilities of any individual and therefore need to be divided across a navigation team. Finally, the co-operative nature of the task requires substantial sharing of information, while the presence of overlapping regions in the role system

underlying navigational computations qualifies the team as a socially distributed knowledge system. Following the cognitive tradition, Hutchins' study emphasises the role of information processing and representation. However, it does so by taking a situated and relational perspective. A major strength of Hutchins' study lies precisely in its ability to subtly conceptualise the navigation activity as a knowledge system. Under these circumstances, the context of navigation identifies a minimal form of organisation, relating the task, the role system, the representational artefacts and equipment (e.g. nautical charts and measuring instruments) supporting the team's activities. The notion of a distributed knowledge system emphasises the fact that knowledge does not reside in the head of the team members, but rather is situated in a variety of organisational structures and sensemaking devices connecting the team's activities in a coherent whole.

The problem of the context also informs those related theories of knowledge and action which hold that knowledge is embodied in praxis (Pentland, 1992). According to Scribner (1987), learning is centred around problem-solving and is intricately related to the context, understanding by "context" here i) the problem's conceptual structure as well as ii) the purpose of the activity and iii) the social milieu in which it is embedded. Doing and knowing, or what she calls "practical thinking", are seen as open-ended processes of improvisation with the social, material and experiential resources at hand. In the workplace setting, learners acquire knowledge, competencies and skills through engaging in activities, continuously trying out new strategies, routines and interventions, and drawing on all available resources in the solution of practical problems. Practical problem solving is thus an open system that includes components lying outside the formal problem itself - objects and information in the environment, goals and interests of the problem solver, and social relations between workers.

1.2.3 Knowledge and sensemaking

Thus far, we have addressed only marginally the issue of meaning and interpretation of action, which is crucial to the construction of organisational knowledge. Consequently, our analysis needs to descend to a further level of detail in order to understand how organisations make sense of the flows and processes which

characterise their activity. Karl Weick has been the scholar who has introduced the sensemaking perspective into organisational study and has made this concept the analytical cornerstone of his phenomenology of organising (Weick, 1969). Sensemaking literally means the making of sense (Weick, 1995:4). It deals with how social agents construct meaning out of a flow of action and events and how this meaning is crystallised into sensible structures. As Thomas *et al.* (1993) have pointed out, the concept of sensemaking keeps action and cognition together. Like knowledge, of which it represents the "in becoming" aspect, sensemaking is closely related to action, contexts and time. Sensemaking is an ongoing activity related to how people cope with equivocal flows of action.

Although the concept of sensemaking seems to deal mostly with cognitive phenomena, when applied to organisations it proves to be extremely insightful. The ongoing character of sensemaking activity is reflected in the organisational routines conceived as carriers of tacit knowledge (Nelson and Winter, 1982). Also, in organisations we find a fundamental analogy between the workflow and the flow of meanings surrounding the execution of tasks and routines. If sensemaking keeps action and cognition together, the cognitive content of action emerges only in specific occasions, namely when action and cognition are set apart. This stresses the importance of breakdowns and triggers as entry points to tacit knowledge. Luis and Sutton's (1991) discussion of conditions for conscious cognitive processing, when people shift from automatic to active thinking, provides a valuable overview of occasions for sensemaking. The authors identify three kinds of situations in which actors are likely to become consciously engaged:

First, switching to a conscious mode is provoked when one experiences a situation as unusual or *novel* —when something "stands out of the ordinary", "is unique" or when the "unfamiliar" or "previously unknown" is experienced. Second, switching is provoked by *discrepancy* —when "acts are in some way frustrated", when there is "an unexpected failure", "a disruption" "a troublesome... situation", when there is a significant difference between expectations and reality. A third condition exists of *deliberate initiative*, usually in response to an internal or external request for an increased level of conscious attention—as when people are "asked to think" or "explicitly questioned" or when they choose to "try something new" (p. 60, also cited

in Weick).

Interruption is a common antecedent of sensemaking occasions. However, the mere presence of discontinuities in action is not sufficient. The sensemaker is an active agent and realities and environments are "enacted" by the actors who face them through processes of bracketing, punctuation and retention (Weick, 1977). In a similar vein, Luis and Sutton contend that "the situation alone does not determine whether the previously unknown or discrepant event will be experienced as such, whether it will 'stand out'. Instead, the predispositions and experiences of the individual in the situation contribute to the actor's sensitivity and openness to environmental conditions" (pp. 60-61). In other words, occasions for sensemaking are themselves constructed, after which they become a platform for further construction (Weick, 1995:85). The last observation highlights the importance of contexts for sensemaking and the act of interpretation. An action can become an object of attention only after it has occurred, and the choice of what the action means is heavily influenced by the situational context (*ibid.*:26). Hence a context affects both the process of noticing (Starbuck and Milliken, 1988) and the interpretation of what is noticed. It defines the scope and meaning of action.

The above considerations have important empirical consequences as the presence of a major crisis or disruption make sensemaking activities particularly conspicuous. A good example of the above is Weick's classical study of a group of fire fighters facing a major disaster in Mann Gulch (Weick, 1993). Drawing on secondary data provided by Norman Maclean's (1992) book *Young Men and Fire*, Weick describes in detail how a group of "smoke jumpers" performs in the face of a major fire. Failure in co-ordination between the group of fire fighters and their leader is reconnected to discrepancies in the group's "cosmology", i.e. the cognitive structure governing the sensemaking processes of the group. Specifically, the cosmology operating in Mann Gulch enables certain types of action while disallowing others (e.g. following certain types of orders). A major finding of the study is that serious dysfunctions in minimal organisations' performance may derive from the concurrent failure of sensemaking capacities (e.g. the ability to improvise) and organisational structures (e.g. the role system). The notion of cosmology points to the rigidities inherent in the institutionalisation of a knowledge system, i.e. what the members of a community

have come to take for granted over the years. The Mann Gulch disaster underscores the consequences of such rigidities in a dramatic fashion and this, aside from the author's elegant prose, is probably one of the narrative devices that make Weick's account so compelling.

1.2.4 Critical remarks

While the cognitive focus has added to our understanding of organisations in many ways, the predominant vision that has guided a major portion of cognitive studies has been symbolic cognition and the computer model of the mind. Boland and Tenkasi (1993) contend that this metaphor presents some limits. Firstly, it confuses information processing with meaning making. In fact, while a digital computer operates on the physical form of the symbols it computes without any concern for their meaning (syntax), the human mind is not indifferent with respect to meaning. Put another way, the computer model of the mind neglects the semantic dimension of knowledge creation. Secondly, it overlooks and reifies the fluid, shifting and often contradictory nature of human understanding to a fixed and static image. Thirdly, and most importantly, the computer model of the mind is ill-equipped to explain the dynamics of conceptual change in human beings and organisations.

More generally, the two chief assumptions underlying the cognitive approach – all types of action have a cognitive basis, and organisational cognition is an extension of individual cognition – raise major criticisms. A first point of controversy is that the view of knowledge purported by the cognitive approach is informed by an exclusive preoccupation with the mind. In contrast with the planning model, the situated cognition perspective has pointed out that knowledge does not necessarily need to be explicitly represented (Suchman, 1987). Argyris and Schön have made clear that theories in use do not need to be explicit. Advocates of the "thinking organisation" (Sims and Gioia, 1986) recognise that mental structures often operate unconsciously. Even Simon (Vera and Simon 1993), in a recent article written in response to the criticism coming from the situated action approach, has made clear that the fact that organisational actors operate according to plans and symbolic representations, cannot be questioned by their not being aware of that. In other words, cognitive processing and conscious awareness are two distinct issues. Secondly, organisational cognition is

derived from individual cognition without a clear explanation of how individual knowledge is organisationally amplified. For example, Argyris and Schön recognise that organisational knowledge creation stems from the interplay between private images and public maps of the organisations, but they do not explain the process that leads to sharing those images. Since the socially constructed nature of organisational knowledge is neglected, the cognitive perspective is not able to explain the genesis and evolution of a certain belief system. Furthermore, the emphasis on cognition overlooks the institutional dimension of knowledge and the role of contextual factors. As a consequence, the taken for granted aspects of knowledge underlying organisational behaviour are underestimated. The above considerations, expose the pervasive conceptualisation of cognition and action, individuals and organisations, as separate entities within the same phenomenon. This problem represents a major obstacle for understanding how organisations think. Indeed, the term "thinking organisations", coined by Sims and Gioia, provides a way to capture a paradox: organisations are the products of the thought and action of their members; they do not behave independently of the people who construct and manage them. At the same time, organisations also seem to take on a life of their own, thus offering a view of a "corporate mind".

In sum, the cognitive approach - based on a pervasive analogy with the computer model of the mind - draws on structural-functionalist assumptions, proposing an abstracted, disembodied view of human understanding. According to this vision, invisible, ordered patterns are supposed to lie beneath the conscious activity of the human subject. Thus, representation, conceived as a reified underlying pattern becomes a thing to be unearthed in order to promote organisational change processes. This position, which reflects the traditional Cartesian split between the mind and the body, has been nicely captured by Gilbert Ryle (1949) as the "dogma of the ghost in the machine". The ghost is represented by the invisible knowledge structures animating the human body and producing human behaviour. Given the "ghostly" nature of knowledge, it is always problematic to empirically derive specific actions and decisions from internal (invisible) representations of organisational actors. As a consequence, the problem of studying knowledge empirically remains unresolved. On the other hand, the situated cognition approach and the sensemaking perspective seem to close the gap between organisational theory and practice, and therefore provide the

conceptual basis for an empirical study on knowledge. In this respect, they provide a distinctive contribution towards the construction of a theory of knowledge in organisations that recognises the cognitive dimension while taking into account the importance of meaning and context.

1.3 Knowledge as commodity: the strategic management approach

1.3.1 The resource-based theory

A great deal of the current literature about organisational knowledge, ranging from those considering the economics of knowledge and its production to those considering the management of innovation and organisational design, begins with the distinction between knowledge and the traditional factors of production: labour, capital, and land (Spender, 1996). Prominent authors such as Drucker (1993), Quinn (1992), Reich (1991), Nonaka and Takeuchi (1995) have contended that knowledge has become the most important or "strategic" factor of production, so managers must know how to focus on its production, acquisition, movement, retention and application.

The resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984) draws on recent theoretical developments in organisational economics and in strategic management, as well as on a growing body of anecdotal and empirical literature (principally on product development) that highlights the importance of firm specific factors in explaining firm performance (Teece *et al.*, 1997). Most of this literature builds upon the increasing success of Japanese firms throughout the 80s and the relative competitive decline of Western companies. Indeed, the opposition Western/Eastern is a *leitmotiv* of most influential knowledge-based theories (e.g. Nonaka and Takeuchi, 1995).[1]

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[1] Interestingly, this point contrasts with the setback of Japanese firms during the 90s. In other words, the early debate on knowledge and competitive performance seems to be grounded in historical as well as contextual contingencies that do not hold true anymore.

The resource-based perspective attempts to develop a theory of strategy formulation which is an alternative to the traditional competitive forces approach developed by Porter (1980) and regarded as the dominant paradigm in the field during the 80s. According to Porter, competitive advantage results from the strategic positioning of a firm with respect to its environment, the latter being defined by the industry sector in which a firm operates. In particular, industry structure strongly influences competitive rules of the game and thereby the repertoire of strategic choices potentially available to firms. This perspective emphasises the actions a firm can take to create a defensible position against competitive forces (Teece *et al.*, 1997).

In contrast to the competitive forces approach, the resource-based theory (RBT) emphasises firm-specific capabilities and assets as the fundamental determinants of firm performance. At the heart of the firm's competitive strength is a process that develops distinctive, core capabilities, i.e. capabilities that differentiate a company strategically and deliver competitive advantage (Leonard-Barton, 1992a). Core capabilities develop through a fundamental *transformation process* by which standard resources available in open markets are used and combined, within the organisational context of each firm, to produce capabilities which in turn can become the source of competitive advantage, especially if they are rare and difficult to imitate or substitute (Barney, 1991).

Within the RBT panorama Prahalad and Hamel's (1990) conceptualisation of core competence has arguably provided the most influential knowledge-based theory in the strategic management field. Drawing on anecdotal evidence of American and Japanese firms operating in the same business, the authors argue that the superior competitive performance of the latter can be clearly reconnected to distinctive core competencies. Examples of core competencies include Sony's capacity for miniaturisation, Honda's distinctive competence in engines and power trains, NEC's digital technology and system integration skills, JVC's technology in video recording, and Casio's competence in display systems. And among non-Japanese innovative firms, Philips' optical-media expertise (laser disc), and 3M's competence with sticky tape.

The most innovative aspect of Prahalad and Hamel's approach is the re-conceptualisation of the firm around knowledge-oriented factors, namely core

competencies. The firm is compared to a (knowledge) tree, articulated according to a series of planes - end products, business units, core products, and core competencies - each reflecting in a more or less in-depth way the distinctive body of knowledge of a firm:

> The diversified corporation is a large tree. The trunk and major limbs are core products, the smaller branches are business units; the leaves, flowers, and fruit are end products. The root system that provides nourishment, sustenance, and stability is the core competence (p. 82).

The rejection of market determinism by resource-based theorists makes organisational knowledge a central theoretical concern. In particular, the knowledge base of a firm - as instanced by its portfolio of core products and core competencies - is seen as a source of distinction and "difference", i.e. what makes the firm what it is. As a consequence, difference, and not other factors, is the ultimate cause of competitive advantage. The use of the attribute "core" points in that direction. This is clearly visible in the choice of core competencies to explain the superior performance of Japanese firms.

The focus on endogenous, firm-specific resources as competitive forces raises important implications for the interaction between knowledge-based factors and organisational learning. The relevance of organisational learning processes is at least two-fold. Firstly, firm-level resources are based on tacit know-how and therefore highly idiosyncratic. For example, Rumelt (1984: 561) notes that the strategic firm "is characterised by a bundle of linked and idiosyncratic resources and resource conversion activities." These idiosyncratic resources result from the firm's specific learning trajectories which have been developed over time. Secondly, the set of existing competencies and capabilities may enable or constrain the learning potentials of a firm through path-dependency. As Teece *et al.* have pointed out: "resource endowments are 'sticky': at least in the short run, firms are to some degree stuck with what they have and may have to live with what they lack" (1997:514). This point is consistent with Leonard Barton's (1992a) notion of "core rigidities".[2] She sees capabilities as institutionalised assets (literally infused with value), which

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[2] The presence of core rigidities points to Hedberg's (1981) work on "unlearning". As Pettigrew and Whipp (1991) have pointed out, the jettisoning or refashioning of entrenched knowledge and beliefs may play a critical role in the dynamic of competition and strategic change (p. 277).

organisational actors have come to take for granted. Building upon illustrative cases of new product development in five American companies, the author finds that firm-specific capabilities are characterised by a fundamental duality: they can promote competitive advantage, or, conversely, provide a source of incumbent inertia. A major managerial challenge, therefore, derives from the firm's ability to handle the paradox of core capabilities and core rigidities. More generally, the notion of path dependency points to the institutional features of organisational knowledge (although as we shall see the process of institutionalisation of knowledge does not come under scrutiny) and highlights important learning dilemmas.

From an epistemological standpoint, RBT refers to a positivist-functionalist tradition, which sees knowledge as an objectified transferable commodity (Spender, 1996). Within this perspective, competence and other knowledge-based factors are somewhat immanent to products. For example, Prahalad and Hamel refer to products as "physical embodiments of corporate competence." In a similar vein, Rumelt contends that "product market competition is merely the superficial expression of a deeper competition over competences" (1994, p. xvi). In other words, products are the tip of the iceberg representing the stock of knowledge governing a firm's performance.

This commodification-reification of knowledge within RBT is reflected in a structuralist view of the firm. Indeed, the knowledge-based perspective brought forward by RBT challenges the traditional vision of the firm as a functional-hierarchical entity. For example, the tree metaphor suggested by Prahalad and Hamel points to a hierarchical knowledge architecture (roots vs. leaves), spanning through different organisational layers, each being an embodiment of a lower level one. Within this framework, core competencies are the "deep" structures underlying organisational performance. Likewise, Sanchez and Mahoney's (1996) modular perspective of the firm highlights the isomorphism between knowledge structures and the firm's core products.

A major consequence of the above re-conceptualisation of the firm is that the traditional functional structure, based on the division of labour and the employment relationship, is replaced by a more subtle division of knowledge. Within the firm context, core competence acts as a generative principle reflected in the structure of

core and end products, and core businesses.

1.3.2 Towards a dynamic knowledge-based theory of the firm

The resource-based approach seems to deal more with the elemental components of knowledge-based systems rather than the interactions between them. The need to account for the dynamic aspects of organisational knowledge is the main focus of most recent knowledge-based theories of the firm. Although this trend is becoming increasingly popular in the strategy field (see for example Grant, 1996; Spender, 1996; Teece *et al.*, 1997), most dynamic knowledge theories can be reconnected to the pathbreaking work of Nonaka and Takeuchi (1995) and Nelson and Winter (1982). Both works assume Polanyi's distinction of tacit and explicit knowledge as their point of departure. However, the two conceptualisations reach different conclusions about the entities involved in knowledge creation dynamics and ultimately, the evolution of the firm.

Nonaka and Takeuchi's (1995) theory of knowledge creation attempts to explain the systematic capacity of Japanese firms to outplay their Western competitors. By organisational knowledge creation the authors mean "the capability of a company as a whole to create new knowledge, disseminate it throughout the organisation, and embody it in products, services and systems" (p. 3). At the heart of Nonaka and Takeuchi's framework is Polanyi's (1966) distinction between tacit and explicit knowledge. Tacit knowledge is related to experience and is idiosyncratic. It can be defined as the stock of background knowledge that individuals take for granted in their everyday coping with the world. Explicit knowledge refers to knowledge that can be codified and articulated and therefore transmitted in a formal way. The two alternative types of knowledge are often referred to as know-how and know-that (Ryle, 1949). While the former is created "here and now" in a specific, practical context and conveyed through analogies and metaphors, the latter is contained in manuals and procedures and oriented towards a context-free theory.

According to Nonaka and Takeuchi (*ibid.*), knowledge is created and expanded through a continuous and dynamic interaction between tacit and explicit knowledge. Specifically, knowledge creation occurs through four modes of knowledge conversion

of tacit and explicit knowledge - which they call socialization, externalization, internalization, and combination - each one characterised by a particular content. This theory of knowledge creation encompasses both an epistemological dimension (types of knowledge at hand), and an ontological one (knowledge creating entities). As far as the latter is concerned, Nonaka and Takeuchi contend that knowledge is created only by individuals, although the conversion process is a social process between individuals and not confined within the individual. Subsequently, knowledge is "organizationally" expanded and amplified through the four modes of knowledge conversion and crystallised at higher ontological levels (group, organisation, inter-organisation). To exemplify this process the authors use the metaphor of the knowledge spiral, in which the interaction between tacit and explicit knowledge becomes larger in scale as it moves up the ontological levels.

Nonaka and Takeuchi hint at the primacy of tacit knowledge over the explicit when they affirm that "the key to knowledge creation lies in the mobilisation and conversion of tacit knowledge" (p. 56) and accordingly emphasise the role of individuals as carriers of knowledge and organisational innovation. In fact, unlike information, knowledge is about beliefs and commitment and therefore essentially related to human action (Kolb, 1979). Accordingly, knowledge creation is linked with dynamics of interpretation and sensemaking. However, the authors do not develop this important aspect of their theory and leave the problem of agency unresolved (Spender, 1996).

The conceptualisation of knowledge as a commodity and the above mentioned distinction between tacit and explicit knowledge also inform Nelson and Winter's (1982) knowledge-based theory of the firm. They see organisations as knowledge repositories. The knowledge of a firm resides essentially in its memory, and is stored in organisational routines. The authors suggest that the routinisation of activity constitutes the most important form of storage of organisational knowledge and that organisations essentially "remember by doing". Accordingly, they identify the routinisation of activity as the "locus" of operational knowledge in an organisation.

Following Polanyi (1966), the authors argue that much operational knowledge in organisations exists at a tacit level and that routines are the carriers of such knowledge. First of all, routines are ways of doing things that have consolidated over

time. They constitute quasi-automatic responses that have been deeply internalised by organisational actors and therefore escape their awareness (are executed without conscious volition). Routines are characterised by opacity and rigidity. Secondly, routines are to organisations what skills represent for human behaviour. Like humans, organisations are characterised by bounded rationality. Accordingly, they find it difficult or impossible to articulate a full account of the details of performance and, most of all, to be aware of the relationships that link those details.

The authors recognise to some extent the role of the individual as a knowledge agent. Information is actually stored primarily in the memories of the members of the organisation, in which resides all the knowledge, articulable and tacit, that constitutes their individual skills (p. 104). Accordingly a firm's performance depends on the ability of its members to "continue to know their jobs" and on the their capacity to interpret correctly and respond to the messages they receive form the working environment. However, the knowledge stored in human memories is meaningful and effective only in a certain context. In this respect, organisations provide the context that underlies the acts of interpretation performed by its members and consequently the background knowledge that informs the execution of skilled performance. The context typically includes firstly various forms of external memory - files, message boards, manuals, computer memories, magnetic tapes - maintained in large part as a routine organisational function. Secondly, the context includes the physical state of equipment and of the work environment generally. Performance of an organisational memory function is in part implicit in the simple fact that equipment and structures are relatively durable. Finally, the context of the information possessed by an individual member is established by the information possessed by all other members. Individual memories are linked by shared experience of the past - experiences that have established the extremely detailed and specific communication system that underlies routine performance (p. 105).

In sum, Nelson and Winter's conceptualisation of knowledge implies that organisations are able to 'know' independently of their members. Routines constitute the "genetic" material of organisations and evolve by genetic mutations, e.g. through the adaptation of the knowledge shared by organisational members to the environmental conditions. Accordingly, the evolution of a firm seems to be governed

more by stochastic processes than by deliberate choice.

1.3.3 Conceptual and methodological issues

Most existing knowledge-based theories of the firm seem to be governed by what can be called a "functional" vision of knowledge. This vision can be synthesised in two fundamental assumptions. Firstly, knowledge is objectified and treated as a "ready-made" product that can be put at the service of the organisation. The examples of core competencies quoted in Prahalad and Hamel (1990) provide an exemplification of the pervasive analogy between visible inputs/outputs (resources and products) and the stock of knowledge underlying their production (core competencies and capabilities). Competence seems to result from a mix of technology and production skills: "core products are the tangible link between identified core competencies and end products - the physical embodiments of one or more core competencies" (p. 85). As a consequence of this "commodification" of knowledge, a firm's core product is implicitly related to the way knowledge is utilised. Furthermore, the fact that most empirical studies on organisational knowledge very often focus on new product development and R&D activities demonstrates the power of the conceptualisation of knowledge as a commodity. In its turn, the commodification of knowledge is instrumental in suggesting a causal relationship between organisational knowledge and competitive performance, and prescriptions to improve the way organisations manage their patrimony of knowledge. Knowledge is linked to such terms as best practice and world class performance. The performativity of knowledge thus constitutes the second core assumption of the functionalist perspective[3]. Clearly, the vision of the firm as a production function, brought forward by classical economics, turned the organisation into a black box (see Spender 1996). Conversely, with knowledge-based theories competitive performance itself comes under scrutiny. The main aim of those theories is precisely to analyse the causes of competitive performance. In this respect, the knowledge-based perspectives posit a

[3]Indeed, the meaning of the word "performance" is ambiguous in itself. It may refer to the way organisations carry out their operations (e.g. to perform an activity) or, as it is currently used by the literature, it could have some value attached (e.g. "poor" or "successful" performance).

functional/causal link between knowledge and competitive performance.

The above theoretical statements characterise the mainstream literature on organisational knowledge and explain the success of such literature. Indeed, the fact that knowledge management has established itself as one of the "buzzwords" of the late 90s does not come as a surprise. In fact, the way knowledge is conceptualised by the mainstream approaches constitutes a sort of wishful thinking for the firm: the durability of knowledge (product) enables the firm to use it instrumentally. This perspective is therefore consistent with the image of organisation as a machine and knowledge is reconnected to the production process. On the other hand, the above assumptions underlying knowledge-based theories of the firm highlight major methodological difficulties. Competencies, resources and capabilities may well provide a sound terminology for a theory of knowledge, but at the same time they seem to be problematic as far as empirical validation is concerned. In fact, the epistemological difficulty implicit in the search for a conceptual definition of knowledge-based factors seems to conceal a deeper methodological problem. The assumption of the performativity of knowledge underlying the resource-based approach implies treating knowledge as an independent variable. However, as Scarbrough (1998) has noted, knowledge-based concepts such as those mentioned above defy measurement. As a consequence, is it difficult to appreciate to what extent organisational performance is really affected by its knowledge base.

Furthermore, the equation of knowledge and products bears dangerous empirical consequences, since the fundamental conversion process that transforms inputs into outputs is only implied rather than scrutinised. The theories analysed above display a tendency to abstract knowledge from practice and accordingly overlook the importance of action. In different versions, they all imply some kind of transformation process that leads to knowledge production as its outcome. The resource-based approach, for example, highlights the way resources are transformed into core capabilities within a structuralist, static view of the firm; Nonaka and Takeuchi see knowledge being generated through a dynamic interaction (conversion) between tacit and explicit knowledge; and finally, for Nelson and Winter the evolution of the firm results from a process whereby knowledge is stored and memorised in organisational routines. How these transformation processes occur is

not explained since emphasis is placed on outcomes rather than on the processes that lead to such outcomes. Nonaka and Takeuchi's framework probably provides the best exemplification of this critical omission. The interaction between tacit and explicit knowledge is explained by drawing on the metaphor of the spiral. But this image of a seemingly evolving process is itself a kind of black box - a tacit and unexplicated bridge between organisational resources and knowledge outcomes. As a consequence, the spiral glosses over the sensemaking dynamics and interpretation processes which lead to knowledge creation. A direct consequence of the above gap between theory and practice, outcomes and processes, and so on is a drift of these dynamic theories of knowledge towards stasis. As Spender (1996) and Tsoukas (1996) have pointed out the models proposed by the above authors appear to be formistic and based on Weberian ideal types as they implicitly assume that knowledge can be harnessed into static categories. Accordingly, the knowledge-based perspective tends to produce a content theory (Scarbrough, 1998, Spender, 1996), and gloss over the processual aspects of knowledge creation. More importantly, the commodification of knowledge makes it unproblematic and purely instrumental with respect to organisational performance. Organisational knowledge is not allowed to be controversial; it is not about hypotheses, let alone about disputes. Instead, making knowledge is about codifying experience and rendering it transparent. Accordingly, organisations turn knowledge into products, functions, tools, structures, objects and routines, divorcing it from epistemological questions.

To recap: in attempting to explain the causes of the firm's competitive advantage, knowledge-based theories of the firm posit a functional link between knowledge-oriented factors and competitive performance. This causal correlation raises important theoretical and methodological issues. Indeed the very notion of "intangible asset" seems to be permeated by an intrinsic tension. This makes the definition of knowledge-oriented factors somewhat problematic, at times tautological (skill, capability, etc.), or based on analogy ("glue that binds existing businesses", "roots of competitive advantage", "knowledge spiral"), or deducted from visible outputs (knowledge is equated to products). Put another way, core competence seems to refer to a commodity that transcends commodities, and ultimately a commodity which is not a commodity. As a result, the endeavour to build a knowledge-based theory of the firm seems to end up in a kind of reification of knowledge in the attempt to bring to

the surface something that by definition is not visible or empirically observable. As Scarbrough (1998) has pointed out, a major risk related to the above conceptualisations is that of opening the black box of organisation only to find another black box.

1.4 The organisational perspective

Although studies of knowledge in organisations have been a mainstay in the field of organisation theory (OT) for a long time, an organisational perspective on knowledge has emerged only recently (e.g. Blackler, 1995; Scarbrough, 1998), without yet being explicitly articulated. Interestingly, organisational theories attempt to reconcile the split between cognitive and normative elements of knowledge within a relational perspective on knowledge. As Scarbrough (*ibid.*) has rightly pointed out, a relational view of knowledge "highlights first of all, the way knowledge emerges not from manipulating representations of an objective reality, but from patterns of social relations and dynamic practice" (p. 227). Likewise, Blackler underscores the distinctive features of the OT approach by counterposing static, abstract notions of knowledge with action-based "knowing":

> "... rather than talking of knowledge, with its connotations of abstraction, progress, permanency and mentalism, it is more helpful to talk about the process of knowing... which is situated, distributed and material" (Blackler, 1995, p. 1035)

The added value of the OT perspective becomes apparent if compared to the other approaches described earlier. In a recent review of RBT, Scarbrough (*ibid.*) analyses the main issues where RBT and OT offer conflicting views of organisational knowledge. RBT defines knowledge as asset or commodity, and accordingly derives a conceptualisation of the firm as a stable configuration of resources (e.g. a portfolio of competencies). The emphasis is on the functionality of knowledge which is causally linked to performance through the creation of innovation and new products. Within this perspective, learning is seen as an incremental process based on changes in organisational routines and path-dependency. In contrast, OT authors see the firm as a social institution, a site of power and control. Accordingly, where RBT studies see change in terms of a process of evolution, OT authors emphasise crises, conflicts and dilemmas (Scarbrough, *ibid.*). Their focus is on the tacit features of learning and

knowledge acquisition, emphasising processes of social construction and the role of organisational contexts in shaping the dynamics of knowledge acquisition. A final point of divergence concerns the view on management. As it was said earlier, RBT is characterised by a managerial focus, emphasising the role of the manager as a decision-maker. For the OT perspective, managers are social actors among others, implicated in the political processes of negotiation within the firm and the wider societal context.

Interestingly, part of the above remarks on the RBT approach also apply to some theorists belonging to the cognitivist tradition. For example, the conceptualisation of knowledge as an objectified reality that can be explicitly manipulated; the functional link between cognition and action, and the emphasis on decision-making and managerial cognition. In this respect the two approaches present interesting converging points, albeit within different domains of knowledge definition and application.

Finally, the OT perspective on knowledge draws on the distinctive contributions of the institutional approach to organisational analysis (Powell and Di Maggio, 1991). The theoretical contribution of the institutional approach derives primarily from its specific focus on the tacit features of organisations. According to Zucker, institutionalisation is a "phenomenological process by which certain social relationships and actions come to be taken for granted" (Zucker, 1983: 2). In other words, institutionalisation refers to the degree of tacitness of knowledge and, in that sense, it can be seen both as a process and a variable. The taken for granted quality of certain practices and their reproduction in existing institutional arrangements is seen as a source of persistence, which accounts for the accumulation and maintenance of knowledge in organisations. The presence of reproduction mechanisms also highlights the ritual and ceremonial aspect of knowledge creation (Meyer and Rowan, 1977). Finally, the institutional approach takes into account the political dimension of knowledge creation, i.e. the conditions whereby a community reaches consensus about what is valid knowledge. The latter emphasises the socially constructed nature of knowledge and the role of power and legitimisation.

Following the above remarks, the contributions to a theory of knowledge in organisations deriving from an OT perspective can be summarised in two main

points. Firstly, the OT perspective highlights the situated nature of organisational performance and the processes of social construction underlying knowledge creation dynamics. In addition, it offers a political theorising of knowledge by stressing the importance of the institutional contexts and the normative assets in which knowledge creation takes place. Studies stressing the first aspect include the situated approach to learning and knowledge acquisition. Their focus is on organisational practices, conceived as embodiments of knowledge, and on the situations inducing or constraining processes of learning and knowledge acquisition (Brown and Duguid, 1991; Pentland, 1992; Lave and Wenger, 1991). Empirical studies falling within the political-institutional tradition encompass, amongst others, longitudinal studies of change and innovation (Pettigrew, 1985; Whipp and Clark, 1986). Here, the focus is on the linkages between time, action and structure in the strategic change process, as well as on the structural repertoires influencing the production and reproduction of organisational knowledge. In the following sections we review the main theories and empirical findings derived from OT studies.

1.4.1 Situated knowledge and the role of praxis

As we have shown above, the distinction between tacit and explicit knowledge can be misleading since they are mutually constituted and should not be viewed as two separate types of knowledge. In other words, the distinction is more analytical than substantial. Indeed the split between explicit and tacit reflects, to some extent, the philosophical dichotomy between mind and body. As we have seen, this distinction underlies the so-called dogma of the "ghost in the machine", and informs the two perspectives on organisational knowledge encountered earlier.

The situated approach adopts a pragmatic definition of knowledge, which rejects the Cartesian split between mind and body. Drawing on sociological theories of practice (Bourdieu, 1977) and on philosophical pragmatism (Dewey, 1938; Rorty, 1979), Pentland suggests that knowledge is neither ghost nor machine, but consists of situated performance or praxis. Likewise, Tsoukas in his constructionist approach to knowledge systems contends that "the human agent's understanding resides, first and foremost, in the practices in which he participates. The locus of the agent's knowing how to follow a rule is not in his head but in practice, that is to say, his understanding

is implicit in the activity in which he engages" (Tsoukas, 1996:16).

The situated perspective is informed by a conceptualisation of work as practice as opposed to the traditional employment relationship. Canonical descriptions of work organisation rely on the analysis of procedures, data flows, activities, "objects", transactions and processes, assuming that "work" can be ultimately decomposed in such constituent elements. However, the study of situated work practices has pointed out, in a variety of office and manufacturing settings, that work is more than a random collection of analytical abstractions and models to be rationalised (Wynn, 1979; Suchman, 1987; Zuboff, 1988; Brown and Duguid, 1991). Rather, it is a complex bundle of situated actions and interpretations aimed at making sense of resources and structures, and maintaining the identity of the members and the working community confronted by both routine and breakdown events. Within the situated perspective, the canonical, formalised organisation contained in organisational maps and prescriptive documentation is counterposed to non-canonical, emerging communities of practice engaged in everyday coping with the world. Ultimately, the situated approach challenges the artificial separation of knowledge and practice, structures and representations, put forward by traditional perspectives on work organisation.

The situated approach has produced a rich body of empirical studies. Orr's ethnography of photocopy repair technicians (reps) probably provides one of the most classical applications of this perspective. By following in detail the technician's "talk about machines", Orr discovers that the practices enacted by the reps in their everyday coping with troubled machines is much richer and more complex than the prescriptive documentation provided by the company manuals would suggest. For example, narratives and story telling constitute a fundamental aspect of the technicians' job.[4] Narratives have at least three functions. Firstly, they act as diagnostic tools and provide sensemaking devices; diagnoses and repair interventions are based on the successful solutions of problematic situations of the past, and learning occurs through success stories. Secondly, they foster knowledge transfer; knowledge is created day-by-day and maintained through the circulation of success stories. Finally, the circulation of success stories contributes to building the

technician's identity as a competent worker:

> Narratives form a primary element of this practice. The actual process of diagnosis involves the creation of a coherent account of the troubled state of the machine from available pieces of integrated information, and in this respect, diagnosis happens through a narrative process. A coherent diagnostic narrative constitutes a technician's mastery of the problematic situation. Narratives preserve such diagnosis as they are told to colleagues; the accounts constructed in diagnosis become the basis for technicians' discourse about their experience and thereby the means for the social distribution of experiential knowledge through community interaction. The circulation of stories among the community of technicians is the principal means by which the technicians stay informed of the developing subtleties of machine behaviour in the field. The telling of these narratives demonstrates and shares the technicians' mastery and so both celebrates and creates the technicians' identities as masters of the black arts of dealing with machines and of the only somewhat less difficult arts of dealing with customers... (Orr, 1996:2).

The empirical implications of the situational approach are very important. Firstly, if knowledge is embodied in practice it has to be retrieved by following organisational actors in their everyday dealings. Secondly, situations and not individuals become the most appropriate level for sociological analysis. The actions of organisational members are always shaped, to some degree, by the situation in which they find themselves. The situation provides the point of contact between the individual and the organisation (Pentland, 1992: 529). In operational terms, Pentland introduces the concept of the "move" (Goffmann, 1981) as a unit of analysis for his theory of organisational knowledge. The move is the elementary unit of organisational performance, be it a problem solving procedure or a different kind of routine. Drawing on empirical evidence of technical service interaction in software support hot lines, Pentland identifies a set of organising moves with which technical support operators respond to customer calls. The analysis of such moves leads him to conclude that the moves that specific actors use in certain situations both enact and reflect the structure of the organisation. The situational perspective offers a way to interpret members' performances in terms of organisational structures, such as hierarchy, the division of labour, and so on. Finally, knowledge is situated in the sense that it is highly contingent upon the interaction among people, resources and routines present in a given situation. Accordingly, each time we study knowledge in organisation we must start from the question: "where is knowledge situated?" and look for those features of a situation which constrain or induce intentional

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[4] As we will show in chapter 6, Orr's emphasis on the narrative dimension of knowledge strongly resonates with the findings of one of the case studies presented in this work.

performances or at least fall into the scope of attention of the actors in the situation (Ciborra, Patriotta, Erlicher, 1995).

1.4.2 Formative contexts: the double structure of practical knowledge

Practice theories focus primarily on tacit knowledge and the role of knowledge-producing practices in the workplace. According to Turner (1994), the meaning of practice is difficult to grasp, since it refers to and overlaps with a broader family of terms such as paradigm, tacit knowledge, *Weltanschauung*, tradition, ideology, and framework. All these concepts highlight the problem of empirical access to practices. From an analytical point of view it is useful to distinguish between practices and practice. The former refers to habits, custom, beliefs, and principles pointing to the fact that practices are shared. Conversely, the meaning of the term "practice" can be grasped as opposed to theory. What is emphasised here is the telic connotation of practice as activity seeking a goal. The two meanings are closely interconnected in that practices provide a shared background of readiness to hand for the execution of goal oriented activities (practice). In this respect, practices provide the causes for practical activities. The above distinction raises a crucial question for understanding the production and transfer of organisational knowledge. Turner asks: "to what extent does a practice in the telic sense require "practices" in the sense of *ingrained habits or bits of tacit knowledge?*" (italics added). When applied to organisations, the above question emphasises the relationship between visible activities and the tacit premises governing their execution. In fact, this distinction points to a double structure of practical knowledge.

A further insight into the concept of practical knowledge is offered by the notion of formative context (Unger, 1987; Blackler, 1992; Ciborra and Lanzara, 1994). According to this perspective, practical knowledge that informs human action is structured according to two distinct levels: it has a visible aspect which refers to the level of practices and routines. The execution of work routines is, however, governed by a stock of background knowledge that people usually take for granted and apply in situated actions. This second level, which is labelled formative context, relates to the tacit, unstated dimension of knowledge within which routines are "formed" and from which they receive their scope and meaning. The formative context directs our

attention to the cognitive, social and material foundations of the context that inform actions. Ciborra and Lanzara (1994), in extending Unger's (1987) ideas about formative context and applying it to organisational analysis, have defined the term as "the set of pre-existing institutional arrangements, cognitive frames and imageries that actors bring and routinely enact in a situation of action. A formative context thus comprises both an organisational and a cognitive dimension and has far-reaching, subtle influences: it constitutes a background condition for action, enforcing constraints, giving direction and meaning, and setting the range of opportunities for undertaking action" (p.70).

The distinctive feature of the formative context, as elaborated by Ciborra and Lanzara, is its dual emphasis on the cognitive and the institutional. When enacted in a situation of action, formative contexts are expressions of a social cognition that transcends the individual. "Such cognition may well be embodied in material or symbolic artefacts, organisational structures and procedures, institutional settings, and, most crucially, in the relationships or 'couplings' binding actors and their work tools in a sort of microecology of stable uses and shared meanings" (*ibid.*, p.72).

The context is "formative" in that it shapes the ways people perceive, understand, perform and get organised in a situation bounded in space and time. It is 'formative' because it may help people to see and do things in new ways, or on the contrary, make them stick stubbornly to old ways. Accordingly, the formative context sets a path for learning. For example, in their analysis of the process of innovation in a large European computer manufacturer, Ciborra and Lanzara reconnected phenomena of resistance to change and emerging work practices of the users to the interaction between the pre-existing hierarchical formative context and the emergent network-based one. Their findings point once again to the conventional distinction between a conceptualisation of work as employment relationship and work as practice, contrasting the official, formalised organisation with emergent communities of practice enacted by the daily acts of re-invention and improvisation performed by the users.

The outcome of a formative context is a texture of routines, roles and tasks, a division of labour, and a set of co-ordination mechanisms that come to possess 'an aura of naturalness' for those who execute routines within that context. Given its tacit nature

a formative context is empirically unveiled when organisational actors experience a situation of displacement, when new objects and routines are introduced in a pre-existing context or, conversely, when familiar objects and routines are withdrawn from that context. As we shall see later on in greater depth, one of these conditions is represented by the situations of breakdown, when the obviousness of daily routine becomes problematic.

1.4.3 Longitudinal and processual analysis: action, context and time

In a broad sense, the authors encountered in the previous two paragraphs have explored the relationship between action and structure (be it cognitive or institutional), their chief claim being that action, in the form of practice and routines, is deeply embedded in contexts. However, the dynamic character of action has been somewhat overlooked and we are still left with a static picture of knowledge in organisations. The idea of a social reality in becoming informs Pettigrew's (1997) definition of process and processual analysis. Following Sztompka (1991), Pettigrew argues that "social reality is not a steady state. It is a dynamic process. It occurs rather than merely exists. Accordingly, the overriding aim of the process analyst is to catch this reality in flight" (Pettigrew, 1997: 338). Indeed, Pettigrew's work is aimed at providing a theory of method that allows the analyst to capture the dynamic quality of human conduct. Echoing Van de Ven (1992), Pettigrew defines a process as "a sequence of individual and collective events, actions and activities unfolding over time in context." This broad definition identifies three crucial ingredients of processual analysis: action, context and time. The interplay between action and contexts has been discussed earlier. The added value of processual analysis is the emphasis on the dual quality (Giddens, 1979) of contexts and action: contexts are shaping and shaped. Actors are producers and products. More importantly, the distinction between action and context provides only an oversimplified picture of the organisational reality. In the interactionist field we have to imagine several processes occurring alongside, interacting and intersecting with one another, and shaping and being shaped by varieties of contexts. Accordingly, a processual analysis is driven by a holistic ambition, one that is able to tame the complexity of the interactionist field by linking processes and outcomes under investigation. In Pettigrew's words, "the

irreducible purpose of a processual analysis remains to account for and explain the what, why and how of the links between context, processes and outcomes" (Pettigrew, 1997: 340).

The attention to action and processes and the definition of organisations as entities "in becoming" inevitably leads the analyst to deal with issues of time. Time and history are at the centre of any processual analysis. The centrality of time in organisational phenomena has been previously highlighted by Pettigrew in his longitudinal approach (Pettigrew, 1990). In dealing with issues of time, Pettigrew emphasises the dual dimension of this phenomenon. On the one hand, time can be conceived as a sequence of events and chronology. On the other hand, history is to be understood not just as a neutral chronology: time is essentially socially constructed. Again, time shapes and is shaped. To understand the importance of this duality of time in organisations let us consider how a firm organises its activities around time. The working day is divided into shifts, the pace of machinery is governed by a working cycle, plans are calendarised, a product is characterised by a life cycle, cycles of crisis follow cycles of growth of the firm. Additionally, time frames are built around innovation processes, for example, the design and development cycle of a car, or the long process (time to market) of taking an idea for a new drug from the laboratory to the marketplace (Pettigrew, 1990: 273). In all these situations time punctuates and measures a sequence of events and, conversely, organisations appropriate time through a varieties of structuring devices which constitute the essence of organising. Time shapes the behaviour of organisational actors and is shaped by them. An important implication of this duality of time (time as chronology and time as social construction) is that we have to study events and the social constructions of those events in the context of the important time cycles which help to provide the implicit rhythm of particular social systems. What is critical is not just events, but the underlying logics that give events meaning and significance (p. 273). Finally, longitudinal analysis also deals with the issue of finding a temporal entry point for accessing organisational reality. Here the question reads as follows: how do we determine the time span which should be covered by our analysis? In presenting his theory of method for conducting longitudinal field research on change, Pettigrew (1990: 272) interestingly suggests to focus on major social dramas, breakpoints and disjunctures in a firm's history which indicate the end or beginning of periods of

continuity or change. As we shall see in chapter 2, the identification of crucial turning points in the unfolding of action will be used as a core idea for understanding the role of breakdowns in organisations.

The longitudinal and processual analysis has been fruitfully applied in empirical studies dealing with the management of strategic change and innovation. In their study of the design and innovation process at Rover, Whipp and Clark (1986) highlight the constraints on change arising from the "structural repertoires" developed by the company through its institutionalised past experience. For example, the shift from refined design processes to mass production schemes, following the merger with British Leyland, called into question not only the skills of the Rover designers, but also their identity of professionals. Importantly, structural repertoires embody a worldview. They link product, production process, and work organisation in a coherent whole. In this respect they point to the systemic nature of knowledge in organisations. In a similar vein, the perspective on change followed by Pettigrew in his classic study of ICI (1985), attempts to conceptualise major transformations of the firm in terms of the linkages between the content of change and its context and process. Drawing on rich empirical evidence, the study follows in detail the strategic change process across five in-depth case studies in order to identify the main patterns of strategic change and continuity developing over time in the large British chemical company. The findings of the study highlight the political nature of the change process. The development learning of strategic change at ICI is seen as "a political learning process... designed to establish the dominating legitimacy of a different pattern of relation between strategic content, context and process" (Pettigrew, 1987: 666). Finally, Pettigrew and Whipp (1991) have analysed the implications of a firm's knowledge assets on competitive performance from a longitudinal perspective. Their study draws on empirical evidence on the relative performance of firms over long periods to demonstrate the link between competitive success and the ability to manage the change process, conceived as a critical knowledge asset. The study compares and contrasts the patterns of competition of eight high and low performing firms operating in the four sectors of automobiles, book publishing, merchant banking and life assurance. The competition pattern emerging from the study can be described according to an interconnected set of intangible assets. From an empirical standpoint, these intangible assets can be operationalised through five interrelated aspects of

managing strategic and operational change: environmental assessment, leading change, managing the link between strategic and operational change, human resources as assets liabilities, and management of coherence. The findings point to the interlinked character of the process of strategic change and competition. To conclude, the strength of the longitudinal approach to the study of knowledge in organisations is both theoretical and methodological. It emphasises the linkages between the content, process and context of knowledge creation and institutionalisation, whilst providing a sound methodological framework for studying knowledge as a dynamic, emergent phenomenon.

1.5 Knowledge and the laboratory: the techno-science approach

In the previous sections we have come across a number of oppositions that represent the tension between alternative modes of thinking about knowledge in organisations. But knowledge itself is subject to this tension. In analytical terms we have to distinguish between *knowledge,* the physical product, the outcome, and *knowing*, the process that leads to the social construction of commodified knowledge. In order to settle this dialectic tension we now need to address the way the two terms of the opposition are translated into each other. That implies "opening" organisational black boxes and exploring their content.

The techno-science approach takes a "constructionist" stance to knowledge-related phenomena and refers to that branch of the sociology of knowledge which is interested in the process of social construction of reality (Berger and Luckmann, 1967). As the label indicates, this perspective derives from the sociology of science and technology and focuses mainly on the work of scientists, inventors, and engineers and the organisations of which they are part. The laboratory, conceived as the locus where knowledge is produced and transformed, is the pervasive metaphor underlying this body of literature. With some notable exceptions (see, for example, Tsoukas' constructionist approach), the techno-science perspective has not been extensively or explicitly applied to the field of organisation theory. However, some of the principles informing it can be complementary in understanding the process of organisational knowledge creation and offer an additional insight into the tacit features of organisations.

The techno-science approach offers a contested view of knowledge. As for science in general, knowledge is about the "making of facts" and is thus linked to discourse. Scientific discourse undergoes a process of validation whereby knowledge is initially provisional and contested before being turned into agreed facts. For science, making knowledge is about resolving controversies. It is about reality and sensemaking. However, once controversies are turned into facts, knowledge is closed off and becomes a "black box". Here again emphasis is placed on the durability of knowledge, but this durability is the outcome of an epistemological closure of controversies rather than an instrumental resource.

The techno-science approach rejects the traditional separation of science and technology based on the conventional wisdom whereby "science discovers, technology applies". Instead, scientific facts and technological artefacts are reconnected to the same dynamics of knowledge production and institutionalisation. More generally, the techno-science approach denies conventional dichotomies deriving from subject-object distinction, such as those between mind and body, nature and science, technology and society, science and technology, internal and external. In contrast to traditional dualistic epistemologies, the authors within this perspective take a holistic, systemic approach to knowledge creation, and favour a more comprehensive definition of the entities involved in knowledge creation dynamics.

The rejection of dichotomies in favour of systems and networks is informed by the assumption that knowledge creation in science and technology eludes any categorisation. "System builders are no respecters of disciplinary and knowledge boundaries." Rather, their work encompasses a seamless web of interactions, associations and translations. In the work of scientists, inventors, engineers and managers - and the organisations of which they are part - the technical, scientific, social, economic and political matters tend to overlap. Accordingly, the observation of professionals at work must equally blur the above categories in order to account for the messy interactions occurring within knowledge-producing networks.

In line with the above assumptions, the chemical transformations occurring in laboratories and the electrical networks underlying the functioning of technological systems become an analogy of the knowledge creation process. This view wishes to counter the determinism of hard sciences which sees the development of scientific

and technological innovations as a set of linear and mechanical interconnections. Furthermore, knowledge creation is not defined as an exclusively endogenous process. The systemic approach and the notion of a seamless web, highlight the role of the wider socio-institutional context in shaping the knowledge creation dynamics through mechanisms of legitimisation and epistemological closure.

1.5.1 The social construction of technological systems

As stated in the introduction, the techno-science approach is primarily empirical in its focus. The empirical literature produced in this field is quite rich, encompassing social constructionists approaches to science and technology, social shaping of technology, history and sociology of technology, laboratory studies, actor-networks, and so on. A first strand of literature analysed in this section focuses on the social construction of technological systems.

Drawing on history and sociology of technology, Pinch and Bijker (1989) attempt to sketch a theory for studying the social construction of scientific facts and technological systems. From the early history of the bicycle, the authors provide examples of closure and stabilisation, social shaping, interpretative flexibility, and the influence of social groups. Their focus is on the controversies surrounding the development of this technological artefact. More specifically, what interests them is the conflicting perceptions of different social groups engaged in the definition of problems and the invention of solutions through processes of negotiation and collective interpretation. The interplay between relevant social actors, problems and solutions leads to a temporary closure and stabilisation of the technology, which is nonetheless subject to the emergence of further controversies and "reverse salients". The case history of the bicycle presents technological development as a non-determined, multidirectional flux that involves constant negotiation and renegotiation among and between groups shaping the technology. Their model is far from the rigid, categorised, linear one sometimes presented for technological development. Furthermore, the findings of the case suggest a three-stage framework to analyse the processes whereby knowledge, in the form of scientific facts or technological artefacts, is created and institutionalised within a given social context.

In the first stage, the interpretative flexibility of scientific findings is displayed; in other words, it is shown that scientific findings are open to more than one interpretation. This shifts the focus for the explanation of scientific developments from the natural world to the social world. Interpretative flexibility highlights the contentious nature of knowledge and the equivocality of action by focusing on technological controversies. Also, by stressing the equivocality of action, it directs our attention towards processes of collective sensemaking. Although this interpretative flexibility can be recovered in certain circumstances, it remains the case that such flexibility soon disappears in science; that is, a scientific consensus as to what the "truth" is in any particular instance usually emerges.

Social mechanisms that limit interpretative flexibility and thus allow scientific controversies to be terminated are described in the second stage. This level of analysis focuses on closure and stabilisation, i.e. on those mechanisms whereby knowledge is stabilised, made durable and turned into a black box. "Closure occurs in science when a consensus emerges that the "truth" has been winnowed from the various interpretations; it occurs in technology when a consensus emerges that a problem arising during the development of technology has been solved. When the social groups involved in designing and using the technology decide that the problems is solved, they stabilize the technology" (p. 12). Closure mechanism highlight issues of consensus, legitimisation, institutionalisation, and articulation.

A third stage, which according to the authors has not yet been carried through in any study of contemporary science, involves relating such "closure mechanisms" to the wider socio-cultural milieu. Basically, this third stage challenges the assumption that knowledge creation is an endogenous process. In this respect, knowledge creation can be assimilated to the creation of a public good: it is a matter of consensus, legitimisation and institutionalisation within the wider social context.

Callon (1980) uses his study of electrical vehicle development in France to sketch the actor-network approach. The actor-network represents a higher level of abstraction that subsumes science, technology and other categories. Actors are the heterogeneous entities that constitute a network. They include both human and non-human entities. For example in the case of the electrical vehicle, Callon's actors include electrons, catalysts, accumulators, users, researchers, manufacturers, and ministerial

departments enforcing regulations affecting technology. These and many other actors interact through networks to create a coherent actor world. Callon's actor-network posits the "indeterminacy" of the actor, opening the actor world to non-human entities and allowing them to speak.

1.5.2 Opening organisational black boxes

A second rich strand of empirical literature produced within this approach concerns the study of laboratory life (Latour and Woolgar, 1979; Latour, 1987) and the manufacture of scientific knowledge (Knorr-Cetina, 1981).

In *Science and Action*, Latour (1987) offers a brilliant theory of method for studying the "fabrication" of scientific facts and technical artefacts.[5] The latter are conceived as black boxes that have undergone a controversial process of social construction. The word black box, borrowed from cybernetics, is used metaphorically by Latour to indicate a final product, be it a fact or a piece of equipment, that has become taken for granted by the community of users. The task that a researcher has to face in order to deconstruct a fact is precisely that of re-opening the black box. But how is this mission to be accomplished? Again, we are looking for a way to access a particular system of knowledge, be it a scientific fact or an organisational system.

In the introduction of *Science and Action*, Latour asks: "where can we start a study of science and technology?" (p. 2). The proposed strategy, or "rule of method" to enter facts and machines is a tricky one. He invites us to forget about end products and to look at science "in the making" as opposed to "ready-made" science: "We go from final products to production, from 'cold' stable objects to 'warm' and unstable ones. Instead of blackboxing the technical aspects of science and *then* looking for social influences and biases, we realised how much simpler it was to be there *before* the box closes and becomes black" (p. 21). This temporal inversion in the choice of a point of departure is the key for studying knowledge creation as a process of social construction. Controversies and not finished products provide a way in. The analyst

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[5] It is interesting to note how facts and machines are both conceptualised as black boxes, as "physical" outcomes of a social construction process.

will then follow the characters involved in the construction of a fact "while they are busy at work", and attempt to reconstruct the network of events, decisions, physical artefacts, and institutions, surrounding the "making" of things.

The technique adopted by Latour is that of the flashback, of the journey in space and time since any process of social construction always has a historical dimension. The flashback takes us back to a moment when knowledge has not been institutionalised, when the black box has not yet been closed. During the flashback, the black box gets re-opened allowing the analyst to trace back retrospectively the processes that have led to a certain outcome. Although the technique is fascinating, the task is not an easy one. The "actor-network" is characterised by a variety of heterogeneous processes occurring alongside and intersecting with each other. Latour seems to be aware of the complexity of the interactionist field and of the risk of drifting endlessly: "How are we going to account for the closing of the black boxes? It is all very well to choose the controversies as a way in, but we need to follow the closure of these controversies." In other words, we also need a way out.

The complexity of the knowledge in the making arena is captured by the notion of the actor-network (Callon, 1980). The concept emphasises the equivocal nature of action and processes and the social construction of categories (headlines) under which we synthesise processes belonging to different domains. The actor-network is a "quasi-object" (Latour, 1993), a hybrid made of people, institutions, physical artefacts, and social practices. The actor-network contains a story that gives some unity to the heterogeneous material of which it consists. However, it is a shifting story, or better a shifting trajectory, that acquires different meanings as we shift our focus of attention. In other words, the boundaries of the actor-network are brittle and the plot that it is made out of it crucially depends of the judgements of the external observer. The narrator's account, as the phenomena observed, is itself socially constructed. It depends on contingent factors, such as the narrator's past experience, the institutional and cultural setting in which he/she conducts the research, or even, as Pettigrew (1990) pointed out, the moment in which he/she decides to put pen to paper. The observer him/herself is part of an actor-network.

Like Latour, Knorr-Cetina (1981) is interested in the problem of "facticity" of knowledge. Facts are seen as laboratory fabrications (from the Latin *facere* = to

make) as opposed to given entities. More specifically, by focusing on the practices of knowledge production and reproduction in the laboratory setting, Knorr-Cetina aims to build an ethnography of knowledge that eventually leads to a theory of such practices (see Bourdieu, 1977). The above conceptualisation of scientific facts has crucial implications for the study of knowledge as an empirical phenomenon:

> Once we see scientific products as first and foremost the result of a process of construction, we can begin to substitute philosophical theories of knowledge with an empirical theory of knowledge (Knorr-Cetina, 1981:3).

More generally, the laboratory challenges the epistemological concept of "truth" stressing a pragmatic definition of knowledge related to "making things work". The laboratory, conceived as a workshop where knowledge is instrumentally manufactured, is described in phenomenological terms as a "local accumulation of instruments and devices within a working space composed of chairs and tables" (p. 3). The main argument derived from the study of laboratories is that "products of science are contextually specific constructions which bear the mark of the situational contingency and interest structure of the process by which they are generated, and which cannot be adequately understood without an analysis of their construction. This means that what happens in the process of construction is not irrelevant to the product we obtain. It also means that the products of science have to be seen as *highly internally structured* through the process of production, independent of the question of their external structuring through some match or mismatch with reality" (p.5).

Processes of fabrication of facts highlight the controversial nature of knowledge. They involve chains of decisions and negotiations through which their outcomes are selected and derived. The process of social construction refers precisely to a decision-laden fabrication of scientific products. In turn, decisions and interpretations within the laboratory are contingent upon the historical context (context of selection) in which they are situated. (p. 9). In sum, the approach followed by Knorr-Cetina in the study of laboratory practices attempts to establish the symbolic, contextually contingent character of the scientific manufacture of knowledge. In this respect, her approach bears important similarities with the situated perspective encountered before.

Having reviewed some relevant empirical studies within the techno-science approach

we are now in the position to assess the main contributions of this perspective to the theorisation of knowledge in organisations. One important caveat it suggests, given the intangible and provisional nature of knowledge-in-the-making, is the need to bracket the link between organisational knowledge and performance. The focus is on the chain of transformations that knowledge undergoes over time and the conditions that lead to the epistemological closure of black boxes, rather that on the finished products. As we shall see in chapter 7, black boxes are characterised by a fundamental duality of being and becoming. In this respect, content theories like RBT and social constructivism can be fruitfully combined in order to study the linkages between content, process and context of knowledge creation and institutionalisation. Having said that, the positive contribution of the constructionist approach to the study of knowledge in organisations is at least twofold. The first relates to method. Since, as in science, knowledge is treated as an empirical phenomenon, it suggests that we should concentrate on the inner workings of knowledge and look for ways to make knowledge empirically observable. The second is more theoretical. Since the process of knowledge production is context specific and needs to be appraised case by case, the inference is that knowledge systems can help to explain the uniqueness of organisations (or organisational performance in the sense of behaviour and without any value attached to the word). In other words, the distinctive features of organisations derive from the way they create, use and disseminate knowledge: knowledge is a source of "difference".

On the other hand, the above approach is not immune from criticism. In its most radical formulation, the techno-science perspective replaces technological determinism with an even stronger form of social determinism. Secondly, the notion of seamless webs and actor-networks raise the issue of boundaries to knowledge creation. In other words, the assumption of the indeterminacy of the actor leads to a more general indeterminacy principle underlying the development of scientific facts and technological artefacts, and ultimately any knowledge creation process. In addition, the definition of the actor-network as a metalevel concept transcending knowledge categories leads to a reification of the concept.

1.6 Gaps in the literature and researchable questions

As already stated in the introduction of this study, the existing literature on organisational knowledge seems to be characterised by a dearth of empirical studies. Taking into account this major limitation, the present chapter has reviewed four main perspectives on knowledge in organisations in order to assess the main contributions and gaps in the literature. Specifically, the analytical approach adopted in the review has aimed to systematically uncover the tacit assumptions underlying existing knowledge-based theories. At the theoretical level, the debates identified within the literature raise the issue of commensurability. Put another way: do the four perspectives analysed above relate to each other or are they independent of each other? Are they complementary or do their underlying assumptions exclude one another? A second major issue concerns the empirical focus of the study, that is: where to direct observation since not all forms of knowledge are, and indeed may not be, directly accessible?

In order to answer the above questions one has to bear in mind the state of the debate on knowledge in organisations. Echoing Scott (1987), it is appropriate to say that knowledge theories have just entered the adolescent phase with some perspectives still in an early stage of development. This fact possibly justifies the absence, at least so far, of established and competing paradigms on organisational knowledge. Within this scenario, the four perspectives presented above provide different theoretical and empirical vantage points on knowledge-oriented phenomena in organisations.

Taken individually, the four perspectives are characterised by distinctive strengths and weaknesses. The cognitive perspective stresses the linkages between action and cognition and therefore offers the insight that knowledge is mobilised in the form of representations. A typical source of empirical evidence is provided by thought experiments, developed in the field of artificial intelligence (e.g. Weizenbaum, 1976; Touring, 1982; Winograd and Flores, 1986), aimed at assessing the "inner workings" of the mind. Such experiments are based on a pervasive analogy between human knowledge and intelligent machines, stressing issues of language and communication, computations, and mental representations. At the same time, emphasis on cognitive processes leads to a reification of the mind, based on the antithesis of inner and outer worlds. As a result, knowledge is defined in abstract as a representation of an

objective world existing "out there". Furthermore, the focus on individual mental processes overlooks the collective, public dimension of knowledge.

The strategic management perspective probably offers the most consistent conceptualisation of knowledge, which is reflected in the attempt to build a knowledge-based theory of the firm. It provides a sound vocabulary for the study of knowledge-related dynamics in organisations while stressing the critical linkage between knowledge and competitive performance. However, the commodified view of knowledge purported by this perspective presents both theoretical and empirical limitations. At the theoretical level the strategy approach seems to be informed by a set of reductionist assumptions, such as the dichotomy tacit/explicit, the identity of knowledge as a product, and the exclusive managerial focus. At the empirical level, the treatment of knowledge as the main determinant of competitive performance presents problems of operationalisation, which have been discussed earlier. These problems are reflected in the wide use of anecdotal evidence and emblematic cases as a source for theoretical generalisations (e.g. Prahalad and Hamel, 1990; Nonaka and Takeuchi, 1995).

The organisational perspective's major strength lies in its relational focus. Knowledge is conceptualised in a holistic fashion stressing the linkages between action, context, and processes. The organisational perspective is also strong in its empirical tradition, characterised by interdisciplinary focus and reliance on case studies as the main source of empirical evidence. However, the review of the literature within this perspective has signalled a lack of significant empirical studies on knowledge as a phenomenon in its own right. A notable exception is Alvesson's (1995) study of a large IT consultancy firm in Sweden. Overall, despite the presence of themes that are akin to knowledge (e.g. change, innovation, and learning), the organisational perspective seems to be a late comer in the theoretical and empirical debate on knowledge in organisations.

Finally, the techno-science approach highlights the controversial, socially constructed nature of scientific facts and technological artefacts. Its focus of inquiry is on chain of transformations that knowledge undergoes over time and on the conditions that lead to the institutionalisation of knowledge outcomes, rather than on finished products *per se*. The empirical focus, combining ethnography and history as methods of

inquiry, is the distinctive trait of this perspective and a main point of strength (e.g. Knorr-Cetina, 1981; Latour, 1987; Pinch and Bijker, 1989). On the other hand, certain variants of social constructionism (e.g. actor-network theories) seem to display a tendency toward total relativism, which denies the existence of an objective reality and therefore overlooks the material, content-related aspects of knowledge creation.

Admittedly, each perspective is characterised by distinctive assumptions about knowing and things to be known. At the same time, the main approaches to knowledge considered in this chapter are quite varied in themselves and present, to a higher or lesser extent, a good deal of controversies and conflicting positions. The latter defy any attempt to view those approaches as monolithic theoretical constructs. Furthermore, the complex and interdisciplinary character of the subject under study makes it difficult to draw a line between perspectives. In this regard, the classification proposed in the chapter represents an attempt to cut up the literature in a pragmatic manner. For the same reason it seems appropriate to speak about perspectives rather than paradigms in order to stress the controversial and multi-faceted nature of knowledge in organisations.

The presence of dialectics and controversies within and across perspectives points to a possible solution to the problem of incommensurability. Recent debates on issues of incommensurability have highlighted the importance of relying on pluralist epistemology (Spender, 1998) and paradigmatic pluralism (Kaghan and Phillips, 1998) as a way to capture knowledge-related phenomena in a more holistic and systemic way. As suggested by Spender, pluralism admits multiple forms of approach, evidence, and reasoning (Spender, 1998: 235). At the same time, there are also dangers related to the adoption of a pluralist perspective. Namely, the tendency toward pluralism, eclecticism, and integrationism can lead to excessive drifting and indeterminacy. This could result in the development of an indistinct viewpoint where "anything goes" and the author is not accountable for his/her position. In this regard, any study of knowledge in organisations should be informed by a twofold intent. On the one hand, it should draw on the insights offered by all the four perspectives presented above while being open to contaminations coming from related, but more distinct disciplines such as history and anthropology. On the other hand, it should attempt to build a distinctive position on the subject under investigation.

At the methodological level, the discussion of the four perspectives highlights the need for shifting the analytical focus of inquiry from abstract knowledge categories to everyday organisational activities. This requires a new empirical attention to action, practices and routines, conceived as the multi-faceted aspects of the everyday life of organisations. In this respect, the present study aims to capture the micro level foundations of knowledge in organisations and thereby relate forms of action to modes of knowing and organising. In order to tackle this challenge this research combines case studies with ethnographic strategies of inquiry.

The main researchable questions that can be derived from the above discussion are informed by the need to maintain an open conversation between different theoretical perspectives in order to gain a better understanding of knowledge in organisations. The questions are both theoretical and empirical, inasmuch as the two aspects are inextricably bound together by the objectives of this study. Secondly, the research questions are built upon the main strengths and weaknesses identified within existing perspectives on knowledge in organisations. They aim to fill some important gaps in the literature and at the same time are prompted by the theoretical and empirical contributions provided by that literature. In particular, the review of current knowledge theories suggests at least five important themes to be explored in this study: 1) empirical knowledge and processual focus; 2) knowledge systems; 3) knowledge institutionalisation; 4) knowing and organising; 5) knowledge and time.

1. Empirical knowledge and processual focus: The emphasis on empirical focus is solicited by the techno-science approach and by those studies that have applied ethnographic-based methods to the study of knowledge (e.g. situated cognition). In spite of the wide recognition of a tacit dimension of knowledge, there is no indication in the mainstream literature of any method to make tacit knowledge empirically observable. For instance, the conceptualisation of knowledge as an independent variable that accounts for such phenomena as innovation, change and, more generally, organisational performance, presents major problems of operationalisation. This omission is reflected in the predominance of content theories (e.g. RBT) over process ones. For example, emphasis on product development as a metaphor of knowledge creation provides no explanation of the transformation process by which knowledge is translated into stable assets. *How do we empirically observe the processes whereby*

organisations create, use, and transfer knowledge? What are the micro level foundations of knowledge in organisations? What type of problems do social actors produce and attempt to resolve in everyday organisational activities? How does that affect the creation and further institutionalisation of knowledge?

2. *Knowledge systems*: Existing typologies and classificatory systems of knowledge seem to provide partial viewpoints on knowledge as a holistic phenomenon. Under these circumstances, the organisational perspective represents a notable exception and suggests the development of a relational, contextual view on knowledge. *How is it possible to build a theory of knowledge able to dynamically link the content, process and context of knowledge creation and institutionalisation? What are the main outcomes of knowledge creation and institutionalisation in different organisational settings? How do different social actors invent, try out, and learn new patterns of action and routines? What sorts of knowledge arise from them? In what settings and through which processes?*

3. *Knowledge institutionalisation*: The attention on knowledge institutionalisation is prompted by the contributions of the institutional approach to the study of organisations. This set of questions underscores the over-emphasis that has been placed in the last few years on knowledge creation and change to the detriment of the critical processes by which knowledge is accumulated, made durable, and maintained. *How do organisations legitimise and institutionalise the knowledge they create? What are the conditions that lead to the institutionalisation of stable knowledge outcomes? How is knowledge crystallised and capitalised in organisational structures of signification? In what visible aspects of organisation is knowledge evidenced and displayed? What are the sources of persistence of a firm's patrimony of knowledge?*

4. *Knowing and organising*: The fourth set of questions links knowledge dynamics to sensemaking. It derives from organisational psychology and from those theories that have emphasised the socially constructed nature of reality (Berger and Luckmann, 1967). This set of questions underscores the importance of viewing organisations as ordering devices and the conceptualisation of knowledge-related phenomena as "ways of worldmaking" (Goodman, 1978). Admittedly, each of the knowledge perspectives encountered in this chapter is associated with a distinctive theory of the firm. However, there are no attempts in the literature to link distinctive modes of

knowing to the broader principles of organising. This fact seems to highlight a gap in the ability to link organisational epistemology to the ontology of organisations. *What is the relationship between organisational knowledge and the phenomenon of organising? How do people in organisations make sense of the activities in which they engage? How do they relate those activities to the broader organisational reality? How does that affect the construction of organisational knowledge?*

5. *Knowledge and time*: The fifth set of questions states the significance of time and history in the study of knowledge-oriented dynamics in organisations. This particular angle on organisational knowledge has been introduced in the field by those scholars who have undertaken longitudinal studies of organisation (e.g. Pettigrew, 1985; Whipp and Clark, 1986). A dynamic theory of knowledge ought to be able to link knowledge transformations to the process of organisational becoming. A time dimension needs to be introduced. *How do we account for the transformations that knowledge undergoes over time? How does knowledge shape and is shaped by the evolution of organisation? How does a knowledge system emerge and evolves over time? How does it acquire a normative value? What is the nature and the process of knowledge acquisition in different organisational settings and evolutionary phases?*

CHAPTER 2: RESEARCH METHODOLOGY

2.1 Introduction

Taking into account the theoretical approaches and analytical assumptions specified in chapter 1, the basic task of the methodology is to provide an account of organisational patterns of knowledge creation, utilisation and institutionalisation. In order to tackle this challenge the study deploys qualitative-inductive methodologies based on participant observation and a "thick description" of everyday practices and routines (Geertz, 1973). Specifically, the research method relies on the development of qualitative case studies as a main strategy of investigation (Yin, 1994). Empirical evidence is provided by three in-depth case studies conducted at Fiat Auto, Italy. Case 1 (Melfi 1) deals with the construction of an avant-garde assembly plant from a green field site. Case 2 (Melfi 2) considers the same plant four years after its foundation in order to assess the main transformations in the patterns of knowledge creation and institutionalisation once the plant had reached its full production capacity. Case 3 (Mirafiori) investigates the nature of organisational knowledge processes in the setting of a brown field pressing plant. In each setting we look at how people at work engage in collective actions and reflections, which lead to the mobilisation of existing knowledge and the production of new knowledge. The methodological approach emphasises the rich and complex character of naturalistic settings and the importance of context, specificity and detail. Its relevance to work settings has been greatly promoted by Suchman's (1987) work on "situated actions" and Engestrom's development of the notion of "activity systems" (1987), both of whom signal a new attentiveness to the nature of working life as a context-bound social activity. Such a cultural, interpretative perspective looks at well-known organisational phenomena in new ways, directing attention to the shared systems of meanings and the way in which people perceive and interpret established behavioural patterns, work routines and symbols and artefacts used in the workplace. These serve as a kind of "collective storage" for workplace knowledge and experience, and are passed on to members and new generations of members as a "fabric of meaning", producing and reproducing collective understandings (Bodker and Pederson, 1991).

In the wake of the growing popularity of qualitative research, recent years have seen a parallel increase in the publication of textbooks on qualitative methods (e.g. Strauss and Corbin, 1990; Hammersley, 1992; Denzin and Lincoln, 1994). The contribution provided by such publications has been at least twofold. They have a) set up the debate about qualitative research and emphasised the need to look for a theory of method; b) brought to the surface in a systematic way, practices of investigation which researchers were using only implicitly, thereby allowing for a more structured way of designing qualitative research. Nonetheless, existing publications seem to overlook those factors that hinder the research process and the practical implications of them. As some authors (e.g. Becker, 1989; Nelson *et al.*, 1992; Denzin and Lincoln, 1994) have pointed out, a researcher can be seen as a *bricoleur* who is constantly amidst disruptions of all sorts. Getting funding, working on different projects at the same time, and coping with personal problems, for example, really make it difficult to work in the structured, sequential way suggested by many of the above mentioned textbooks. As a consequence, the fluid, lean view of the design process augured by the theory seems to clash with the reality of experience.

A research design can be seen as a decision-making process since it deals with planning the various stages of a research process while envisaging possible consequences and outcomes of the study. But of course, it is possible to approach decision making according to a wide range of theoretical stances ranging from full rationality to garbage can models: any research process comprises some structured planning along with opportunistic elements and muddling through strategies.

Given the above considerations, a research design ought to be flexible enough to allow the researcher to cope with disruptions. It should provide space for corrections, thereby enabling the researcher to rephrase, sharpen and fine tune the research questions according to the input coming form the field. As emphasised by grounded theory (Glaser and Strauss, 1967), the research design should also allow for a movement back and forth between data collection and emerging conceptualisations. In this way the researcher could at any moment reflect back on what he has done, revisit his data and interpretations, and redesign his research according to what emerges from the interactionist field (this is true especially in the early stages of a study). In a nutshell, a research design should provide structure and discipline while

allowing for learning and improvisation. But, how do we accomplish that?

This chapter exposes the epistemological and practical principles underlying the present study. The following paragraphs are not aimed at providing any additional recipe or prescriptive recommendations. Rather, they will be informed by the awareness of the limited rationality of the researcher and the complexity of the reality in front of him. Throughout this exposition of the research process, I will try to keep those limits as explicit as possible, sometimes thinking aloud, sometimes sharing my doubts with the reader.

The chapter contains nine sections. The next section outlines the epistemological assumptions underlying the research method. In particular, it explores the main issues related to the application of interpretative, ethnography-based approaches, to the study of organisations. The analysis is based on a critical discussion of Geertz's notion of thick description (Geertz, 1973). Section 3 attempts to tackle the methodological problems highlighted in the above discussion by illustrating how thick description generates interpretation. Section 4 presents a three-lens framework deployed in this research to study knowledge as an empirical phenomenon. The three lenses include: history, breakdowns, and narratives. Section 5 and 6 describe in detail the research design and research strategy. Section 7 addresses issues of validity and rhetorical representation of theory. It suggests that most of the difficulties encountered in articulating interpretive theories are related to the language and discursive paradigms adopted by the analyst. Interpretation is seen as an imaginative act, while the act of writing highlights the identity of the researcher as an author. The concluding section discusses the limitations related to the design process followed in this study.

2.2 "Thick description": in search of a theory of method

In *The interpretation of cultures* (1973), Clifford Geertz provides a brilliant example of interpretive anthropology in practice, in his "thick description" of the Bali cockfight. Starting from a local episode, the cockfight, and describing how this event is dramatised within the Balinese community, he is able to trace back the fundamental institutional forms of the Balinese society. In closing his essay, Geertz observes:

"Societies, like lives, contain their own interpretation. One has only to learn how to gain access to them" (Geertz, 1973: 453).

The above statement contains a fundamental methodological question for the present study: how do we access knowledge systems since, as we have shown in chapter 1, they are made of assumptions which are mostly taken for granted? Admittedly, knowledge structures do not exist outside the practices and behaviours that they govern; rather they are "immanent" to them. As we have stated earlier, knowledge is embodied in praxis and it is organised according to complex architectures that the researcher needs to decode and uncover starting from their visible elements.

In presenting the basic principles of the ethnographic method of inquiry, Geertz seems to suggest that it is precisely the vividness of description that provides access to interpretation. In other words, interpretation is embodied in thick description. Accordingly, the task of the ethnographer is to construct a reading of what happens within an organisation, community or knowledge system, and disclose the basic structures of signification underlying their functioning.

In doing this, ethnographers play on their unfamiliarity (something of a therapeutic distance) with the context under study, which provides them with a sort of privileged observational perspective. In fact, the ethnographer's description is informed by his belonging to a different cultural context, and it is precisely this contextual gap that makes interpretation possible: "the famous anthropological absorption with the exotic is essentially a device for displacing the dulling sense of familiarity with which the mysteriousness of our own ability to relate perceptively to one another is concealed from us... Understanding a people's culture exposes their normalness without reducing their particularity. It renders them accessible: setting them in the frame of their own banalities, it dissolves their opacity" (Geertz, 1973: 14). Reading some of Geertz's brilliant prose, the method appears to be quite suggestive. However, as the author himself points out, it also hides a number of important methodological problems, closely related to each other, that the present study will have to address. These problems include: the scope of the description, the relationship between description and interpretation, and the resistance to generalisations and theory construction.

a) The description is microscopic:

A common trait of ethnographic studies is the movement from detailed, protracted descriptions of small matters to large-scale interpretations. In doing so, abstract concepts take a lively, homely form in the rich and circumstantial accounts of the ethnographer. That is exactly the advantage. On the other hand, there is a risk of letting the description linger at a local level—incidents, anecdotes, episodes— failing to offer a holistic picture of the phenomenon under study (see problems related to the episodic character of breakdowns in the present study). The problem of how to move from local truths to general visions is a major methodological issue.

b) Impossibility of divorcing description from interpretation

Ethnographic description is interpretive. Since ethnographic accounts are normally presented in the form of an actor's-eye description, however, the line between the description of a natural fact and its interpretation tends to get blurred. A researcher has to make sense of how other people make sense and accordingly always deals with "interpretation of interpretations".

On the other hand, any attempt to "artfully" disentangle empirical facts from the material complexity in which they were located—"from what, in this time and place, specific people say, what they do, what is done to them, from the whole vast business of the world"—and then attribute their existence to some autonomous principles or meta-categories would considerably impoverish the relevance of any descriptive account (Geertz, 1973).

This embeddedness of social practice explains the impossibility of severing interpretation from the immediacy of detail. It is then necessary to redefine interpretation as a form of inscription: "Interpreting consists in trying to rescue the "said" of social discourse from its perishing occasions and fix it in perusable terms. The ethnographer "inscribes" social discourse, he writes it down. In so doing he turns it from a passing event, which exist only in its own moment of occurrence, into an account, which exists in its inscriptions and can be reconsulted... He observes, he records, he analyses—a kind of *veni, vidi, vici* conception of the matter. However, distinguishing these three phases of knowledge seeking may not, as a matter of fact, normally be possible; and indeed, as autonomous "operations" they may not in fact

exist" (*ibid.*: 19-20).

c) Resistance to generalisations and theory

Lack of categories, rhetorical limitations and the peculiar relationship between the observer and the interactionist field explain why interpretive approaches tend to resist conceptual articulation and thus escape systematic modes of assessment. Unlike those sciences that can rely on more abstract modes of theoretical formulations, for anthropology, description—in the sense of narrative—is the only possible form of representing theory. Furthermore, from the analyst's perspective, there is a problem of how to disentangle him/herself from his/her own accounts. In fact, the analyst him/herself is in a condition of being-in-the-narrative: "The tension between the pull of this need to penetrate an unfamiliar universe of symbolic action and the requirement of technical advance in the theory, between the need to grasp and the need to analyse, is, as a result, both necessarily great and essentially irremovable. Indeed, the further the theoretical development goes, the deeper the tension gets" (p. 24).

If what has been sketched above is a fair account of how theory functions in an interpretive science, there is a need to redefine the conventional distinction between description and explanation. According to Geertz, theories generated from thick descriptions proceed through cycles of "inscription" and "specification": the double task of the ethnographer consists in setting down the meaning particular social actions have for the actors whose actions they are, while stating, as explicitly as he can manage, what the knowledge thus attained demonstrates about the society in which it is found and, beyond that, about social life as such (p. 27).

The above considerations about the limitations of the ethnographic method emphasise the fundamental issue of the validity of a study and raise some serious problems of verification and appraisal. These issues will be tackled in the concluding section of the chapter.

2.3 Thick description at work: the subtleties of interpretation

During one of my first visits to the shop floor at the Fiat's Mirafiori plant, my attention was attracted by the presence of a large area where a great number of dies—painted in different colours, each carrying an identification number, and piled up in a manner that made them look like totems—were stored. This fact did not come as a surprise since very often our attention is caught by odd things and that was the first time I had ever seen such objects.

Thinking about one of my favourite readings in anthropology—Geertz's "thick" description of the Bali cockfight—I started wondering whether it would have been at all possible to trace back the social system of the plant by simply describing those dies piled up in an enclosed area of the shop floor.

I could have started by describing the dies as mere objects, their shape, material, and colours. At some point my account would have compelled me to say what those objects were for. The heavy cast iron objects painted in different colours would have then been turned into instruments, characterised by a specific function (in-order-to): stamping car parts. For this reason each die is composed of an upper and lower part that match perfectly. The lower die contains the blueprint of a car part (the figure), while the upper one carries the punching tools. Soon I would discover that the way dies are stocked in a confined area is not without purpose. Each colour indicates a specific car model and the serial number stands for a specific car part (a door, a roof, a bumper, a dashboard, and so on). Widening the focus of my observation I would have immediately realised that dies do not exist as isolated objects, but along with a whole range of equipment. Borrowing Heidegger's terminology, I would have explained that this peculiar piece of equipment dwells in a heterogeneous network of other materials and equipment which define the shop floor and within which it acquires its meaning: coils, metal sheets, pallets, presses, production lines, forklifts, cranes, finished parts, and containers, would have come to populate and enrich my account.

The description of the use of dies on the shop floor would have expanded the scope of the network by adding human "actants" (Latour, 1993) performing social actions, thus bringing the shop floor into life. Now we would have a practical context,

defining the activity of stamping, and against which equipment functioned. That stage of the description would have encompassed the routine operations performed by the work teams along the production lines, the description of how dies are transported along the lines and finally the die change, which is normally regarded as the bottleneck in the system and constitutes the key event on the shop floor of a stamping shop. For instance, the rituals accompanying the execution of a die change and the way the event is dramatised, would have given an additional insight into the meaning of social action within that community. Speaking to shop floor operators, gathering war stories, would have furthered my understanding of those operations. I would have also learned that dies are a very expensive technology, that they have to be taken with care and undergo regular maintenance. For this purpose there is a dedicated maintenance area with dedicated maintenance people. But that also explains their "sacred" value.

Carrying on the description, it would have probably been possible to deduce concepts that we normally infer from organisational charts: the role system and the division of labour, the production process, along with the meaning of existing practices and conventions. I remembered what Mary Douglas (1986) had said about artefacts, that they often embody a whole social system, and I thought of her brilliant work on wine labels and wine classification systems in California and France. But, at this point, I also realised that my description could generate a huge number of relationships and my problem now actually was where to stop the narrative.

The above phenomenological, camera-eye description of the shop floor at Mirafiori, provides a good example of how thick description generates interpretation. It also illustrates the kind of puzzlement that a researcher has to face when entering the interactionist field.

The first thing to notice is that phenomenological descriptions disclose the world as a web of references. Namely, it is through this reference game, of something referring to something else, that relationships are constructed, pictures emerge from backgrounds, and small matters speak to grand realities.

Secondly, thick description, like any other type of description, implies the presence of a director behind the camera, deciding about focus and close-ups, back-stage and

front-stage, establishing linkages and connections between objects, people and events, hinting at meanings. Each time a new object, event or character is brought into the picture, it has to be characterised in order to ensure that its meaning is grasped by the reader. In other words, each element of the description is linked to other elements that are normally taken for granted by the community under study, but are not obvious for the non-natives. It is the task of the researcher to establish a conversation between the two worlds: that of the natives and that of the readers.

Interpretation is fundamentally about choice, it is a problem of judgement. The interpreter, far from simply describing a reality out there, is constantly engaged in deciding what meaning should be attributed to what he is describing. Furthermore, thick description is not a seamless account of the reality in front of the observer—a list of things, a stream of consciousness—but it has a purpose and is therefore interpretive. In analytic terms, it is possible to distinguish three moments in the interpretation process, each embodying a problem of choice/judgement:

1. *Selection*: Selecting the relevant features of a situation, its characters, and objects. (see grids in the next section). Scanning and sectioning the interactionist field. Defining the relationship between picture and background. For instance, the choice of the dies as a starting point in the above description.

2. *Emplotment*: Generating references. Establishing linkages and connections within the situations and between situations. Creating a perspective by locating action in space and time, thus bringing the phenomenon to life. Building a plot through sequencing and punctuating events.

3. *Closure*: Very often phenomenological accounts display a resistance to closure encouraged by the constant drifting of the description. A last fundamental problem of judgement for the researcher is deciding where to stop the description and accordingly frame the phenomenon under study.

To conclude, interpretation is a process of discovery as well as invention (a fiction according to Geertz), a quest for meaning, whereby a picture gradually emerges from a background. Of course, the author is able to exercise control over the research process, but his basic task is simply to let relationships emerge. The tension between discovery and control is the creative engine of any research process.

2.4 Three methodological lenses to study knowledge as an empirical phenomenon: history, breakdowns and narratives

The methodological framework adopted in this study is driven by the research questions outlined at the end of chapter 1. More specifically, the framework described below responds to a three-fold requirement: Firstly, it should provide a composite tool for studying knowledge as an empirical phenomenon. In this regard, a major issue addressed by the methodology concerns the possibility of gaining empirical access to highly idiosyncratic knowledge systems. Secondly, it should allow the researcher to describe in detail the context, process and content related to the dynamics of organisational knowledge creation and institutionalisation. Finally, the methodological techniques adopted in the study should be able to capture the changing forms of organisational knowledge and follow its transformations over time. What is relevant here is the possibility of linking knowledge transformations to the phenomenon of organising and the changing forms of organisation.

In order to tackle this challenge, we develop three "lenses" for studying knowledge as an empirical phenomenon: history, breakdowns and narratives. The three lenses provide effective tools for deconstructing the fundamental processes of knowledge creation and institutionalisation, and exposing the multiple facets of knowledge-oriented phenomena in organisations. Following Latour (see chapter 1), we refer to the process of unpacking tacit knowledge as opening organisational black boxes. In this respect, the three lenses provide complementary points of entry into tacit knowledge.

The three lenses adopted in the present study draw on discontinuities as descriptive devices, which allow the researcher to penetrate an initially obscure world and bring to the surface the tacit features of organisations. They can be seen as variations of the concept of "thick description", which provides the main methodological principle as well as narrative device adopted in the study. In this respect, the three lenses described below provide different angles for accessing knowledge-related phenomena in organisations. The rationale underlying each of them is counter-intuitive, since the main research questions of the study require breaking into consolidated practices and tacit stocks of knowledge, which time has rendered opaque and therefore taken for granted by the users. Organisational knowledge creation and institutionalisation rely

on the progressive acquisition of structural repertoires (Whipp and Clark, 1986) which over the years have provided successful responses to the emergence of problematic situations. In turn, structural repertoires can be seen as the outcome of three interrelated process of institutionalisation:

- the sedimentation of knowledge-oriented patterns over time

- the routinisation of successful responses to problematic situations

- the embodiment of successful practices into some forms of organisational discourse

The above assumptions provide a common rationale for the three lenses mentioned above. History looks at the dynamics of institutionalisation and the transformation that knowledge undergoes over time. It points to the sedimentary nature of knowledge and to the deep structures that govern daily practices in the work setting.

Breakdowns focus on discontinuities in action. They reveal the purposefulness of organisational routines of which they represent the other side of the coin. By interrupting the ongoing sensemaking activity of organisational actors, breakdowns also disclose important cognitive dynamics and highlight the cognitive dimension of organisational knowledge. Finally, narratives refer to discourse. The focus on narratives allows the researcher to gain an insight into how organisational actors represent and make sense of their everyday coping with the world. In this regard, organisational action is treated as a text that the researcher attempts to decode and to reconnect to general patterns.

In the following sections each lens is discussed in some detail in order to assess their methodological relevance.

2.4.1 History

The first methodological lens adopted in this study relies on the historical dimension. Its use in the study of organisations has been brought to the forefront by those scholars who have emphasised the importance of the time dimension in the study of organisational phenomena such as change and innovation (e.g. Pettigrew, 1985, 1987, 1990; Whipp and Clark, 1986). When applied to the phenomenon of knowledge

creation and institutionalisation, the rationale for the use of this dimension reads as follows: if knowledge institutionalisation occurs over time, the solution devised to penetrate stocks of knowledge that have become tacit and mostly taken for granted consists in travelling back in time in order to re-open organisational black boxes before they became black (see Latour, 1987). More specifically, the case in the present study where this lens has been applied considers the time span running from the design of a new avant-garde factory born from the green field to its official opening. The time period considered encompasses about ten years, from 1990 to the present day. The case relies on real time data as well as archival material and reconstruction provided by the actors involved in the design and implementation of the new plant. As Whipp and Clark have pointed out, the use of the historical dimension raises at least four important issues: the type of approach; the conceptualisation of time; the identification of long term trends and of major turning points; and the influence of the past on the present and over the future. Below, each of these issues is analysed in some detail.

1. Traditionally the epistemologies underpinning the historical method have oscillated between the so-called analytical and narrative approaches. The analytical approach refers to a positivist tradition privileging explanation and the identification of law-like causalities. Accordingly, this perspective tends to deny the importance of events in favour of more generalised patterns and structures. In its most radical formulation, known as the "cover law model" (Ricoeur, 1984), the analytic approach aims to develop predictive models of historical evolution and therefore to endow history with the same status as science. A typical application of the analytical approach is Marx's notion of historical materialism as used in the analysis of capitalist societies. Despite the strong criticism levelled at the analytical approach, its added value lies in the possibility of identifying patterns and regularities and therefore reconnecting organisational phenomena to some kind of causal explanation. At the other end of the continuum, the narrative approach denies any causality in favour of the objectivity of the plot (i.e. how one writes history and tells the story). For narrativists, the pointlike event constitutes the minimal unit of analysis. The historical account relies on the construction of a plot out of a collection of equivocal events. In this respect, the work of the historian is about sensemaking rather than tracing back patterns and regularities. The craft of the historian lies in his capacity to cut out the field of events

in order to build a meaningful plot (Veyne, 1971). Plausibility and probability are the criteria of validation of the historical account.

A critical point of synthesis between the above perspectives is provided by the Annales School (see Bloch, 1953; Braudel, 1972-74), which attempts to integrate the contributions of history and sociology. Representatives of this School tend to deny the singularity of the event and the role of the individual in favour of holistic notions such as social facts. History is not made of heroes and battles. In this regard, the Annales School is close to the positions of the analytic approach, although within an antipositivist orientation (Ricoeur, 1984). At the same time, the Annalists recognise the importance of human understanding advocated by the narrative approach. Most of the recent approaches have tended to set themselves in some sort of intermediary position. For example, the historical account of the dynamics of change and innovation at Rover provided by Whipp and Clark (*ibid.*) can be defined as an "analytically structured narrative". The above considerations on alternative historical approaches provide the analytical cornerstones for analysing the remaining three parameters related to the use of the historical dimension in the study of organisations.

2. The divergences in the above approaches are significantly reflected in the conceptualisation of time. Specifically, while the analytic approach tends to treat time as a commodity (e.g. Marx), for the followers of the narrative perspective, time punctuates the unfolding of the story and therefore intervenes in the construction of the plot.

Time has at least a two-fold relevance for this study. Firstly, the institutionalisation of organisational knowledge and the related evolution of organisational phenomena occur over time. The selection of the three case studies takes into account the time variable as a source of institutionalisation (as reflected in the age of the plants, the nature of the work force, the organisational setting). In this respect, chronological time and history point to the sedimentation of organisational knowledge. Secondly, time is related to action, pointing to the ways specific organisational actors engage in collective processes of sensemaking and social construction. For example, discontinuities in action caused by breakdowns affect the way organisational actors perceive time. The disruption of commodified time as reflected in organisational artefacts impacts on cognition and emotional responses. In fact, the lapse of time

between the occurrence of a breakdown and its solution can be seen as a moment of equivocality characterised by emotional dynamics.

3. The identification of seizures and breakpoints in the unfolding of history has been pointed out by the longitudinal approach. As Pettigrew (1979, 1990) has noted, breakpoints, seizures and dramas provide a useful point of entry into institutionalised, and therefore tacit, knowledge. Interestingly, discontinuities in time stress the complementarity of the historical approaches analysed above. On the one hand, discontinuities highlight the turning points in the unfolding of action over time, and thereby make possible the construction of narratives. At the same time, they identify discrete phases, which enable the historian to organise events around temporal sequences.

4. Finally, the use of the historical dimension implies to some extent the notion of "pastness" (see also retrospection), i.e. the idea that the past exerts an important influence on the present and over the future. The theorisation of the influence of the past on organisational performance can be reconnected to theories of imprinting (Stinchombe, 1965), according to which the explanation for current performance of a firm or institution can be traced back to its foundation. As we shall see, the present study theorises the role of foundational knowledge - embodied in organisational scripts - as a crucial determinant of organisational performance. More specifically, the first case study will attempt to conceptualise the script related to the coming into existence of a factory as a founding analogy (Douglas, 1986).

2.4.2 Breakdowns

A main contention of this study is that knowledge originates from those processes whereby organisations appropriate order out of disorder. Accordingly, the analysis of any social organisation or social action needs to be performed at the cleavage between organisation-disorganisation (Cooper, 1990). Breakdowns, in the form of discontinuities, interruptions, and so on, provide such a cleavage, and therefore can be fruitfully deployed for an empirical investigation on organisational knowledge.

As a methodological technique, breakdowns draw on discontinuities in action as a

mode to disentangle knowledge from consolidated work practices and routines. In so doing they point to the processes whereby order is disrupted and eventually recomposed within organisations. At the empirical level, the dialectic organisation-disorganisation translates into the dynamic interaction between routines and breakdowns. As Louis and Sutton (1991) have pointed out, breakdowns occur at the intersection between the "business as usual" of routine situations and the conscious engagement of active thinking, and therefore act as a watershed between tacit and explicit knowledge. By displaying a temporary failure in the application of knowledge, they bring the tacit to the surface either by forcing organisational actors to mobilise existing knowledge or by emphasising specific learning requirements.

The above conceptualisation of breakdown as a methodological lens needs to be assessed against the existing empirical literature. Part of this task has been accomplished in chapter 1. Here, it is sufficient to reiterate that, within the knowledge literature, the notion of breakdown and related phenomena has been deployed mostly within the cognitivist tradition. Indeed, there is a considerable body of literature dealing with disruptions and sense-making (Weick, 1988, 1990, 1993; Perrow, 1984; Shrivastava *et al.*, 1988). These studies emphasise the cognitive implications of major events such as crises, accidents and failures, often in relation to the use of technological systems.

Typically, the crisis literature tends to focus on low probability/high consequence events that jeopardise the mission of the organisation. Furthermore, given the unpredictability of a crisis, research deals with situations of high discretion in which the cognitive/emotional responses of individuals faced with a breakdown will ultimately prevail over the structural properties of the organisation. Accordingly, the scope of these studies is inevitably bounded by the nature of the task (high risk systems/situations) and the characteristics of the organisation (e.g. small outfits) that constitutes the object of analysis. For example, Perrow applies the notion of "normal accidents" to the study of risky enterprises such as nuclear power plants (Perrow, 1984). The same rationale underlies accident investigations based on the analysis of cockpit conversations (Ginnett, 1990). In all these studies, the nature of the task at hand is such that a serious disruption could easily determine a "collapse of sense-making" (Weick, 1993) and threaten the most fundamental goals of the organisation.

As a consequence, disruptive events seem to result from the encounter between a failure in the system and the human inability to read the situation. At times we find a sort of fatalistic element (the "unexpected") that defies the sensemaking capabilities of particular organisational actors confronted with a risky situation. A typical example is the presence of consolidated organisational cosmologies within a group of "smoke jumpers" in Mann Gulch, which impeded effective communication between the group leader and the other fire fighters, and eventually led to a disaster (Weick, 1993).

The meaning of breakdowns partially overlaps with the concepts encountered in the crisis literature. Breakdowns are "accidental", unexpected, related to the performance and the reliability of a system, and they can be more or less serious, local or systemic. Furthermore, in line with the above literature, we argue that breakdowns relate to the domain of everyday life and to our way of encountering things. In other words, breakdowns pinpoint the disruption of a pragmatic connection with tools and equipment. They express discontinuities, mismatches, disjunctions, seizures between knowledge and experience, representations and praxis, and between the obvious and the concealed.

Drawing on the contributions of the existing literature, the use of breakdowns in the present study sets out from the following assumptions:

1. Breakdowns are treated as a pervasive, everyday phenomenon that organisations are able to absorb and to harness thanks to their repetitive pattern of recurrence (see interplay between routines and breakdowns described below). In other words, the focus of the research is on low risk breakdowns in large organisations.

2. Sense-making is not considered as a mere psychological process, but is anchored to the phenomenon of organising.

3. Breakdowns are not mere attributes of technology systems. Rather they are conceived as a more existential phenomenon related to our way of encountering things.

The next section will explore the above assumptions in some detail in order to identify the knowledge implications of breakdowns and their methodological

relevance.

Organisation, knowledge and breakdowns

This section illustrates the conditions whereby breakdowns produce a disclosure of the tacit features of organisations. By and large, these conditions are related to the borderline location of breakdowns in the opposition organisation-disorganisation. Borrowing Heidegger's (1962) ontological categories for defining our way of encountering things, it is possible to stress two basic aspects of organisational knowledge. The first is instrumentality, i.e. the fact that knowledge is used for something or towards something. Instrumentality points to a definition of knowledge as a commodity which is functionally related to organisational performance. On the other hand, the mere functionality of knowledge is not sufficient to define it. Organisational knowledge acquires meaning within a background of interlocking practices and routines (or practical context) against which it can be purposefully applied. This second level highlights a pragmatic-relational definition of knowledge as situated performance.

The above two levels identify alternative modes of knowledge utilisation pointing to different types of intentionality (Dreyfus, 1991). In routine situations, organisational actors are absorbed in coping with business as usual. The content and the context of the task at hand are somewhat enfolded in a single knowledge system, which makes the task itself transparent to the user. In other words, when things are functioning smoothly, organisational knowledge is experienced as something "ready-to-hand" and used almost unreflectively.

On the other hand, when disruptions occur, the coherence of the task (what Heidegger would call the constitutive assignment of the "in-order-to") is called into question because the functional relationship between action and goals, activity and context, has been disturbed. Since, in those situations, knowledge needs to be applied in a deliberate way, the ongoing flow of action and sensemaking is articulated in the form of narratives, moves and decisions, while projects emerge as they are interrupted. In order to restore normality organisational actors need to explicitly interact with the tacit background against which knowledge is used. As a consequence, knowledge references to the context of use are disclosed and emphasised. In this respect,

breakdowns bring tacit knowledge to the fore by exhibiting it as "present-at-hand".

In the light of the above considerations, it is possible to reformulate the relationship between knowledge and organisation and to point out the role of breakdowns. Any knowledge system is situated or dwells in a complex social network that includes institutions, equipment, practices and conventions. Thanks to this situatedness, the particular stock of knowledge governing the execution of organisational tasks and routines is transparent to the user. Put in Heidegger's terms, this knowledge is part of a background of "readiness-to-hand" that is taken for granted without explicit recognition or identification as an object. Nonetheless, the emergence of a breakdown reveals the task as a problematic activity and thereby uncovers its obviousness.

This has two major consequences for the disclosure of tacit knowledge. Firstly, breakdowns produce a de-coupling of action and cognition and thereby reveal the projects behind the execution of the task. Secondly, practical knowledge is disentangled from its context of use and is de-situated. The analysis of breakdowns provides, then, a useful method of reflecting upon the organisational context "hosting" a particular knowledge system and opens up the possibility of deconstructing the meanings embodied in organisational artefacts, routines, and other knowledge-based products. Breakdowns provide a window through which it is possible to access the organisational reality as they put the organisation in a situation that requires deliberate attention. In this respect, they serve as a method for "voicing the background".

Routines and breakdowns

Through the mechanism of repetition, routines characterise organisations as quasi-liturgical entities. Within this framework, the role of breakdowns is similar to that of social dramas as dissected in the work of Victor Turner (1974). In Turner's words, social dramas are public episodes of tensional irruption. They refer to a situation of obvious opposition in the interests and attitudes of individuals and groups within a community. Therefore, social dramas point to discordant phases of the ongoing social process. However, as routines, social dramas are characterised by a "processional" form which is aimed at recomposing the schism produced by their occurrence. It is thus possible to say that, to some extent, breakdowns are part of the liturgy. Nelson

and Winter (1982), for instance, contend that breakdowns are absorbed by organisations through the incorporation into some kind of problem solving routine. They provide the following example:

> Consider the foreman of a work team responsible for a particular operation (set of routines) who observes that a machine is not working properly. He routinely calls the maintenance department, which in turn routinely sends out a machine repairman. The machine repairman has been trained to diagnose in a particular way the troubles that such a machine might have. He goes down a list of possible problems systematically, and finds one that fits the symptoms. He fixes the part so that the machine again plays its role in the overall work routine. He may also, however, report to the foreman that this particular kind of trouble has become very common since the supplier started using aluminium in making the part in question and that perhaps the machine should be operated in a different manner to avoid the difficulty (Nelson and Winter, 1982:129).

The authors suggest that "the responses described fall into the typical pattern in which a crisis or 'exception' condition in one part of the organisation is part of the routine content of jobs of other personnel. On the other hand, it is significant that the problem-solving responses routinely evoked by difficulties with existing routines may yield results that lead to major change" (*ibid.*:130).

Indeed, the above example may be seen as a good argument for blurring the distinction between routines and breakdowns. However, from the perspective of knowledge-in-the-making, we contend that the example highlights precisely how organisations attempt to anticipate action in space and time in order to make sense of their everydayness. Here we have an exemplification of how the routinisation of activity allows organisations to harness the occurrence of disruptions. Echoing Cooper and Law (1995), problem solving routines are "a matter of constructing the future so that it looks like it's always been there."

Secondly, the above example illustrates how breakdowns can provide an insight into the purposefulness of routines. In fact, the actors involved in the solution of a problem are forced to articulate knowledge through a series of "organising moves" (Pentland, 1992), decisions, narratives and so on, which enact certain structural features of organisation (the division of labour, the application of problem solving procedures, the deliberate use of equipment and work tools).

Finally, when the occurrence of a breakdown does not enact an automatic, routinised response, the observation of the dynamics triggered by the disruption points to specific learning requirements and reveals knowledge that has not been

institutionalised and embodied in organisational artefacts. This is controversial knowledge that yet needs to be confronted with the organisational reality. It could lead to innovation or, conversely, it could be abandoned and surrender to the existing reality.

The "dramatic" character of organisational action suggest that the disclosure of the tacit features of organisation does not occur in a straightforward way. Rather, it is mediated by processes of *mise-en-intrigue* (emplotment) (Ricoeur, 1984) whereby disruptions are socially dramatised in order to help organisational actors make sense of the situations they encounter. It is only then that knowledge is expressed in a deliberate way and becomes visible to the researcher. For this reason, in order to empirically observe how organisations create, use and disseminate knowledge, we have to look for disruptive events conceived as turning points in an ongoing flow of activities. We have to observe the discontinuities and asynchronies, even local or temporary, that breakdowns bring in the smooth functioning of everyday practice, and to follow how they affect the fluid unfolding of action in space and time. The above observations contribute to reinforce the argument against the risk of treating critical incidents as isolated episodes occurring at specific points in time. Since, in order to become meaningful, disruptions need to be contextualised through the construction of narratives, the researcher should be able to avoid that risk by systematically linking sensemaking dynamics occurring around breakdowns to the broader organisational context.

To conclude, breakdowns do not destroy organisations, let alone routines. Rather, they help us understand why and how certain strands of knowledge have become tacit. Once a specific routine has been invented, the problem addressed by it simply stops being a (conscious) problem. Echoing Latour's terminology, it is possible to argue that breakdowns constitute an alternative way of opening organisational black boxes and uncovering concepts that have become tacit. The close examination of disruptions takes us back in space and time and, hopefully, leads us to the understanding of the organisational devices designed to anticipate them. To use an analogy, just as in science, a fact or a paradigm is challenged by the emergence of a counter-evidence that leads to a controversy, in organisations the concept of organising is challenged by the occurrence of disruptive phenomena.

2.4.3 Narratives

Narratives can be seen as a form of problem solving in our everyday coping with the world. In a sense, narratives provide access to the world conceived, in William James' terms, as a buzzing, pulsating, formless mass of signals, out of which people try to make sense, into which they attempt to introduce order, and from which they construct against a background that remains undifferentiated (James, 1950, cited in Czarniawska, 1998). The above consideration underscores the role of narratives as a methodological technique. In a nutshell, narratives point to a tacit background of knowledge underlying our concernful dealings with the world. This section sets out to explain how narratives can be deployed as a methodological lens.

The importance of narratives in the work setting has been widely recognised in the literature. For example, Boland and Tenkasi (1995) have emphasised the cognitive implications of narratives and story telling. They believe that explicitly recognising the narrative mode of cognition is important for understanding how perspective making and perspective taking occur within a community of knowing (p. 353). In a similar vein, Weick (1995) contends that stories simplify the world by providing cognitive devices to guide action. Orr (1990, 1996) has anchored the idea of narrative to a conceptualisation of work as practice. According to him, narratives appear to be fundamental diagnostic devices, enabling operators to perform a coherent description of troubled machines. In addition, they maintain the stability of the work setting by fostering the circulation of organisational knowledge within the community of workers. Brown and Duguid (1991) have linked the narrative process to organisational learning within communities of practice (Lave and Wenger, 1991). As for Orr, narration is seen as a central feature of work practice. Stories and their telling can reflect the complex social web within which work takes place. Accordingly, the practice of creating and exchanging stories has two important aspects. First of all, story telling allows organisational actors to keep track of their behaviour and of their theories; secondly, stories act as repositories of accumulated wisdom (p. 45). More recently, Czarniawska (1997, 1998) has underlined the methodological potentials of the use of narratives in qualitative research. She sees organisation as a story, as a social construction that is interactionally relevant and constraining. More specifically, narratives can be conceptualised as a specific form of text that presents events

developing in time according to (impersonal) causes or (human) intentions. Ultimately, narratives identify a distinctive "mode of knowing". For this reason, they are considered as "the main carriers of knowledge in modern societies" and as a vehicle for organisational learning: "almost certainly, the greater part of organizational learning happens through the circulation of stories" (Czarniawska, 1997: 8).

Narratives share similar features with the two lenses encountered before as they rely both on discontinuities in time and action. Typically a narrative is defined by three moments: an original state of affairs, an action or event (perturbation), and a set of consequences deriving from the event (Czarniawska, 1998). The use of narratives as a methodological lens combines the observation of real time happenings with the analysis of retrospective sensemaking based on after-the-fact recollections. The former disclose controversial processes of "knowledge in the making", since they emphasise the transformations that action undergoes as part of a sensemaking endeavour. The latter highlights issues of memory and collective remembering in relation to learning processes.

Narratives encompass both the process and the content of organisational knowledge. In fact, they stress the fundamental sensemaking processes leading to the enactment, punctuation and retention of organisational action (Weick, 1977). In this regard, the focus on narratives allows the researcher to look at how organisational actors articulate knowledge by weaving webs of signification (Geertz, 1973). Through narratives, occurrences are located in space and time and equivocal happenings are translated into meaningful events by organisational actors in order to make sense of the situations they encounter. Emplotment is the process whereby actors impose a logical structure (a beginning, a middle and an end) upon a flow of equivocal happenings through processes of ordering and sequencing. Time plays a critical role in conferring consistency to the plot and thereby promotes sensemaking. In fact, the strength of narratives as interpretative devices stems precisely from their ability to link the present to the past and the future, anticipation to retrospection and repetition.

On the other hand, sensemaking related to the construction of narrative accounts implies building plots out of equivocal happenings and thereby framing action into some kind of meaningful structure. Through narratives, tacit knowledge is articulated

into a text, thus allowing organisational actors to make sense of the situations they encounter. In other words, knowledge is externalised through discourse.

The above considerations have important implications for knowledge. Firstly, narratives show how knowledge in organisations is mobilised through discourse, and therefore highlight a narrative dimension of knowledge related to the everyday coping with the world. Secondly, narratives link the dynamics of knowledge creation, utilisation and institutionalisation insofar as they disclose the modes by which sensemaking processes are translated into text-like contents, and knowledge is capitalised in a narrative form. Finally, because of their connection to experience, narratives display common sense wisdom - in the form of anecdotes, jokes, war stories - in organisational discourse. As we shall see in chapter 6, common sense is based on unspoken premises and therefore underscores the tacit aspects of knowledge in organisations. Narratives, articulated as plots, are the carriers of such a deep-seated, sticky, commonsensical stock of knowledge. The deconstruction of organisational narratives should then allow the analyst to penetrate a knowledge system that has become deeply tacit and institutionalised.

Within the framework depicted above, the task of the researcher is simply to describe in detail how organisational actors make sense of equivocal happenings in the work setting while attempting to identify emerging patterns and regularities of action. Since the role of thick description is paramount in any narrative-based approach, most empirical studies drawing on this lens adopt an ethnographic perspective. On the other hand, the focus on narratives highlights important consequences as far as the relation between actors and observers is concerned. In fact, the observer is him/herself involved in the construction of narrative accounts in order to make sense of certain patterns of behaviour. He/she too engages in the construction of plots (texts) out of equivocal events and in so doing he/she deals with "interpretation of interpretations" or texts about texts. In this respect the relation between actor and observer may become self-referential insofar as the distinction between the actor and observer's accounts get blurred. Narratives are a sensemaking device in a two-fold sense: they allow actors to articulate knowledge through discourse; and they provide the observer with access to tacit stocks of knowledge that have been externalised in a text-like form. It is therefore important to distinguish between narratives as a

methodological lens (focus on actors) and the narrative voice of the observer in describing certain organisational phenomena (see Hatch, 1996). The latter relates to issues of rhetoric of representation and will be discussed in the last section of this chapter.

2.5 Research design

Fieldwork was carried out within a leading European car manufacturing company: Fiat Auto, Italy. The choice of the automotive sector for a study on organisational knowledge was dictated by distinctive features of the competitive environment in which car manufacturers operate. More than fifty years ago, Peter Drucker (1946) defined car manufacturing as "the industry of industries" and today, the car market is still the one in which competition is most fierce. In the last decade, the industry of industries has undergone a major transition from Fordist mass production systems to new organisational models derived from Toyotism (Womack *et al.* 1990). As a result of this critical transition, avant-garde organisational concepts such as lean production, total quality management, just in time, teamwork, along with the adoption of cutting edge technologies, have been pioneered in car manufacturing in response to competitive market forces. The above characteristics of the sector bear critical consequences for knowledge creation, change and innovation.

Within this framework, the choice of Fiat derived both from opportunistic factors and the characteristics of the company. Given the nationality of the researcher it was certainly easier to negotiate access to an Italian company. Moreover, I had previously collaborated with the company on a European project that included Fiat amongst its partners. More fundamentally, the choice of Fiat was primarily driven by the consideration of what the company represents in total to Italy and the world auto industry. Fiat is the most important Italian firm and one of the market leading companies within the car manufacturing sector. Furthermore, during the period in which the study was conducted, Fiat was undergoing a major re-engineering process which led to a transition from mass production to a new organisational model called the "integrated factory". Although, for the purpose of this study, the transition itself is not explicitly put under scrutiny, it nonetheless provides the critical background for the observation of knowledge-related dynamics (creation, utilisation,

institutionalisation). In particular, the presence of a dynamic process of change and innovation provided a fertile ground for the observation of organisational learning processes. Finally, the selection of the plants for conducting the fieldwork was aimed at introducing variations in context in order to address the issues raised by the main research questions. The rationale for the selection of the cases is explained in detail in the next section.

2.5.1 Selection of the cases

Two organisational settings - a green field site and a brown field - pointing to different cultural traditions, knowledge, skills, and possibly attitudes towards breakdowns, were considered. Three case studies (two of which were in the green field site and the other in the brown field) were conducted in two major Fiat plants: "Mirafiori Presse" in Turin and "Fiat SATA" in Melfi. The two field sites present a number of variations including the nature of the work force, the technology deployed, and the factory sub-culture. The Mirafiori Presse plant is an old pressing plant located in the company's headquarters (Turin) and set up in the 50s. Its highly institutionalised context is characterised by experienced work force, often with low levels of education and mostly composed of emigrants who came up from the south of Italy during the 50s and 60s. In the past, the plant has been renowned for the high levels of conflict in industrial relations and hierarchical managerial practices. Fiat SATA Melfi is one of the most avant-garde assembly plants in the world. The plant, situated in the south of Italy, is a "green field" site, set up at the end of 1993 and, after an experimental phase, opened officially in October 1994. Melfi's green field can be qualified as an emergent context, characterised by young and highly educated work force recruited from a homogeneous cultural and geographical background. Finally, since its opening Melfi has been the factory with the lowest level of conflict in industrial relations amongst Fiat plants. The two factories also differ in the type of technology/production system deployed. Mirafiori Presse produces car parts, Melfi produces cars. The batch production system typical of pressing plants can be seen as a discontinuous system, which in theory should display a better tolerance of disruptions and breakdowns. The assembly line that we find in the Melfi factory, instead, can be characterised as a continuous production system, which in theory

should display a lower tolerance of breakdowns. Production systems can be seen as knowledge systems which have a strong influence on how time is structured, action is punctuated, and, more generally, on how people make sense of their working environment. The two factories were followed throughout a major re-engineering process undertaken by the company at the beginning of the 90s. As mentioned above, this period marked the shift from total automation to a new organisational model known as the "integrated factory" and designed according to the lessons coming from "lean production". As for the company, the selection of the field sites was driven by the main research questions of the study. Figure 1 summarises the rationale behind the choice.

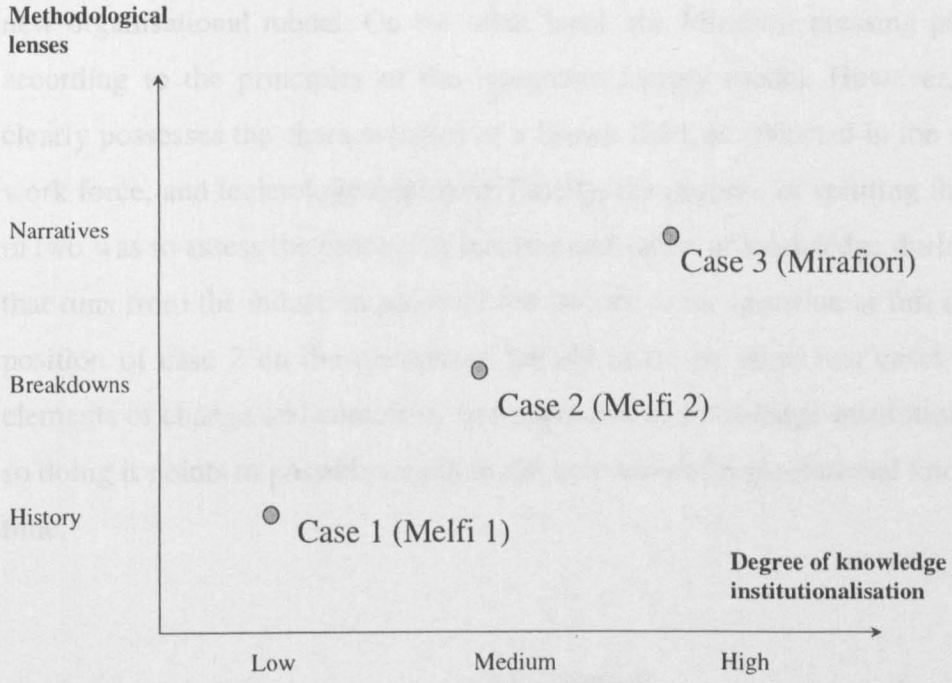

Figure 1. Selection of the cases

At the synchronic level, the selection of the cases is aimed at gaining an insight into the multiple faces of knowledge-related phenomena. The design of the three lenses responds to this need. More specifically, the variations in context offered by the cases allows the researcher to gain access to different modes of knowledge creation, utilisation and institutionalisation. At the same time, the study looks at knowledge as a dynamic phenomenon. In this respect, it takes a diachronic perspective in order to follow the transformations that knowledge undergoes over time. The three case

studies can be placed on a continuum characterised by increasing levels of knowledge institutionalisation (degree of tacitness). In particular, the distance that separates case 1 from case 3 highlights the presence of polar situations. The latter has been emphasised by the literature (e.g. Pettigrew, 1990) as a fundamental requirement for studying processes of change and knowledge transformations over time. The characteristics of the settings illustrated above are consistent with this need.

Admittedly, the construction of the Melfi factory from the green field takes into account the "industry recipes" (Spender, 1989), and the stock of idiosyncratic knowledge developed by the company over the years. At the same time, the rationale behind the strategic choice of a green field site points to crucial dynamics of innovation, namely the need for a fresh start as a pre-condition for implementing a new organisational model. On the other hand, the Mirafiori pressing plant operates according to the principles of the integrated factory model. However, the factory clearly possesses the characteristics of a brown field, as reflected in the nature of the work force, and technology deployed. Finally, the purpose of splitting the Melfi case in two was to assess the process of institutionalisation of knowledge during the period that runs from the induction phase of the factory to its operation at full capacity. The position of case 2 on the continuum ideally links the other two cases by stressing elements of change and continuity in the process of knowledge institutionalisation. In so doing it points to possible trends in the evolution of organisational knowledge over time.

2.5.2 Access

As mentioned above, initial access to the company was provided by my former involvement in a European project which included Fiat amongst its partners. Luisella Erlicher, a consultant for the training company of Fiat, introduced me to some of her colleagues at Fiat. Since then I have had the opportunity to establish some links with people within the company. As my PhD project advanced, access to the company gradually increased. The reference persons varied *in itinere* throughout the duration of the project, given the impressive rate of turnover that characterises the company at the plant management level. However, a crucial encounter was the one with the Director of Industrial Relations of Fiat, Luciano Massone, who had also been

critically involved in the design and implementation of the Melfi plant (he was the first Director of Personnel at that plant). He proved to be a key informant throughout the project and gave me access to a rich variety of internal documents. In particular, he helped me recollect the decision-making process preceding the construction of the Melfi plant, and the radical transformations in the company strategy underlying the transition from mass production to the so-called integrated factory model. Within the last two years, I have been allowed to visit the headquarters, the plants and the training company of Fiat whenever I needed. The collaborative attitude of the company's managers has given me the opportunity to perform regular checks and fine tunings of the results emerging from the study and to fill the gaps in the findings at the time needed.

2.6 Research strategy

In entering the work setting, a primary task for the researcher was to make sense of the complexity of the shop floor. For this reason the methodology relied on grids rather than questionnaires, providing a general framework for observation and interviews with relevant actors in the organisational setting (see Tables 1-3).[6] The grids served both as data sources and case study protocols, thus offering a compact way to select the relevant features of the phenomena under study. In this respect, they can be seen as a tool aimed at performing a systematic audit of the work setting. The rationale for the choice of the grids goes back to the objectives of the study and to the literature analysed in chapter 1. As a methodological tool, the grids focus on the observation of action, practices, and routines, conceived as the multi-faceted aspects of the everyday life of organisations. In this respect, they are informed by the principles of methodological situationalism (Knorr-Cetina, 1988), stressing the situated nature of organisational knowledge processes and the conceptualisation of work as practice.

The application of the methodology involves two levels of inquiry (see Van Maanen, 1979). The first level addresses the issue: "Where is knowledge situated?" This level

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[6] The grids were adapted from a previous study in which I had been involved (see Ciborra, Patriotta, Erlicher, 1995).

of analysis is aimed at providing a detailed account of the organisational "activity system" (Engestrom, 1987; Blackler, 1992) through the actions and words of its members. Specifically, it observes relevant events, visible behaviours and artefacts, and helps to select domains in which breakdowns potentially occur. The above defined items are conceived as selected features of a situation, which constrain or induce intentional performances or at least fall into the scope of attention of the actors in the situation. The situation sets the stage where people engage in processes of interpretation and sense-making (Daft and Weick, 1984). A key resource is members' own accounts of activity within their setting, that is the "language, concepts, categories, practices, rules, beliefs and so forth, used by them" (Van Maanen, 1988: 13). Thus, two types of phenomena stand out: observed behaviours and interpretations provided by the actors. The second level of inquiry deals with the "institutional" dimension of knowledge (Douglas, 1986). Its purpose is to trace back from the observation of visible behaviours and artefacts, the "theories in use" (Argyris and Schön, 1978), or interpretative schemes (Orlikowski, 1992) informing them, together with the organisational contexts that shape them. The framework in which action takes place consists of specific institutional arrangements and the stock of knowledge (Schutz, 1967) that actors are thought more or less to share and take for granted in their everyday activities. As we have seen earlier, such a context emerges only in situations of breakdowns and critical circumstances, when the obviousness of daily routines becomes problematic. This second order analysis deals with what is referred to as "interpretation of interpretations" whereby the researchers represent and display a system of knowledge, as it is described and interpreted by its members, in a narrative (Van Maanen, 1988). Though interpretation is inevitably theory-laden, this second-level analysis desirably leaves the way open for new constructions and orderings of the descriptive material to emerge. Moreover, the researchers' perceptions and interpretations can be reflected back to actors in the naturalistic settings, and in turn their concepts and interpretations integrated.

Grids for the methodology

FLOWS & SYSTEMS	EVIDENCE
ORGANISATIONAL STRUCTURE	organisational units, tasks and roles
WORK FLOW	lay-out, production cycle, work operations, production lines
INFORMATION SYSTEM	computerised production control, "Andon" boards
QUALITY CONTROL SYSTEM	quality control procedures, quality indicators and certificates
EQUIPMENT	Machinery, work tools, measuring devices

Table 1. Where is knowledge situated? Flows and systems

ACTIONS & EVENTS	EVIDENCE
MEETINGS	analysis of interaction patterns, language, idiosyncrasies, attitudes
COACHING	analysis of transferred values, skills, behaviours, coaching styles, attitude towards errors, job rotation
INFORMAL COMMUNICATIONS	face to face interaction, conversations
DISRUPTIONS	breakdowns, line stoppages, technological perturbations (e.g. die change), product/process anomalies
WORK PRACTICES	organisational routines, rituals, patterned activities
LEADERSHIP STYLES	language, management of individuals, groups and resources, leader background

Table 2. Where is knowledge situated? Actions and events

OBJECTS & ARTEFACTS	EVIDENCE
VISUAL CONTROL TOOLS	notice boards, panels on the line, kan ban, error messages
ORGANISATIONAL RECORDS	organisational maps and charts, anomaly cards, problem solving procedures, customer feedback, diaries, informal memos, charts, performance indicators
ORGANISATIONAL SYMBOLS	writings, signs, metaphors
DOCUMENTATION	company brochures and journals, archival material (e.g. photographs, reports, etc.) press releases, existing literature on the company and the field sites

Table 3. Where is knowledge situated? Objects and artefacts

2.6.1 Data sources

Following the categories specified in the above grids, evidence for the case studies relied on three main sources: documentation and organisational records, interviews, and direct observation.

Documentation and organisational records

Internal documents and archival records were collected throughout the duration of the research project, both at the field sites and at the company library. The types of documents utilised in the study are specified in the grids above. Archival data was primarily used to reconstruct the organisational context in which the study was being performed and accordingly provide the necessary background (e.g. company history, business activities, organisational structure, and so on) for the description of the case studies. However, in specific instances archival data was deployed right on the front stage. In chapter 4, for example, photographs documenting the advancement of the construction work on the green field site constitute an integral part of the argument developed in the chapter. Overall, organisational documents have been extensively utilised as visual aids within the empirical chapters of this research.

Interviews

Research combined open-ended with focused interviews with key actors. Following the topics outlined in the grids, respondents were stimulated to narrate stories related to their work as well as providing their insights into specific occurrences and situations. Overall, I interviewed about 53 people at the field sites, and spent about 8 weeks on the shop floor distributed over 10 visits to the plants. The total number of interviews across the case studies was distributed as follows: 30 for case 1, 10 for case 2, and 13 for case 3. Interviews encompassed a variety of profiles including managers of different functions (19), middle managers and technicians (26), and, to a lesser extent, generic workers (8). The duration of interviews would vary between 30 and 60 minutes. Typically, conversations with middle managers and generic workers would focus on operational issues (e.g. concrete problem solving), while those with first line managers were aimed at getting a more holistic picture of the factory and shop floor operations (e.g. background information, production process). However, the bulk of the data was collected along the production lines while following the team members at work. All the interviews and conversations along the production lines were tape recorded and transcribed. Additional informal conversations were not recorded.

Further interviews with three top corporate managers were conducted during four visits at the company's headquarters in Mirafiori. The people interviewed included: the Director of Industrial Relations (2 interviews); the Director of Production; the Director of Personnel and Communication. The topics covered in the interviews included both background information about the plants under study and ongoing evaluations of the results achieved by the study. Throughout the duration of the project I regularly visited the training company of Fiat (ISVOR) to collect documents and background information from the company library. During those visits I had several informal conversations and a few interviews with employees, managers and consultants of the company. Finally, I had several informal conversations with the Director of Industrial Relations of Fiat Auto and the Director of Personnel of the Melfi plant during a 10 days visit to Warwick Business School.

Direct observation

Direct observation covered both ordinary behaviours and disruptive phenomena. Everyday activities were observed as defined, enacted, and made problematic by

persons going about their normal routines. Particular emphasis was placed on the observation of instances of perturbations, interruptions and breakdowns since these events trigger sensemaking activities and expose the tacit features of the organisation. Direct observation implied taking detailed and descriptive field notes. Field notes of all that could be remembered were made soon after leaving the setting. An important specification throughout the fieldwork concerned the identity of the researcher. Clearly, given the time constraints and the nature of the field site it was not possible to define the observer as a complete participant. Nonetheless, the access and support guaranteed by the company allowed me to develop a sufficient level of proximity and mutual trust with the observed, albeit maintaining the observer-observed relationship. The attitude of the observed was generally very open and informal, albeit with interesting variations within the two field sites. In Melfi, most of the people would treat me as a peer, probably because we were in the same age range. In Mirafiori, however, the team members initially took me for an engineer, the reason being my apparent knowledge of car manufacturing issues (which actually came from books and previous research experience). Typically, their attitude would be that of the experienced workers exposing narratives to a junior who was willing to listen and possibly learn something. As we shall see in the description of the case studies, the above attitudes seem to be indicative of the different sub-cultures present within the two field sites. Overall, the researcher assumed the identity of "participant as observer" (Denzin, 1989), witnessing concrete occurrences on the shop floor.

2.6.2 Data collection

Fieldwork was conducted during the period 1994-1998. The shop floor team provided the basic unit of analysis (observational setting). Following ethnographic methods, data collection combined naturalistic observation with open interviews. Interviews were mostly conducted along the production lines rather than in locations separated form the workplace. Typically, data collection would entail the following stages:

- preliminary visit to the plant (1-2 days): presentation of the study to the plant management and introduction to the shop floor

- full immersion period in the work environment (about 2 weeks), conducting

interviews and direct observation

- second round of interviews and observation (2-3 days)

- fine tuning period (1-2 days), which involved meetings with selected groups of managers to discuss and validate preliminary findings.

As mentioned above, the research was initiated in parallel with a European project in which I was involved and which included Fiat amongst the partners in the consortium. The project provided me with the opportunity to conduct extensive fieldwork in the Melfi plant throughout the year 1994. This was a crucial period for the plant since it coincided with the start-up and official opening of the plant in October 1994. In fact, the "in-becoming" nature of the factory context provided a fertile ground to assess the main assumptions underlying the design concept and witness, to a certain extent, the emergence of a core nucleus of organisational knowledge. Data for the first case study was gathered during five visits to the body welding and assembly units of the plant, which included a two-week period of immersion in the work environment. A total of eight teams were observed while they were working in the plant and shop floor operators were interviewed at their workplace. Also, the design concept of the factory (1991-1993) was reconstructed retrospectively using the archival data and interviews with key organisational actors involved in the construction of the factory (see chapter 4).

After the termination of the above mentioned process, I followed the evolution of the plant from 1995 until the present day, relying on subsequent visits to the plant, archival documentation and retrospective accounts provided by the interviewees. The design and development of a second case study on Melfi involved two one-week visits to the plant. Evidence for this second case relied on direct observation of a best performing team in the body welding unit, which had been jointly selected with the plant's management on the basis of generic performance indicators. The fieldwork involved shadowing the team members along the production lines and asking questions only to call them to account for concrete occurrences.

The third case was conducted during a two year period (1996-1997), involving five visits to the plant. The observational technique adopted in the fieldwork was identical to the one deployed for case 2 (i.e. shadowing a best performing team on the shop

floor). Additional interviews were conducted with the Plant Director and the Human Resources Manager. The latter acted as a key informant for the development of this case study. Internal documents and archival data were also analysed.

The protocol for each case contained a few variations to suit the nature and the contingencies of the setting (see specific chapters). The most important variation concerned the rationale underpinning interviews and observation. For case 1, given the contingencies of the setting (induction phase of the plant), the breadth of observation and interviews were privileged. In other words, I tried to interview and observe as many relevant actors as possible in order to get a broad picture of how the factory worked. Cases 2 and 3, however, dealt with more consolidated settings, hence the choice of a more focused approach. A second important variation concerned the number of visits to the field sites. The two cases conducted in Melfi shared the same background information and therefore presented considerable overlapping in the data collection stages. Overall the Melfi plant was visited 7 times for a period of about four weeks, while Mirafiori was visited 5 times for a period of about three weeks.

2.6.3 Data analysis

Following Huberman and Miles (1994), data analysis was devised as a dynamic, recursive process, occurring before, during and after data collection, and entailing three linked sub-processes: data reduction, data display, and conclusion drawing/verification. Data reduction activities involved selecting relevant data throughout the research process. A preliminary source of reduction was provided by the specific conceptual framework, research questions, and study design, which guided the data collection process. During the data collection phase, interim analyses were performed drawing on the evidence and preliminary findings emerging from the fieldwork. Interim analysis was crucial in keeping the amount of data collected under control. At the same time it provided the criteria for further, more focused rounds of data collection. In fact, fieldwork was an ongoing process that lasted until the final writing-up stages, even if in the form of quick cross-checking phone calls with some company managers. Finally, once the bulk of the data was available, data reduction implied a set of activities aimed at further data selection and condensation. These involved, amongst others, going through the transcripts of the interviews and field

notes in order to select foreground/background relationships, in accordance with the main research questions of the study; coding and clustering the data by listing relevant themes and subsuming them under knowledge categories. Data display, defined as "an organized, compressed assembly of information" (Huberman and Miles, *ibid.*), was performed on a reduced set of data and served as a preparation for conclusion drawing and/or action taking. It mainly implied writing descriptive reports in order to link emerging themes in a coherent account. More generally, writing proved to be a fundamental sensemaking technique throughout the analytic process. Finally, conclusion drawing and verification involved drawing meaning from displayed data through a variety of tactics suggested by the literature on qualitative methodologies. These included pattern recognition, comparison/contrast, data clustering, use of metaphors, triangulation between different data sources. The above activities should not be seen as a sequence, but rather as a recursive process linking induction and deduction cycles. As Huberman and Miles (*ibid.*) have pointed out, inductive and deductive analyses are mixed:

> When a theme, hypothesis, or pattern is identified inductively, the researcher then moves into a verification mode, trying to confirm or qualify the finding. This then keys off a new inductive cycle (p. 431).

At the overarching metalevel, data analysis followed the two-level framework outlined in section 6 of this chapter, which links description and interpretation. This turned out to be a challenging sensemaking exercise, aimed at progressively framing the complexity and equivocality of the data into structures of signification. In this respect, data analysis can be seen as a cognitive endeavour unfolding according to the distinctive data management and analysis methods described above.

2.7 How do we write the story: rhetoric of representation and the problem of validity

In this concluding section, I shall go back to the methodological problems highlighted in the introductory sections in order to analyse the relationship between the rhetorical forms of representation of theory and the problem of validity. I will argue that most of the difficulties in articulating interpretative theories are related to the language and discursive paradigms adopted by the analyst. I will then go back to Geertz's Bali

cockfight and suggest that its narrative structure could provide a template for the cases contained in this study.

As we have seen in the introductory section, recent years have witnessed a "silent qualitative revolution" (Denzin and Lincoln, 1994). The growing popularity of qualitative methodologies has mostly derived from the numerous attempts to structure and systematise the basic rules of method while defining (nebulous) criteria for assessing interpretative validity. Admittedly, the validity of a given empirical study and of the method informing it, rests on the use of shared interpretative categories that have been legitimised within a certain community. These categories are socially constructed and reflect the institutional canons whereby knowledge is produced, coded and transferred in a given environment.

However, the presence of institutional canons of appraisals have brought about important consequences for the modes of representing theory in qualitative research. Interpretation, far from being an imaginative act (a fiction, a "making" according to Geertz), has become, in some cases, almost mechanical.

Let us consider the conventional way of writing down or presenting a research study[7]. We normally use variables, conceptual categories, and headlines, to circumscribe our descriptions and render them meaningful to the scientific community. In doing so, we also expropriate our account from its value for the community under study ("natives"). We artificially divorce description from interpretation and elevate the order of the latter towards the abstract. It this precisely at that moment that the narrator is detached from his/her own account. He/she no longer speaks with the voice of the characters; instead an institutional voice bursts into the picture. The narrator has stopped conversing with the natives and is now addressing his/her words to the broader academic community, matching the institutional canons of his research environment.

The heavy reliance on abstract categories and the tendency to set clear cut distinctions between description and interpretation, data collection and analysis, may

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[7]Another good example is the quasi-compulsory use of slides in conference presentations. Here the mere use of the medium is a way of legitimising the value of a study.

at times render the phenomenon under study almost transparent. In the field of organisation studies, this may lead to a situation where all organisations look the same no matter what their activity is. They become dead entities and their uniqueness is lost. The above considerations emphasise the need for bringing to life the entity under study and letting the phenomena speak with their own voice. Ideally, the interpretative account should give the reader the feeling of being there.[8]

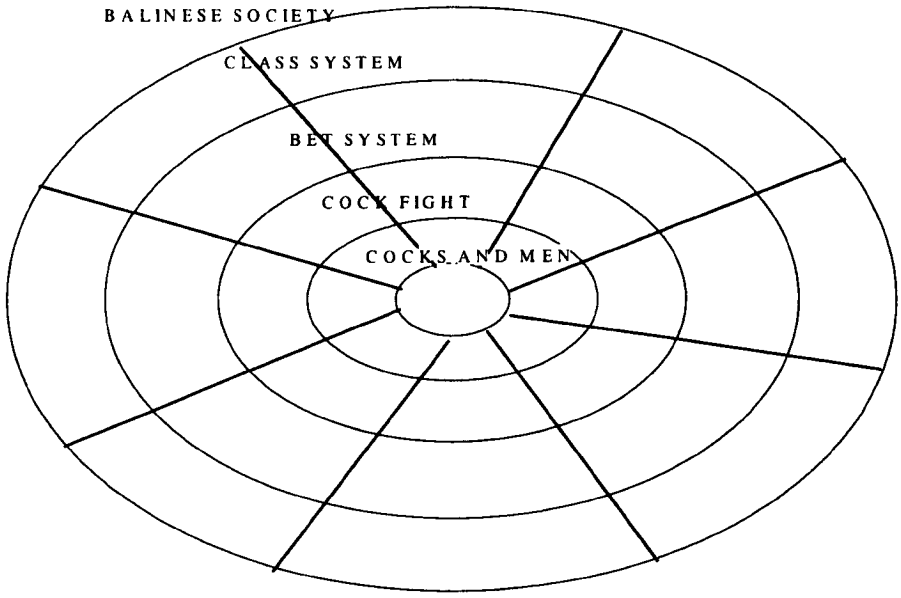

Figure 2. Narrative structure of the Balinese cock fight

Let us go back for a moment to the Bali cockfight and to its narrative structure. The thick description of the event involves speaking about the cocks and their sacred value, the spectators, the rules of the game, the homology between the betting system and the class system in Bali. It is by introducing new elements and new relationships into the picture that the social system of the Balinese society is gradually uncovered and disclosed to the reader. We have also seen that one of the major problems that the observer has to face is how to harness the complexity of the relations generated in the description and eventually decide where to stop the narration. As we have argued in section 3, the construction of a plot and its closure are vital for interpretation.

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[8]An outstanding example is Latour's (1987) description of laboratory life where the author imagines conversations going on between scientists and creates semiotic characters that serve the purpose of the narration.

Following Geertz, it is possible to depict the narrative structure of the Bali cockfight as a web of signification (see Figure 2). The description is carried out by drawing concentric circles that move from the particular towards the general, from description towards interpretation. The circles are held together by rays departing from the core event (the cockfight) and moving outwards.

The narrative texture is such that the conceptual world of the Balinese community is gradually disclosed to the reader.[9] More importantly, the verisimilitude of the account seems to rest on the author's ability to clarify what goes on within the community under study, to reduce the puzzlement of the reader in the face of an unfamiliar world: validity becomes a matter of authorship and difference (Geertz, 1988).

Undoubtedly, problems of generalisation and theoretical formulation are heavily related to the nature of interpretative sciences. However, they also depend on the rhetoric of representation of a given phenomenon within different sciences. Typically, positive sciences find articulation through scientific essays, whereas humanities refer to literature. The interdisciplinary nature of social sciences make them suffer from a fundamental ambiguity between the ambition to be exact sciences and the objective limitations stemming from the nature of the phenomena observed. In the field of organisation studies this ambiguity is reflected in two distinctive modes of representation. On the one hand, the geometrical-positivist way of representing organisational phenomena, with tables, matrices, circles, boxes and arrows, Cartesian axes, and bullets points; on the other hand, the post modernist way, with its minimalist argumentations, its loose and cryptic accounts, whose purpose is often difficult to grasp. This tension points to the need to combine different modes of representation.

To some extent, thick description can represent a satisfactory solution to the problem of rhetorical representation. As we have shown above, the major strength of thick description lies in its ability to generate references, to penetrate the boundaries of any organised form of activity, thus providing rich accounts of social actions.

It is the task of the researcher to decide in which directions to point the description

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[9]The same narrative structure applies to the example of the dies in Mirafiori

and to provide a holistic picture of the broader phenomena in which a small fact is inscribed. Like a captain, he needs to be in control of drifting and keep his ship's course. He needs to find a balance between creativity and authority, govern the tension between discovery and appropriation. Thick description is about patiently weaving webs of signification, drawing concentric circles by moving from small matters to general truths, creating interpretative structures which, like a spider's web, are difficult to spot and easy to break.

To sum up, a writing strategy should serve the purpose of addressing the main research questions of a study in a coherent way by combining inductive and deductive lines of reasoning. In other words, any "argument building strategy" aimed at detecting patterns, categories and analytical reasoning needs a "text building strategy", which makes possible the construction of the argument. For example, the text building strategy of the Balinese cockfight analysed above, allows the author to uncover "deep" social structures. This is achieved through a web-like construction moving in a centrifugal manner towards deeper structures of signification. As we mentioned earlier, such a strategy presents the difficulty of reaching a closure, which basically rests upon the craft of the author rather than the presence of objectives boundaries. The present study adopts a less radical writing strategy in that the construction of the narrative takes into account the importance of research questions and deductive reasoning.

2.8 Main limitations of the study

The main methodological limitations of the study can be summarised in three categories:

- Amount of data collected as opposed to those utilised
- Time spent at the field sites
- Slice of observation

The amount of data collected for the study was really vast: transcription for interviews, personal field notes, organisational documents and archival records were

in the order of the thousands of pages. As it was mentioned in the data analysis section, data reduction was a necessary and exacting task. It is likely that the potential of the data was not fully exploited, partly because of the limited rationality of the researcher in handling the full data set, and partly because of the time constraints imposed by the PhD. Potential themes that may have been overlooked for the above reasons will be probably addressed in future publications.

The actual time spent on the shop floor amounted to only 8 weeks, which may seem very limited for an ethnographic study. Admittedly, gaining access to the shop floor, the heart of the company's operations, is normally very difficult for external people. For example, Melfi is regularly visited by journalists, members of competing car manufacturers, and academics. However, the time normally granted for the visit does not exceed one or two days, during which the interaction occurs with top managers rather than shop floor operators. Spending long periods of time with shop floor workers would imply distracting them from production operations, irrespective of how unobtrusive the presence of the observer was. Under these circumstances, the initial access granted to both Mirafiori and Melfi was made possible by my previous collaborations with ISVOR, the training company of Fiat. Yet, there were limitations in interviewing line workers, at least while they were working along the line. More importantly, the shop floor provided only part of the data set. As explained earlier, a considerable amount of data was collected elsewhere. For example, organisational records and archival data proved to be fundamental in reconstructing the background for the description and interpretation of the case studies as well as providing first-hand evidence supporting the arguments developed in the case studies. The managers interviewed at the company's headquarters and at Fiat's training centre provided additional valuable information. Throughout the study I maintained an ongoing communication process (e.g. phone, e-mail, exchange of documents via conventional post) with the key informants for the study (see above), whom I could contact whenever I was in need of information.

In two of the three case studies, observation focused on one best performing team, indicated by the management of the respective plants. This choice may pose limitations in terms of legitimacy of the selection and overall validity of the data. Narrowing the focus of observation guaranteed a better control of the observational

process. Also, the two teams were not observed in isolation, nor were they divorced from the broader factory operations. The two plants were visited in full, and observation was always related to the broader organisational features. As explained above, essential background information was provided by interviews with top managers as well as organisational records and archival material. Secondly, the selection of the team on the part of the company may have been dictated by opportunistic reasons (e.g. present a positive image of the whole factory, avoid disruptions in the production process). However, given the focus of the study, I had no reasons for objecting to the respective management choices. Finally, given the empirical focus of the study on shop floor dynamics, the inquiry left in the background the role of two important institutional actors: the board of the company and the trade unions. Their views were only voiced indirectly through the analysis of the specialised literature and the recollections of shop floor managers. This resulted in a limited appreciation of the strategic change process in Fiat that triggered the end of Fordism. Furthermore, it possibly downplayed the trade unions' view of the critical knowledge creation and institutionalisation processes that derived from this change.

CHAPTER 3: THE COMPANY BACKGROUND

3.1 Introduction

This chapter intends to set the background to the description of the case studies by providing a brief outline of the firm's origins, business activities, and organisational model. Specifically, the chapter relies on longitudinal analysis techniques combining business history (the evolution of management composition and organisational models) with labour history methods (the relationship between company and labour movements). On the one hand, it outlines the evolution of production systems and organisational models within the company. From this vantage point, three main organisational phases are considered: 1) the early introduction of mass production systems after World War II, acting as a backbone for the company's expansion throughout the 50s and 60s; 2) the investments in heavy automation during the 70s, leading to the adoption of a high-tech factory model at the beginning of the 80s; 3) the paradigm shift from Fordism to lean production at the beginning of the 90s, epitomised by the introduction of the so-called "integrated factory". At the same time, the chapter analyses the historical background against which organisational change takes place. Here, the main line of argument revolves around the presence of conflict, both in the form of strikes and militant antagonism, as a pervasive feature of the history of Fiat. Admittedly, the vicissitudes of Italian industry have mirrored the tensions, contradictions and radical conflicts characterising the economic development of the country since the Second World War. Under these circumstances, Fiat seems to embody the archetype of industrial conflict. Significantly, Mirafiori, the largest factory in Italy, has been defined as the "factory of factories" (Berta, 1998a) in order to stress its archetypal nature so ingrained in the cultural identity of the country. As Berta (1998b) has observed, the imprinting underlying the relations between work and the company seems to be characterised by supremacy games, occurring against a background of high instability and conflict rather than being governed by procedures of reciprocal legitimisation. Under these circumstances, beyond destructive effects, conflict acts as a phenomenal catalyst for change, affecting both the strategy and the management's composition of the company. The next section outlines a profile of the

company by describing the main business operations as well as providing a series of significant performance indicators. Section 3, 4, and 5 analyse the distinctive chronological phases characterising the development of the company. Finally, section 6 presents the main structural principles underlying the organisational model currently adopted by Fiat at the plant level, and hence in the plants considered in this study.

3.2 General: The Fiat Group

Fiat - an acronym for Fabbrica Italiana Automobili Torino - was founded in Turin in 1899. By the first decade of the new century, with the industrialisation of its manufacturing processes, it had become Italy's most important car-making concern. Initially created to build cars, it immediately diversified production into the fields of commercial vehicles, ships, airplanes, trains, agricultural tractors, and construction machinery. The development of its production was soon followed by expansion abroad. From the 1950s, a new burst of international development took the company into more than 180 different markets. In the last twenty years, the Fiat Group has expanded into new manufacturing areas, linked to its original activities by industrial, commercial and financial synergy. Today, Fiat is one of the world's biggest industrial groups, operating in 62 countries via 888 companies which employ about 242,000 people, over 95,000 of them outside Italy. The Group operates 211 production facilities (94 of which are outside Italy) and 126 research and development centres (41 outside Italy). Almost 40% of output is manufactured outside Italy, while exports account for 62% of sales: in fact 5.7 cars, 7.2 commercial vehicles and 9.1 tractors out of 10 manufactured are sold abroad. Fiat Group companies are organised into 10 operating Sectors: Automobiles, Commercial Vehicles, Agricultural and Construction Equipment, Metallurgical Products, Components, Production Systems, Aviation, Rolling Stock and Railway Systems, Publishing and Communications, and Insurance.

Fiat Auto manufactures automobiles and light commercial vehicles. Currently, the automotive division employs 118,109 people (72,883 in Italy) and sells its products in the international markets under the Fiat, Lancia and Alfa Romeo brands. Fiat's car business has been traditionally based on small cars and on the Italian market. Some observers have seen the narrow focus of the firm's operations as a source of

competitive disadvantage. For example, Camuffo and Volpato (1994) have observed that Fiat's two-fold strategy entailed a specialised heritage of competencies, narrowing the scope of future strategic options. However, in the last decade, Fiat Auto has been implementing a purposeful strategy of globalisation, aimed at strengthening its manufacturing presence in the fastest growing markets. This policy has resulted in the opening of huge new factories in Brazil, Argentina, Russia and India to make its so-called world car (the Palio). Since its launch the Palio has given Fiat the lead over Volkswagen in the Brazilian market, which accounts for 70% of the all South American sales (the Economist, 1998). The introduction of the integrated factory model, exported from Melfi world-wide, and the development of a coherent range of models have been the cornerstones of the globalisation strategy.

In 1997, Fiat Auto sold 2,740,000 vehicles, 16% more than in 1996 and nearly 40% more than in 1993. Customers outside Italy purchased approximately 60% of the total output. Car sales are now split roughly three ways between Italy, Europe and the rest of the world. Expansion has already turned Fiat into the world's fifth biggest car company. In 1997 Fiat's turnover was 50,734 billion lire (about 30 billion $); the operating profit was 3,500 billion lire (2.1 billion $), nearly double the previous year, and margins rose from 2.3% of sales to about 4%. Although those figures were improved by government sales incentives (cash to buyers scrapping old cars) in its home market, the figures for 1998 seem to confirm this trend.

Year	1997	1996	1995	1994	1993
Unit sales	2,739,000	2,365,000	2,346,000	2,262,000	1,993,000

Table 4. Fiat Auto's world-wide unit sales (automobiles). Source: Fiat Auto

Since its founding, Fiat has manufactured over 70 million vehicles, many of which represent milestones in the history of automobile development. During the last four years, three Fiat Auto models have been selected as Car of the Year: the Fiat Punto (1995), the Fiat Bravo/Brava (1996) and the Alfa Romeo 156 (1998). The Fiat Group's portfolio of automotive brands also include Ferrari and Maserati.

3.3 The years of perennial conflict (1919-1979)

Fiat automobiles were initially conceived as a luxury item designed for a consumer elite. The early history of the company saw the gradual introduction of mass production schemes. This approach reflected the vision of the founder Giovanni Agnelli, who was already planning methods to strengthen the production system. The result was the Lingotto Project - in its day, the biggest automotive complex in Europe - which went on stream in 1922. The project was based on a specific strategy: to transform the automobile from a product for the elite to one available to the steadily growing mass of ordinary consumers. This was accomplished thanks to the new principles of industrial organisation based on the assembly line.

Since its early days the history of Fiat was punctuated by high levels of conflict unfolding in parallel with the two world wars. Up to the 50s, conflict was partly a continuation of the social agitation following the Second World War, which gradually led to the emergence of a highly politicised labour movement. This period was characterised by strikes, struggles and reciprocal opposition between the unions and the company management. As Berta (1998b) pointed out, the two parties seemed to perceive the contest in the workplace as an exclusive match occurring against the backdrop of the Cold War (p. 14).

In the post-war period, with Vittorio Valletta replacing Giovanni Agnelli at the top of the company, Fiat fully developed mass production schemes drawing on the booming Italian economy and the unions' weakness. A key element in this expansion was the Mirafiori plant, inaugurated in 1939 to enlarge production capacities. Fiat's strategy based on high production volumes, cost efficiency and Fordist work organisation, required a strict control of workers' behaviour (Camuffo and Volpato, 1994). In this respect, the 50s were characterised by a systematic repression strategy pursued by the company to weaken the organisational roots of the labour movement. In the course of the cold war fought within the factory, the scales seemed to tilt towards the company. However, a reversal occurred in the following decade, leading to the so-called "hot autumn". The 60s inaugurated a phase of predominance of the unions that would last until 1980. The high levels of conflict through the 60s and 70s marked the pinnacle of the union's power. In the face of the increasing power of the unions, Fiat decided to engage in an open confrontation in order to restore the authority of the company

within the production sites. The period 1968-1980 represents the extremities of the major phase of conflict in the company's history, conveying an image of industry as a source of unbearable social contradictions. A few significant features are indicative of the scale of the conflict. During the "hot autumn" of 1969, strikes amounted to 9 million hours, the equivalent of 270,000 cars lost. This level remained constant throughout the 70s: 4 million hours of strikes in 1970; more than 3 million in 1971; 4.5 million in 1972; 12 million in 1973; and so on until the end of the decade (Berta, 1998a). From 1972 terrorist attacks occurred both against union representatives and managers (throughout the 70s Italy was hit by a strong wave of terrorism). The oil shock reduced the company's capacity for investment, while the introduction of wage indexation (index-linked pay scale) raised labour costs substantially, affecting Fiat's productivity and competitiveness (Camuffo and Volpato, 1994).

Berta (1998b) described the conflict cycle characterising the period 1919-1979 as a pendulum oscillating between the company and the workers and periodically redistributing the role of winners and losers. He sees the evolutionary process of IR at Fiat as a sinusoidal movement, characterised by peak levels of conflict at the apex, while the lowest points represent a stasis in the strikes occasioned by a power shift in favour of the firm. Accordingly, the collective bargaining activity seems to follow a zero sum game logic, dominated by supremacy games. This opposition between Fiat and the labour movement emphasises a low capacity for the consensual production of shared norms. It also highlights a form of path dependency, where the institutional production structure appears to be precarious and uncertain. In this respect, the 1980s inaugurated a new phase characterised by the end of antagonism and militant confrontation.

3.4 From Fordism to the High-Tech Factory (1980-1989)

After 1980, the industrial relations at Fiat seemed to lose much of their militant and antagonistic character. Camuffo and Volpato (*ibid.*) have characterised the early 1980s as a phase of managerial unilateralism and union demise. A turning point in this phase was the so-called "march of the 40,000" in October 1980, during which a

"silent majority" of workers (mostly middle-managers) stood against the protest strike that had led to the shut down of the firm for five weeks.[10]

The company took this opportunity to adopt a tough line against the unions and the state in negotiating the labour implications of the process of restructuring. Total automation was one of the pillars of the restructuring process. Admittedly, the adoption of the Fordist paradigm at Fiat had been characterised by the presence of high levels of automation since the 70s. According to Camuffo and Volpato (*ibid.*), the automation choice, at least initially, was part of a defensive strategy enacted in response to the increasing levels of conflicts within the company, which had led to conspicuous losses in productivity (see above). In this way the company aimed to reduce conflicts by improving ergonomy and working conditions, while making production less dependent on workers' consent and participation. The same strategy was conceived as a means of by-passing union control on work organisation. The technology strategy was successfully pursued throughout the 80s, becoming a sort of organisational paradigm.

In fact, at the beginning of the 80s, Fiat embarked on the high-tech factory concept, which privileged intense automation to yield high productivity and quality, while reducing the role of human work drastically. The high level of investment in the so-called "flexible technology" was supposed to compensate for the rigidities of the Fordist production system and to adapt to the fluctuations in the market. Termoli and Cassino, the first examples of high-tech factories, were considered to be the most technologically advanced plants in the world at that time.

At the same time, total automation was part of a labour saving policy aimed at the substitution of human labour with machines. In the years between 1980 and 1986 the work force was reduced by 57,000 employees (42% of the total work force). (Cersosimo, 1994).

The high-tech factory model brought positive effects in the short term by yielding higher productivity and a decrease in production costs. The productivity per

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[10] The strike was called by the unions in response to the management announcement of an imminent layoff of 14,469 workers.

employee rose from 15 to 28 cars, bringing a simultaneous decrease in labour costs from 28% to 17% of the company's turnover. In 1989 Fiat, the only Italian car manufacturer, reached a record production level of 1,971,969 cars, placing Italy fifth in the world ranking. (Cersosimo, *ibid.*).

Given the outstanding performance of the Italian company throughout the 80s, the imminent crisis that was to hit the European and American automotive sector did not seem to be perceived by the Fiat management. However, the flaws inherent in the high-tech factory model emerged dramatically in 1990, when the effects of a world-wide crisis in the automotive sector together with the success of Japanese car manufacturers brought radical changes in the strategies and organisational models underlying the traditional mass production systems.

Fiat's two-fold specialisation, which had represented a source of competitive advantage until that moment, turned into a "core rigidity" (Leonard Barton, 1992a), highlighting the incapacity of the company to penetrate foreign markets and to respond to the trend towards integration and globalisation of the market.[11] The same fate befell to the marketing policy based on high production volumes and low prices, and supported by Fordist mass production systems. This strategy, which prioritised quantity over quality, was supplanted by the new way of producing and selling cars put forward by Japanese companies, based on customer orientation and commitment to high quality standards.

At the organisational level, Fiat's technocentric approach revealed some crucial mismatches. Technological investments had not been supported by innovation in the managerial and organisational models. In fact, the high-tech factory was still operating within a Tayloristic-Fordist paradigm. The dominance of the "hardware" (technology) over the software (organisation) led to increasing difficulties in the capacity to harness the complexity of the technical system. Technology was supposed to govern the production system, but no mechanisms had been devised to govern the technology. Technological rigidities quickly started to emerge: the highly

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[11] It is important to remark that throughout the 80s Fiat had pursued a policy of disinvestment in overseas markets, which were considered not profitable, leading to the closure of overseas plants. This stands in sharp contrast to the current Fiat overseas strategy.

sophisticated technological system was not able to cope with continuous disruptions and, although non conflicting, even robots did not seem to be reliable. As a result, the quality of the cars decreased without a simultaneous increase in productivity.

At the end of 1989, in a dramatic speech at the annual company convention, the CEO of Fiat Cesare Romiti recognised for the first time the superiority of the Japanese production system. His analysis of the state of the company highlighted the need for raising the overall levels of efficiency, improving the quality standard of the products and reducing time to market. On that occasion he announced Fiat's new commitment to total quality and to the principles of lean production. It was the prelude to the "integrated factory" model, which would put an end to the Taylorist-Fordist phase at Fiat and bring in a new production paradigm informed by the principles of Toyotism and lean production. As we shall see in chapter 4, this paradigm shift entailed re-negotiating the existing IR policies. The pillars of the re-engineering process are illustrated in the next section.

3.5 The integrated factory model (1990s)

The deceptive results delivered by the high-tech factory concept and the lessons learned from "lean production" (Womack *et al.*, 1990) have led Fiat to the implementation of a new production concept known as the *integrated factory*. The Melfi plant, described in the next two chapters, is the first example of this organisational revolution. The apparent shift from automation to integration, from flexible to lean technology, is attributable to the management's newly acquired awareness that quality cannot be the outcome of sophisticated technology alone, if there is little or no involvement of the work force. The new philosophy of integration tries to reconcile a high-tech infrastructure (including extensive use of robotics) and the rigid synchronisation of the assembly line, with elements typical of the job shop (such as working in teams).

Lean technology means, first and foremost, less technology. Admittedly, the backbone of the integrated factory is still the traditional assembly line, which makes it possible to transform a sequence of orders as specified by the market into a linear, sequential production process. What really changes is the interface between man and

machine, which involves a shift in the concept of automation, from substitution to delegation: within the flexible technology model the professional capabilities of the work force were subordinated to the governance of the technical system; with lean technology, the technical system is explicitly designed in order to promote the development of the potential capabilities of human capital.

The new model required consensus. This led the company to re-define IR policies characterised by a new attention to HRM. A number of accords with the unions at the beginning of the 1990s created the conditions for the institutionalisation of a collective bargaining framework. Camuffo and Volpato (*ibid.*) have identified four emergent themes in the bargaining process:

- work hours and shifts
- work organisation and cycle times
- reward system
- union-management relationships

The need for higher levels of productivity, quality and efficiency required negotiating new work schemes. For instance, in the new Melfi plant work hours are based on 3 daily shifts, six days a week, 8 hours per shift. Another important innovation regarded the flexibility of cycle times. In the light of the accord of June 1993, line speed can be increased up to a maximum of 10% to allow for recoveries of productivity levels in the face of line stoppages.

The higher level of flexibility on the part of the work force has been compensated by the creation of new performance-related incentive schemes based on suggestion systems and competitiveness rewards. Likewise, IR policies have been re-designed according to collaborative patterns, thanks to the introduction of bilateral union-management committees at the plant level.[12] Although the above policies do not

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[12] Here, two major innovations have been introduced: a) the consulting committees, where the firm reports to the unions about the results on quality and productivity; b) the participation committees, which team up plant managers and union representatives in order to facilitate workers' participation (Camuffo and Volpato, 1993)

define a fully-fledged participatory model (unions are just consulted on decisions taken by the company), they recognise an important institutional presence of the unions within the process of change and innovation that Fiat is currently undergoing.

Overall, the above innovations seem to promote a better climate in the workplace by fostering better communication and information sharing, improving trust relationships between different organisational actors, and framing the complexity of the production process under a common language.

3.6 The crystal pipeline: principles and structure of the integrated factory

The integrated factory is divided into operating units (OU) responsible for the different stages of the production process. For example, the typical assembly plant comprises four stages: Stamping, Body Welding, Painting and Assembly. The OUs co-operate in defining the daily production plan, monitoring the advancement of production, and managing critical situations. The longer term production plans are defined in Fiat's head office in Turin. Each OU is divided into a number of UTEs (Elementary Technical Unit).[13] The UTE, which comprises between 80 to 100 workers and supervisors spread over three shifts, is the basic production structure of the integrated factory.[14] It can be seen as a semi-autonomous minifactory managing a whole segment of the production process. Specific objectives and results are assigned to each UTE such as productivity, quality, budget, mix, and quantity. A UTE has a head responsible, supported by a staff of technical specialists dedicated to repairing and maintenance tasks (the "technologists"). The institutional nucleus of the UTE also includes a group of specialist and generic workers, whilst a number of *ad hoc* figures can be called upon to intervene in the event of a concrete problem. Finally, the co-ordination between the different UTEs is entrusted to the Operations Manager, who also acts as the hierarchical chief of the UTE responsible. Typically, a UTE

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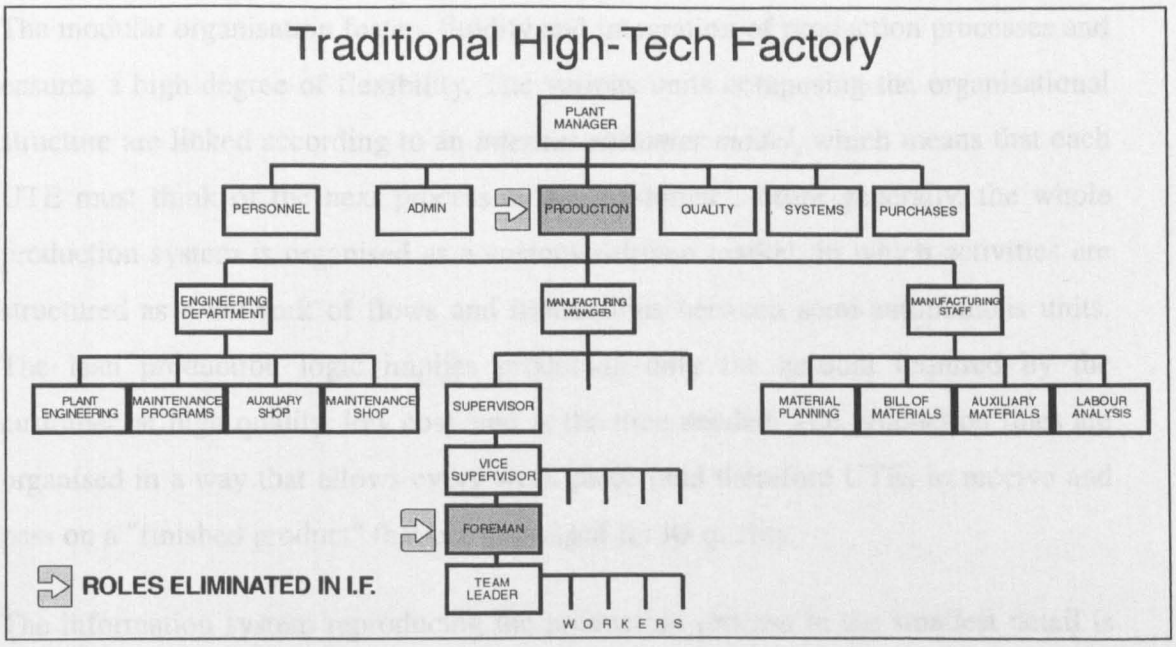
[13] Throughout the study I will maintain the Italian acronym UTE, which stands for "Unità Tecnologica Elementare"

[14] The above figure represents an average size. The size of UTEs varies depending on the OU in which they are located and the nature of the tasks performed at that production stage. For example, UTEs in the assembly unit are characterised by manual operations and accordingly employ more operators than highly automated units.

controls one or more production lines, which are split into a varying number of workplaces occupied by one or two workers (or robots in the automated OUs). The number of workplaces depends on the number of elementary operations which have to be carried out in order to complete a given production sequence.

The organisational principles of the integrated factory model stress the importance of the production process over functional specialisation. Decisions are taken where problems arise and where specific competencies exist for their solution. Accordingly, problem solving and the management of the workflow are delegated to the work team, which stays at the core of the production process. Interestingly, the UTE can be considered as a socio-technical system as it connects two distinct elements: a socio-organisational one - the "team", a collective way of working, collaboration, the intimacy of staying together and sharing; and a technical one, the world of machinery and equipment (see Ciborra, 1996). The delegation of decision making to work teams makes it possible to run factory operations with a reduced number of hierarchical levels. In fact, the integrated factory presents two less hierarchical levels with respect to the previous organisational structure (see Figure 3). A quick look at the two figures highlights the leaner structure of the new organisational model. For one, the governance of the production process is simplified with the decentralisation of previous organisational functions at the level of OUs and UTEs. In addition, the adoption of teamworking practices leads to the elimination of the traditional foreman figures.



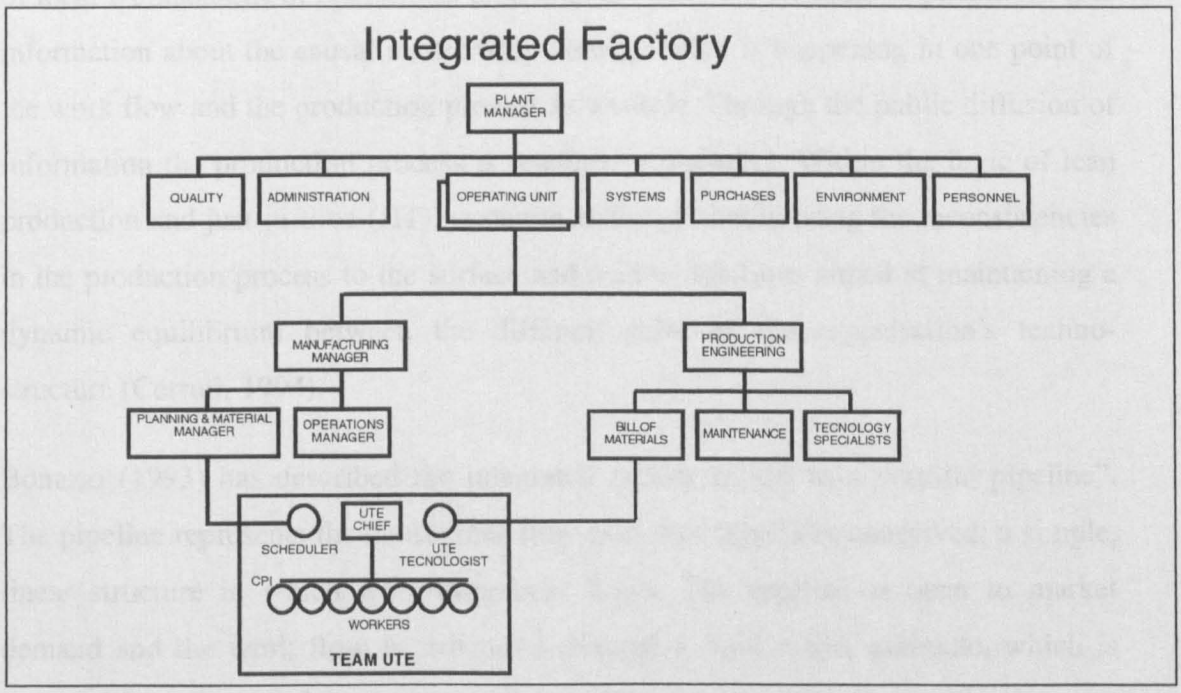


Figure 3. Changes in Fiat's organisational structure at the plant level

The modular organisation fosters fluidity and integration of production processes and ensures a high degree of flexibility. The various units composing the organisational structure are linked according to an *internal customer model*, which means that each UTE must think of the next process as its "customer". More generally, the whole production system is organised as a customer-driven market, in which activities are structured as a network of flows and transactions between semi-autonomous units. The lean production logic implies producing only the amount required by the customer, at high quality, low cost, and at the time needed. The production lines are organised in a way that allows every work place (and therefore UTE) to receive and pass on a "finished product" that can be judged for its quality.

The information system reproducing the production process in the smallest detail is built according to the logic of "systemic visibility". Rather than depicting the status of local workstations or operations, emphasis is placed on systemic implications: it is information about the causal relationship between what is happening in one point of the work flow and the production process as a whole. Through the public diffusion of information the production process is rendered transparent. Within the logic of lean production and just-in-time (JIT), systemic visibility should bring the inconsistencies in the production process to the surface and lead to solutions aimed at maintaining a dynamic equilibrium between the different parts of the organisation's techno-structure (Cerruti, 1994).

Bonazzi (1993) has described the integrated factory model as a "crystal pipeline". The pipeline represents the continuous flow as it was originally conceived: a simple, linear structure in which work-in-process flows. The pipeline is open to market demand and the work flow is structured through a rigid orders schedule, which is imposed from Fiat headquarters according to the productive mix required by demand. The image of the pipeline that portrays lean production indicates a rigid synchronisation of all the processes occurring inside it and a high level of collaboration between the different units. But the pipeline is made of crystal, material that evokes the idea of transparency and fragility. Transparency means firstly eliminating waste and defects. Secondly, avoiding informal stocks and slack, and thus curbing shirking and other forms of opportunistic behaviour. Thirdly, making all available knowledge explicit: work is made transparent and "textualized", (Zuboff,

1988) by representing all relevant aspects of the work flow through the visual control system. The fragility of the pipeline is related to the rigid synchronisation of the work flows and to the lean production concept. Since bottlenecks and the piling up of inventories can disrupt the flow and break the pipeline at any moment, everything in the plant has been synchronised with the purpose of avoiding bottlenecks, work-in-process inventories and buffers.

3.7 Conclusion

At the turn of the millennium, Fiat is facing a number of new challenges such as strategic alliances, globalisation policies, and experimentation with new production systems based on modular manufacturing.[15] In tackling the above endeavours, the firm can possibly draw on a much more favourable internal climate with respect to the past. Yet, some authors (e.g. Camuffo and Volpato, 1994; Cerruti, 1994) have argued that the distinctive labour heritage and structural repertoires of the company will possibly affect the new organisational development. Specifically, they have depicted the IF model as a sort of hybrid between Fordism and lean production, arguing that the development of a fully-fledged lean production model is hindered precisely by the influence of the past in the firm's path dependency. Accordingly, they have questioned the scope of the cultural shift underlying the implementation of the IF model. A significant example concerns the role of generic workers in the control of the production process. As it is known, within the Japanese model, line workers are allowed to "pull a cord" in order to stop the production line in the face of a disruption. This principle follows the assumption that line workers are closer to the production process and therefore possess the tacit knowledge necessary to perform factory operations (Adler, 1993). At Fiat the issue of who is allowed to pull the cord seems to be much more controversial and varies from plant to plant. However, even in the most innovative plants like Melfi, the decision to stop the line seems ultimately to be down to middle managers, possibly following the indications of line workers. The above considerations highlight the typical controversies associated with the design and

[15] This involves building as many cars as possible on the same basic chassis and accordingly achieve massive economies of scale

implementation of a strategic change process. The critical innovations related to the introduction of the integrated factory model encompassed at least three main dimensions: the organisational structure, the technology and production system, and the human resource policies. These changes implied a new division of knowledge at the plant level, albeit with different impacts on the two plants considered in this study. Specifically, while the Melfi plant was born from the green field and conceived according to the new strategic guidelines endorsed by Fiat, Mirafiori had to face a transition from the traditional organisational model and production philosophy to the new one. These issues are discussed in more detail in the next three chapters.

CHAPTER 4: KNOWLEDGE-IN-THE-MAKING: THE "CONSTRUCTION" OF MELFI'S INTEGRATED FACTORY

4.1 Introduction

As explained in the earlier chapters, most of the existing knowledge-based theories of the firm have viewed knowledge as an objectified, ready-made product that can be instrumentally put at the service of the organisation. A main point of convergence in the literature has been on the distinction between tacit and explicit knowledge and on the fact that knowledge creation is the outcome of a dynamic interaction between the two. Yet, from an empirical point of view, few studies have attempted to dig into the "inner workings of knowledge" and analyse the processes that lead to the institutionalisation of knowledge in organisations.

The purpose of this chapter, the first part of a double length case study, is to analyse the process of knowledge construction and institutionalisation surrounding the coming into existence of one of the most advanced car manufacturing plants in the world: Fiat's Melfi car factory. This factory, recently built from the green field, features a lean production organisation, work flow based on assembly lines and teams, advanced applications of IT to production management and control, and extensive reliance on total quality management. Indeed, the factory itself—what today appears as a ready made product, a black box—is the main visible outcome of a dynamic process of knowledge creation characterised by the active involvement of the future work force in the construction of the plant. Following Latour (1987), the strategy of investigation adopted in the case study will be to reopen the black box and follow the characters on the "construction site" while they are "busy at work".[16]

A short journey in space and time will take us to the Melfi green field at the moment

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[16] The analysis focuses on the role of young managers, middle managers and technicians in the process of learning and knowledge acquisition over the green field. The choice of the sample is justified by the fact that these profiles are the most involved in the training process surrounding the coming into existence of the factory. In particular, given their connecting function within the new integrated factory model (i.e. "being in the middle"), middle managers are considered by the company as a crucial asset in the process of knowledge creation and transfer.

when the construction works of the factory are about to begin. Here, we will follow the phases going from the design concept of the factory to its formal opening. The latter marks the technical blackboxing of the original nucleus of organisational knowledge developed over the green field and, at the same time, provides the "closure" point for the analysis.

Under these circumstances, the green field setting provides a privileged observational perspective for tacit knowledge, at least for two related reasons: firstly, it offers the prospect of a *tabula rasa* and therefore points to an organisational context characterised by low levels of institutionalisation of knowledge. On the one hand, one could argue that the construction of the plant from scratch rests upon the highly institutionalised know-how of the company and the "industry recipes" (Spender, 1989) available in the car manufacturing sector. On the other hand, in relative terms a green field site provides a less constraining setting for knowledge construction. In this regard, the coming into existence of the plant itself incarnates an incipient act of organisational knowledge creation, derived from the design concept and inscribed into the genetic code of the factory. Secondly, the sensemaking activities surrounding the construction of the factory refer to a non-routine situation, characterised by discontinuities and shifting trajectories. Hence, learning processes occur against a background that is "in becoming", one where the multiple forces shaping knowledge creation dynamics are, to a certain extent, easily detectable.

A main finding of the study is that the construction of the factory defined a highly situated process of knowledge creation where hard (resources) and soft (competencies) factors became inextricably intertwined. More specifically, the participatory strategy adopted by the company since the early phase of the new plant (namely the decision to involve the work force in the construction of the factory) has led us to see the physical construction of the factory as a fundamental competence and identity building exercise. Melfi's building site has provided a principal learning setting as well as the venue for a process of social becoming.

At the overarching metalevel, the analysis of the chronological phases preceding the formal opening of the factory highlights a distinctive pattern of knowledge creation and transfer relating the content and the process of the learning experience. Learning seems to occur in the form of progressive ownership processes connected to different

aspects of work: the role, the task, the product and production process, and most importantly the work place itself. Rather than a sheer knowledge transmission model going from a knowledgeable source to a passive recipient, ownership processes imply taking a pro-active role on the part of the learners. As a consequence, knowledge creation appears as the outcome of interacting forces working according to "specification-delegation" chains. The latter highlights the interplay between top-down and bottom-up processes, planned and emergent factors involved in the design and implementation of the Melfi project.

This chapter is organised as follows. Section 2 elaborates a conceptual framework for the case study based on a review of existing theories of organisational learning. Section 3 provides a brief sketch of the Melfi plant. Section 4, 5 and 6 describe the main phases characterising the unfolding of the Melfi project, identifying knowledge sources and outcomes, learning settings and organisational actors involved in each phase. This part also discusses the knowledge implications related to the design and implementation of green field plants. Section 7 and 8 review the chronological advancement of the Melfi project in order to identify both the learning-specific outcomes relating to each phase, and the pervasive patterns of knowledge creation underpinning it. The chapter concludes with some consideration about the sedimentary nature of competence and the importance of approaching knowledge-related phenomena from the point of view of knowledge-in-the-making.

4.2 Two perspectives on organisational learning

The learning dynamics revolving around the construction and appropriation of the factory and leading to the creation of organisational knowledge represent the main focus of this case. As stated in the introduction, the factory itself, conceived as a technological artefact, is placed at the centre of the analysis and provides a visible reference point for the description of those dynamics. However, before considering the details of the case study we need a conceptual framework that allows us to relate the observations carried out on the field to the existing theories of knowledge creation and organisational learning.

Conventional learning and training theories are based on a pedagogical perspective

which sees learning as the outcome of a knowledge transmission process going from a knowledgeable source to a passive recipient. Within this perspective, the details of practice, the communities of practitioners and the setting in which the learning experience takes place are specifically excluded (Brown and Duguid, 1991). Interestingly, training in the work situation seems to fall within this instructional paradigm as the following definition, quoted from a glossary of training terms, suggests: "a planned process to modify attitudes, knowledge or skill behaviour through learning experience to achieve effective performance in an activity or range of activities. Its purpose, in the work situation, is to develop the abilities of the individual and to satisfy the current and future manpower needs of the organisation" (quoted in Jones, 1994).

More recent theories have rejected transfer models which isolate knowledge from practice, by emphasising the social, situated nature of the learning experience. A chief claim of situated learning theories is that knowledge is embodied in praxis (Pentland, 1992) and that learning takes place through participation within "communities of practice" (Lave and Wenger, 1991). Rather than being a passive recipient, the community of learners is constantly engaged in sensemaking and interpretation activities whereby knowledge is appropriated out of a wide range of materials. The latter include "ambient social and physical circumstances and the histories and social relations of the people involved" (Brown and Duguid, 1991). Accordingly, what is learned is profoundly connected to the conditions in which it is learned. Importantly, learning is about identity construction through engagement in social practices, including the construction of diverse social bonds with other participants (or co-workers). The identity building aspect of the learning experience is captured by the notion of legitimate peripheral participation (Lave and Wenger, *ibid.*) according to which learning involves becoming an "insider", acquiring a particular community's subjective viewpoint and learning to speak its language. Finally, the situated approach is consistent with adult learning theories. In his extensive review of the literature on the topic, Jones (1994) emphasises the importance of self-directed learning and active participation in the construction of learning events as opposed to the traditional teacher-learner principle. For example, adults seem to learn most effectively through experience, and by means of actual day-to-day jobs and routines (learning by doing) rather than from formal and structured training programmes. In this regard,

meaningful adult learning occurs when it is based on problem solving and connects with a person's general life events and activities. Accordingly, adult learning is seen as a lifetime process, continually shaped by the experience of the past.

The two paradigms described above are characterised by Jones and Hendry (1994) as "hard" learning which is pragmatic, formal and brought about through prescribed training, and "soft" learning which has a more subtle nature and is concerned with the social contexts which shapes the learning process. Accordingly, they imply different perspectives on the agents of the knowledge creation process and the learning path underlying this process. Schematically, the instructional paradigm emphasises the planned factors of the training process and the fact that knowledge transmission occurs in a top-down manner. Situated learning, by comparison, seems to view the dynamics of knowledge creation through learning as a bottom-up process, shaped by those factors emerging along the way.

As we shall see, beyond a physical location, the green field site here under study represents a particular situation, a learning setting characterised by distinctive contextual features, where a community of learners is undergoing a peculiar experience. In order to grasp the uniqueness of this experience the case described below adopts a situated perspective, focusing on two important aspects of the appropriation and learning processes surrounding the coming into existence of the new factory. The first emphasises the holistic character of the learning experience. As Winograd and Flores (1986) have pointed out, any technological artefact is situated or dwells in a heterogeneous network that includes other equipment, materials, institutional arrangements, practices and conventions. Accordingly, any learning process is shaped by the encounter with multiple sources and multiple factors. The second concerns the sensemaking and interpretation dynamics underlying the learning experience. The construction of the factory can be compared to the introduction of an 'alien' object which has to be 'metabolised' and put into context by the community of practitioners in order to represent and understand events related to it.

4.3 Fiat's Melfi plant

The SATA plant at Melfi produces the leading Fiat model, the Punto, today the best selling car in Europe. The factory, situated in the south of Italy between Naples and Bari is a green field site set up at the end of 1993 and, after an experimental phase, opened officially in October 1994. Melfi is the world's first car factory capable of running flat-out three shifts, six days a week.[17] With a production capacity of 1600 cars a day (450,000 per year) employing 7000 people, the factory holds one of the best productivity records in the world. Melfi ranks third in Europe according to a recent table published by the Economist Intelligence Unit (see Table 5).

The Melfi industrial district covers a surface of 2.7 million square meters, including the plants of sixteen suppliers. Their location, close to the main assembly plant, makes possible the reduction of suppliers' lead times. Lean production and Just-In-Time (JIT) are applied as a method of organising the work cycle. The work force in Melfi belongs to a homogeneous cultural and geographical background. The original core group of workers (1000 people) comprised skilled personnel - engineers, middle managers and technicians - with a high level of education (high school diploma or University degree). The local identity is quite strong: workers, managers and employees are young (all under 32 years old, aged 26 on average) and mostly from the South (98%), often at their first job (the region where the plant is located, like the rest of the South of Italy has a very high level of unemployment).

The coming into existence of the Melfi factory is the outcome of a collective effort, involving not only the company but also the future work force. The chronology of the design and implementation of the Melfi project reveals six main sources/phases underlying the construction of the factory and progressively leading to the sedimentation of a core nucleus of organisational knowledge:

1. the design concept;

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[17] The main problem Fiat engineers had to solve in designing the Melfi plant was fitting in repairs and maintenance. Apparently, one of the places they visited was EuroDisney, an amusement park outside Paris. In fact, the huge Disney rides run everyday of the week with only a few hours darkness for service work. So Fiat engineers went to EuroDisney and learned how it was done (The Economist, April 25th 1998).

2. recruitment;

3. formal training;

4. construction work;

5. induction;

6. full production.

The following sections portray the chronological advancement of the Melfi project through the phases defined above.

Manufacturer	Plant	Country	Productivity (vehicles per employee)	Total Work force*	Equivalent Work force	Vehicles produced in 1997
Nissan	Sunderland	UK	98	3,986	2,765	271,784
GM	Eisenach	Germany	77	1,884	2,185	167,481
Fiat	Melfi	Italy	70	6,006	5,786	407,019
Volkswagen	Navarra	Spain	70	4,877	3,948	277,077
SEAT	Martorell	Spain	69	7,733	6,512	449,150
GM	Zaragoza	Spain	67	9,109	6,667	445,139
Honda	Swindon	UK	62	2,311	1,737	108,090
Ford	Dagenham	UK	62	4,440	4,070	251,800
Renault	Douai	France	61	6,590	5,552	338,851
Renault	Valladolid	Spain	59	6,607	3,212	190,955
Ford	Saarlouis	Germany	59	5,740	4,730	280,320
Toyota	Burnaston	UK	58	2,444	1,799	104,830
Ford	Valencia	Spain	57	5,110	4,960	280,860
Renault	Flins	France	57	7,809	5,965	337,433
Fiat	Mirafiori	Italy	54	9,171	8,653	463,075
PSA	Aulnay	France	51	5,225	5,045	259,700
Ford	Genk (cars)	Belgium	49	8,970	7,270	359,620
GM	Luton	UK	39	3,940	4,006	157,700
Volkswagen	Wolsburg	Germany	39	23,251	16,327	637,859
Fiat	Cassino	Italy	39	6,606	6,398	249,664
Renault	Sandouville	France	36	6,577	5,960	212,158
PSA	Vigo	Spain	35	9,198	6,075	210,700
Volvo/ Mitsubishi	NedCar	Netherlands	33	7,006	5,974	197,225
Rover Group	Longbridge	UK	33	9,000	10,000	329,709
Skoda	Mlada Boleslav	Czech	33	18,040	7,942	259,837
PSA	Poissy	France	32	8,619	6,250	198,900
Volkswagen	Emden	Germany	28	9,981	7,845	223,044
PSA	Sochaux	France	25	18,400	9,020	222,800

Table 5. Productivity of selected European plants, 1997. Sources: Vehicle manufacturers, EIU analysis (August, 1998)

* Adjusted for comparative purposes.

4.4 Phase 1: The design concept

Melfi is the first example of Fiat's new organisational model known as the integrated factory. The plant marks the passage from Fordism to a revised version of the Japanese model and coincides with a major re-engineering process undertaken by the company at the end of the 80s. The genesis of the new work organisation lies in the increasing attention devoted by the company to the emergence of the lean production paradigm in Japan and to its diffusion in Europe, and especially in the U.S. For Fiat the successful experience of the Japanese transplants in the U.S. was a clear signal of the need to brake with the old cultural tradition. The following quote from Cesare Annibaldi, the manager responsible for external relations of the company, explains the reasoning behind the shift towards a new production paradigm:

> The need for a radical change in the work organisation had started to emerge by 1986-87. There had been the Japanese experience; but, what mattered most to us, the Japanese model had spread out, albeit with many adjustments, in the U.S. too. Everybody was looking at the Japanese model, and everybody had copied some bits of it; but the rationale behind the model was too closely linked to cultural factors, and therefore difficult to export. When we saw that even the U.S., which had a work organisation very similar to ours, had followed that path, we started to ponder about the cultural implications of the model. However, for some years the change process was stuck. Only in 1989, when the Punto was conceived, was there a physiological convergence between the above reasoning and the new productive needs. A new car, a new organisational model, a new factory. Melfi was born out of those three combined factors (quoted from Donzelli, 1994: 26).

The design of the plant had a major impact on the company's existing culture, since it raised traditional controversies such as the opposition between North and South, novices and experienced, engineers and HRM managers. Interviews with the former Plant Director and the Personnel Director, highlight four major controversial issues related to the design of the plant. A first point of controversy concerned the governance of the socio-technical system. There was a presumption of conflict related to the history of the company, especially as far as IR practices were concerned. In the past, this problem had been dealt with through massive investments in technology to be used as a defensive strategy against social conflict. As we have seen the technocentric approach was only partially successful. The alternative position was represented by those who believed in the role of HRM policies and the partial involvement of the Trade Unions as a strategy to gain consensus on such an ambitious project. Secondly, there was a debate about the new production system. The lean production philosophy, the adoption of JIT, the presence of suppliers on site,

involved eliminating all those forms of external warehouses, which served as the backbone of the traditional mass production systems operating in Fiat's plants. The "crystal pipeline" concept, i.e. the idea of a rigid production flow with no buffers, was more than a technological challenge as it affected the company's traditional culture on production methods. Thirdly, the new team-based organisation and the delayering of the traditional organisational model were at odds with the company's deeply hierarchical tradition. Finally, the green field concept and the involvement of a green work force in the realisation of the project were a major question mark. Some managers believed that the lack of experienced people would impede the project and that at some point the company would be forced to call back the old "cavaliers".[18]

The company board, in charge of the direction of the operations, acted as a sort of tribunal engaged in redeeming controversies between innovators and the so-called "cavaliers". The board assessed the proposals brought forward by the committee in charge of the implementation of the project. It selected between alternative choices by endorsing the entrepreneurial risk behind each option. As mentioned earlier, Melfi certainly represents a breakthrough and a paradigm shift within the Fiat world. It is therefore sensible to imagine that the decision making process underlying the design of the new factory was characterised by a strong negotiation if not open conflict between "innovators" and "conservatives".

However, we do not possess any evidence to document the details of this conflict (e.g. position taken within the board). What can be said here is that the Melfi project was driven from the outset by the idea of radical innovation related to the survival of the company in a fierce competitive environment. The mission, imposed in a top-down manner, set the background against which decisions would be taken within the

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[18] Within the Fiat world, the term "cavalier" refers to powerful, charismatic figures, who have served the company for long periods of time. It also points to a conservative mode of thinking deeply grounded in the old company's tradition.

board.[19]

4.4.1 The cornerstones of innovation

The design concept of the Melfi plant presents several elements of innovation for Fiat and, more generally, for car manufacturing. Traditionally, the company has been renowned for its technocentric approach to design (see plants of the 80s) characterised by the use of cutting edge technologies at the expense of human labour. A distinctive feature of the Melfi project, however, is the active involvement of the HRM function in the design of the plant and, consequently, the significant shift from the technical aspects of design to the socio-organisational ones. The team-based work organisation, the recruitment and training policy, the commitment to ensure better working conditions through massive investments in ergonomy, the innovative patterns of industrial relations, and the collaborative role of the trade unions, all seem to signal the importance conferred on the human element. Furthermore, the pivotal role played by HRM in the design and implementation of the Melfi project also implies a shift in the core competencies characterising the coming into existence of the new factory, as it will soon become apparent from the description provided below.

The Melfi project was devised in 1990 and initiated in 1991. The recruitment of the new work force started at the beginning of 1992 when the factory was still non existing. The plant became physically visible only at the end of 1993. It took 24 months to complete the construction work and the first car body rolled off the line in September 1993. The first thing to be noticed in the above chronology is that the "lead time" of the factory (from the commencement of the building works until the completion of the first car body) was only 24 months, whereas it took nearly three

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[19] Here it is important to reiterate that the research is not concerned with the paradigm shift *per se*, which remains in the background providing a context for description. Specifically, in our account we chose the design concept of the factory as a point of departure, without questioning the decision making process upstream of it. It should be noticed then, that the process under consideration - unfolding according to chronological/thematic phases - is delimited by the presence of black boxes: it starts with a project on paper (a script) and ends with the physical factory.
From the above consideration it is possible to derive the following proposition: in a process of social construction, the status of an object or artefact depends on the arbitrary decision to question it or conversely treat it as a final product or black box. It is a matter of where one sets the boundaries of the description. The latter raises an important methodological issue and highlights the role of research design in cutting up the interactionist field.

years for the original core group of workers to go from recruitment to full production. As a matter of fact, the selection and training of the people who were supposed to run the factory was regarded by the company as a critical success factor within the Melfi project.

The implementation of the project was initially entrusted to a group of 50 young managers, all in possession of a University degree, highly trained, with 2-3 years of managerial experience within the company's production plants. Their mission, as defined by the company headquarters, was to build one of the most competitive automotive factories in the world, which would be erected on a green field site. This high profile group was in charge, amongst other things, of the recruitment and training of the new work force. The group of hired employees initially comprised approximately 1000 workers, engineers, middle managers and technicians, in possession of a diploma or University degree. This group was eventually divided into a number of "Work Breakdown Structures" (WBS), each responsible for the development of a specific aspect of the plant. The bulk of the generic workers (approx. 5000) was hired subsequently and put into training. The philosophical cornerstones of the training policy within the new plant are clearly laid out by the Personnel Director of Fiat Auto, Maurizio Magnabosco, one of the brains behind the design concept of the factory:

> Our training policy is shaped by two fundamental assumptions. The first is the choice of not transferring the "Turin" culture, or at least minimising the transfer. At other times we have seen that when we put together local middle managers with external ones, the former could not stand the latter. In fact, they would not recognise any supremacy related to the possession of a higher level of competence. This time there was something more. In this case we wanted to experiment with a new culture; thus, we had to devise, at least for managers and middle managers, a different type of profile, one to be subject to a long training period. Melfi does not look like a manufacturing plant; rather it looks like a laboratory. Had we hired people already trained in other company's plants, they would have brought their own culture, which is not that of the "integrated factory", with them; they would have sprinkled the new context with their previous culture. For this reasons we hired a green work force, mostly from Melfi and the surroundings, and we took them to Turin to train them. One and a half years for the engineers; six months for the middle managers. The training of the generic workers will be carried out in Melfi and will be shorter (quoted in Donzelli, 1994:30).

The second assumption relates to the content of the training process, specifically addressing the need for acquiring a systemic understanding of the work process:

> It is the peculiar quality of work in Melfi that it requires an extended training programme, specifically aimed at competence acquisition, one that does not only imply learning how to do things, but also looking at the other segments of the production process. In order to put

> into practice a form of training that makes one aware of the lateral whereabouts, one needs to know the boundary, i.e. what is going on in the upstream and downstream processes; furthermore one needs to know how to work in a team, to control certain variables previously uncontrolled, to develop a financial sensitiveness towards the cost of the product (*ibid.*).

As Donzelli (*ibid.*) has rightly pointed out, given the complexity of the new work organisation, the most challenging task Fiat had to face in the training of the new work force was to devise specific learning paths. In other words, the challenge did not seem to lie so much in the "what" of training, but in the "how": how to convey the knowledge (awareness) of the boundary; how to foster a systemic orientation towards work while learning how to do specific things; and how to equip the newly hired work force with cognitive tools appropriate to support this systemic orientation.

4.4.2 The green field strategy

Questions of site location, building construction and plant layout were crucial for the design concept of the Melfi factory. The adoption of a green field strategy was a core design specification and a fundamental pre-condition for a successful implementation of the whole project. Figure 5 illustrates the green field area selected for the construction of the SATA plant in Melfi.

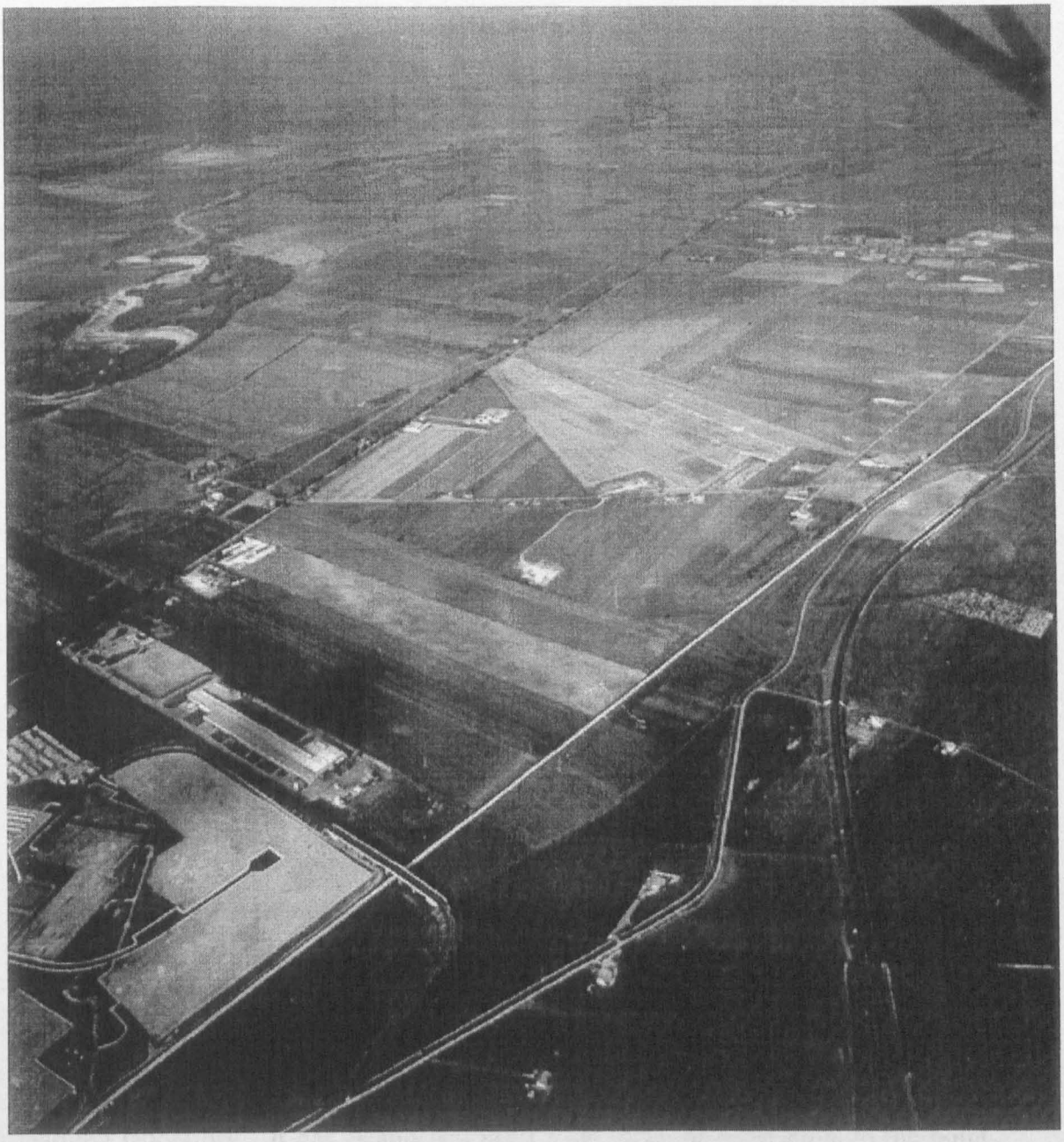

Figure 4. Melfi's green field site (June, 1991)

The rationale behind the choice of Melfi included at least three major reasons. The first was its strategic location within the wide network of Fiat's plants already existing in the south of Italy. Secondly, Basilicata - the region where the plant is located - can be considered as a "green area" in its own right, not contaminated by pre-existing industrial models and yet characterised by the local population's positive attitude towards industry and new work opportunities. Finally, the same region is distinguished by high levels of schooling (knowledge asset), offering an ideal recruitment basin. The strategic implications of green field sites for the management

of innovation and change have been widely recognised in the literature. For example, Lawler (1982) has emphasised the holistic character of design (designing the organisation at once) connected with the adoption of a green field strategy:

> new organisations simply have a number of advantages when it comes to creating high involvement systems. They can start with a congruent total system; they can select people who are compatible; no one has a vested interest in the status quo; it is possible to do the whole organisation at once. (1982: 307)

In other words, the defining structural features of green field sites allow for the design of systems where all parts of the organisation are consistent and the multiple facets of the design concept fit together (Clark, 1995). According to Whyte (1990), it is easier to develop new forms of manufacturing organisations on green field sites because "the spatial design, technology and people involved are all starting afresh."

In reviewing the debate about green field sites in the UK, Beaumont and Townley (1985) identify three different usages of the term:

- a multi-plant organisation building a new plant;

- the physical location of that plant outside a major manufacturing centre;

- the presence of new work practices and arrangements stemming from a new employee relations philosophy.

The first usage stresses the experimental character of a green field plant within a network of existing plants. For example, the Melfi plant is often referred to as a "learning laboratory". It has established itself as a model of innovation, to the point that the term "Melfi-like" has been coined to indicate new green field plants, within the Fiat world, built after Melfi. The second definition refers both to the geographical isolation from a major manufacturing district and to the cultural distance from industrial communities. Green field sites are often located in less developed regions, characterised by high levels of unemployment and by a lack of socially embedded knowledge about industry. Furthermore, those regions are usually eligible for grants from local governments or supranational bodies like the EU. The third definition is the more controversial. It refers to a new organisational philosophy underlying the setup of a green field plant, especially as far as HRM implications are concerned. The IR literature for example, has pointed out how the choice of a green field can be

instrumental in reducing the potential level of conflict within the new plant and possibly by-passing the unions' control of work organisation. As we have seen, a similar strategy had been adopted by Fiat in the past although using different instruments (e.g. automation as a defensive strategy). This time, however, the deal with the unions played a critical role. To a certain extent, the deal was constrained by the very idea of providing a major employment opportunity in a depressed area, which ensured consensus (and major incentives) at the political level, while limiting the bargaining power of the unions. For example, the unions were deliberately excluded from the decision-making process related to the design of the factory. On the other hand, they were crucially involved in the implementation phase through participation in bilateral commissions specifically designed to monitor the advancement of the project. As Rieser (1992) has observed, the main role of the unions in Melfi was to provide feedback in the set-up process and thereby absorb the potential sources of social conflict inherent in the implementation of the new organisation model. In other words, they were part of the company's strategy for building consensus around the project (the Melfi work force is highly unionised, although non-conflictual). More generally, green field sites provide an opportunity for managers to make a philosophical break with the traditional ways of doing things (Clark, 1995). This is consistent with the concerns behind the design of Melfi as expressed above by Fiat's Personnel Director. Beaumont and Townley (1985) have clearly explained this point:

> The green field site offers the prospect of a *tabula rasa*, ... the possibility of establishing work organisation, job design, personnel and industrial relations policies afresh rather than attempting to tackle these issues on and *ad hoc* basis in existing plants. It provides the opportunity to experiment with the development of a coherent "green field philosophy (1985: 189).

For Newell (1991), the greenfield philosophy is not concerned with greenfield or brownfield sites, but rather with the prospect of a radical transformation in the traditional way of doing things. Accordingly a greenfield strategy can be adopted regardless of the physical location of the plant and the labour source. Finally, a fundamental contribution to the above debate is provided by Clark (1995) in his rich empirical study carried out in the UK subsidiary of Pirelli. According to him, the emphasis on HRM, while capturing important features of the green field site phenomenon, also underestimates other important areas in which green field sites

offer the opportunity for innovation, such as building design, internal plant layout, technology, relations with suppliers, customer relations, and distribution and communication networks. Secondly, at a more theoretical level, there is a tendency to over-emphasise the voluntarist, top-down strategies and choices of the company in achieving "green field change" and to downplay the opportunities provided by structural conditions (1995: 46-47). The latter point relates the design and implementation processes of green field plants to the interplay between strategy and structure, stressing the relevance of emerging (contextual) factors in shaping those processes:

> The distinctive systemic feature of greenfield sites is that they provide a strategic structured opportunity (1) to design all aspects of plant operations afresh (2) to design all aspects of plant operations so that they are congruent with each other (3) and to experiment with untried systems or practices (p.47).

The above quotation is particularly relevant in order to see design as a knowledge creation endeavour. As mentioned above, a green field site offers the prospect of a *tabula rasa* and therefore provides a background for learning and knowledge creation which is characterised by a low level of knowledge institutionalisation (degree of tacitness). In other words, it provides a context where it is possible to create not only a new factory but also a whole stock of knowledge from scratch. Green field sites are a mixture of opportunity structures and structural constraints (Blau, 1990: 145, quoted in Clark, 1995). To a certain extent, the structural features of green field sites allow a company to keep the learning and knowledge creation processes under control. For example, the absence of a sedimented industrial tradition associated with green field sites may facilitate the "schooling" the work force and the transfer of knowledge in a top-down manner. At the same time, the low degree of institutionalisation of the initial stock of knowledge creates the conditions for the emergence of unforeseen facts which may challenge the original design concept, enrich its scope and act as new knowledge creation forces.

The design concept of the Melfi plant embraces many of the ideas connected to the choice of a green field strategy. However, the implementation of this strategy, especially as far as training and learning dynamics are concerned, also presents many aspects that are unique and possibly explain the stunning performance of the factory.

4.5 Tales of the "green field": competence building over the Melfi "building site"

Phase 2: recruitment

The selection process was designed following a benchmarking activity on the Japanese plants scattered around the world. A threshold of 10% had been identified as the ideal ratio between selection and recruitment. Consequently, almost 100,000 people were interviewed in order to select 7,000 workers.

> We designed a selection system before a training system. We wanted to select people not only in possession of a theoretical background, but also with a positive attitude towards work, in particular towards teamwork; people willing to put themselves at stake, with a sense of challenge; people with whom it would be possible to build a new factory model, far from the traditional one. In sum, people with a strong personality (Former Personnel Director).

As stated above, the original core group of hired workers can be seen as a group of novices. The basic stock of knowledge they possess comes from formal education. What is the nature of this first minimal nucleus of knowledge? It is formal, non experience related knowledge; it is explicit knowledge, easily detectable since it coincides with a specific school degree; more importantly, as we shall see shortly, it is knowledge that can be manipulated and put to use.

Another important factor is the homogeneity of the work force and the cultural values related to the particular area where the plant is located. The work force incarnates the cultural values typical of a rural community, such as the importance of the family, sense of belonging to the territory, honour and accountability, tinkering and the art of "managing to get along", attitude towards mutual help and readiness to "give each other a hand". Although those values may seem in sharp contrast with an avant-garde industrial project, the production reality within the Melfi plant offers a different picture. In order to function effectively a factory like Melfi needs consensus. Hence the importance of a healthy cultural environment, where local values can be re-invented and turned into a valuable resource for the company. Today, those values find original applications in key areas such as quality control, teamwork, problem solving and organisational learning[20]. On the other hand, in order to be successful, an

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[20] During the interviews some operators described the experience of assembling a Punto as building their own car; others often referred to the team as a family.

ambitious project like Melfi had to be contextualised. A number of sociological studies aimed at assessing the core cultural features of the local population, the local sub-cultures, and the potential impacts of the new plant on the local cultural context were undertaken on behalf of the company as part of the design activity:

> We built a reference values matrix based on comparative sociological studies undertaken here at the headquarters and at the future location of the new plant. We wanted to avoid transferring the traditional company values to the Melfi context. We wanted to avoid cloning or colonisation. What we did, instead, was to combine the two value matrices according to the (knowledge) assets available on the territory (Former Personnel Director).

For example, the presence of a strong local identity and the importance of maintaining close social bonds, suggested to recruit people living within a range of 30-60 km (one hour's drive) from the factory, in order to facilitate commuting to work. In this way, workers could keep living in their home towns and carry on their social activities, without having to move closer to the factory. As a consequence the construction of the factory did not produce a dramatic impact on the territory, as it was the case with previous industrial installations in the south of Italy.

The contextualisation strategy achieved two important results. Firstly, as explained by the former Personnel Director of the plant, it contributed to building consensus and reduced the level of conflict of the work force:

> Melfi represents an innovation even with respect to the other company experiences in the south, characterised by high levels of conflict in the initial 2-3 years of operations. Many people wonder why Melfi did not have to pay this price. I think that a novice who does not find certain cultural references for his working condition will end up rejecting it. With Melfi, we have tried to understand the needs, the motivations and the experience of the individual and to harness these traits for the benefit of the company's performance.

Secondly, as we shall see in the following sections, the "protection" and reception of the local values fostered a crucial process of knowledge creation from the bottom.

Phase 3: formal training

Having gone through selection sessions and been tentatively assigned to a role, the freshly recruited work force was subsequently put through an intense formal training period in Turin. While Melfi was still a green field site, the core group of hired workers spent a one to two year period in the training company of Fiat, ISVOR, in order to acquire some general knowledge about the company, the production process, and the basic principles underlying the new organisational model. Professional

profiles, learning programmes, and career advancement tracks were tailored according to the different educational backgrounds and the individual attitudes emerged during the selection process. The training period at ISVOR encompassed both classroom sessions and simulation exercises in laboratories. Knowledge acquired in the classroom would be continually tested and put to work through rotation in other Fiat plants. The latter provided the first contact with the production reality. Here the training consisted of operational simulations where the newcomers would take part in shadow teams working side by side with experienced operators along the assembly lines. In a subsequent phase, while the new plant was still not available, a real simulation of the production process in Melfi was undertaken in the Fiat factories scattered around Italy. The future work force was organised in virtual teams and assigned to specific UTEs with each member taking up the position corresponding to his/her future role in Melfi. The training experience in Turin also provided a golden opportunity for socialising the future work force. For more than a year, the trainees lived as a community in the residences provided by the company. The company had also arranged cultural and leisure activities, tours at weekends, and trips back home once a month.

Phase 4: construction work

On the building site, 3,000 people belonging to the contracting firms in charge of the construction of the plant were already at work. The contracting firms were responsible for the building works, the installation of the plants and the set up of the machinery. As mentioned earlier, the Melfi project was completed in just 24 months. The entire operation was supervised by an interdisciplinary group that involved automotive production specialists from Fiat Auto working side by side with the civil and structural engineers from Fiat Engineering. From these combined forces emerged the site plan as well as the architectural and structural design of the factory. In September 1991, large-scale construction began on the site. By September 1992, the Fiat Auto engineers could start installation of the production systems. By May 1993, the energy supply systems were ready for testing. By September 1993, the entire plant was ready for operation. To cite just a few figures, the construction site operation amounted to 12 million working hours, 4 million cubic meters of earth were moved, 16,000 meters of foundation were laid, 500,000 cubic meters of reinforced concrete

were used, 90,000 tons of structural steel were erected, 5,000 tons of pipes, 100,000 meters of insulated electrical wiring, 16,000 meters of high and medium tension power lines were used and 16,000 meters of railway track were laid. Figures 6-10 depict the advancement of the construction work over the green field site.

The strict deadlines, foreseen in the project plan schedule, made it necessary to start construction site work concurrently with project development, thus breaking the traditional process of one phase following the other. This innovative methodology required close co-ordination between project partners. More importantly, it allowed for the crucial involvement of the future work force of the factory in the construction work. As soon as the new hired workers completed the formal training period in Turin, they would be sent in batches to the green field site in Melfi and get involved in the construction of the new factory. The migration process from the headquarters in Turin commenced at the end of 1992 and by the summer of 1993 all the training process had been transferred to Melfi, where an *ad hoc* training centre run by ISVOR had been set up.

The strategic choice of the company to involve the future work force in the physical construction of the avant-garde factory played a pivotal role in the process of learning and knowledge acquisition. The whole factory, including walls, production lines, plant layout, and so on was built from scratch with the crucial contribution of the future work force, sometimes drawing explicitly on the professional skills related to the educational background of the core group of hired workers. The following quotation highlights the multiple crafts involved in the construction work (surveyor, mechanic) and how the educational background of the trainees is re-invented and put to work on the building site:

> I was one of the first to arrive here in October 1992. Nothing existed here, not even the shell of the building. Although I had been hired as a member of maintenance staff, I did my first work experience as a surveyor (that is my educational background) working with the firms in charge of the construction work. Together with my colleagues, I traced the grooves that would host the production lines and followed the progress of the building work; together with three other colleagues I assembled the UTE 2 (that's how I know it very well); finally we set up the machinery, and that was more specific to our qualifications since we were born as mechanics. So I was involved in heavy construction jobs before setting up and testing machinery (Technologist, Body welding unit).

More generally, the interviews have highlighted a widespread perception of the participation in the building works as a founding experience for the work force,

involved in the construction of their "own factory":

> The plant was born from the green field. When I arrived here, in May 1992, there were only a few pillars and the roof. One of the first things we did was to bring our work force inside the (Assembly) unit in order to involve them in the issues related to the set-up of the assembly unit. The first group of people who came down to Melfi (from Turin where they were on training courses) were my maintenance staff. They assembled this unit, together with the other companies who were here. They started from the basic element, the "groove", where the electrical system that controls the production lines, is lodged (Production Engineering manager, Assembly Unit).

> I have been here since May of last year (1993). Now it's difficult to explain. There was nothing here: the plants were here but they were not operational; there was nothing on the (shop) floor, we designed the workstations, we built our boxes: none of this furniture was here, there were no desks, we built them on our own, we cut the iron, painted it, built poles, we did a bit of everything. We could not believe that in a few months all that was going to become operational; and yet it happened. We like to think that it is our achievement too (Head of UTE, Assembly Unit).

> During the first few months, since there was nothing here, we would act as operators of the firms which were supposed to build the plant; therefore we would do nothing that was related to our future work, apart from studying the production cycles on paper (Head of UTE, Assembly Unit).

Within the building site, the core group of hired workers was organised into WBS, responsible for the development of the multi-faceted aspects of the avant-garde factory: monitoring the construction of the plants, testing the machinery, and adapting the new socio-technical system to the specific context of the Melfi factory. Each WBS would act as a start-up team, directed by a team leader, and was encouraged to submit written proposals to the newly formed steering committee of the plant. The management structure of the plant was rather loose at the time with the steering committee comprising a group of 22 managers recruited from the original group of 50. The evolution of the training process was kept fluid, grounded on the solutions proposed by the start-up teams and on the critical issues emerging along the way. Follow-up decisions were kept on stand-by, awaiting for new developments.

The WBS became the core operational unit within the building site, with its members witnessing all sorts of learning experiences. The following example illustrates the functioning of a typical WBS engaged in setting up the presses within the stamping shop, while stressing a crucial learning pattern based on a comparative experience surrounding the appropriation of the machinery:

> For assembling the presses we formed two work teams including both internal personnel and members of the supply companies. As you may know Schuler and Komatsu make the presses we use. The Japanese team was in charge of assembling the large presses, while the

> German team took care of the medium presses. The Japanese team had managed to rationalise its activities up to a point where, in the face of a sudden disruption, they were able to suspend the job and keep going somewhere else. They had disassembled the press as if it was a LEGO; they had numbered the container; in each container there was a set of inferential moves, the so-called "ifs" of a project, representing variations or possible ramifications within a planned activity. The Japanese never opened more than two containers at the same time, and therefore utilised a minimal amount of space. They were able to complete the assembling job and test the machinery three months before the deadline. On the other side, the Germans had a very loose planning, and accordingly each single problem encountered while assembling would disrupt their work. The Germans were just on the deadline, but they occupied the entire shop floor, with parts scattered everywhere. Our engineers were involved in both experiences and clearly they learned something about their own work method. They would not make any move without planning, without assessing the possible consequences of their actions. "What happens if..." and they would start assessing the "ifs". (Former Plant Director)

As Cerruti (1994) has rightly pointed out, the objective of the participatory strategy pursued by the company was twofold: to adapt the new socio-organisational model of the integrated factory to the complex technological system in order to accelerate the operations of debugging the production apparatus; and to create a political and professional avant-garde, highly motivated, integrated in the company culture, carrying a deep knowledge of the factory and its inner workings, and able to lead the remaining work force along the principles of the new production policy. As a result, the building site experience promoted within the work force the development of a sense of belonging to a community of "pioneers and constructors".

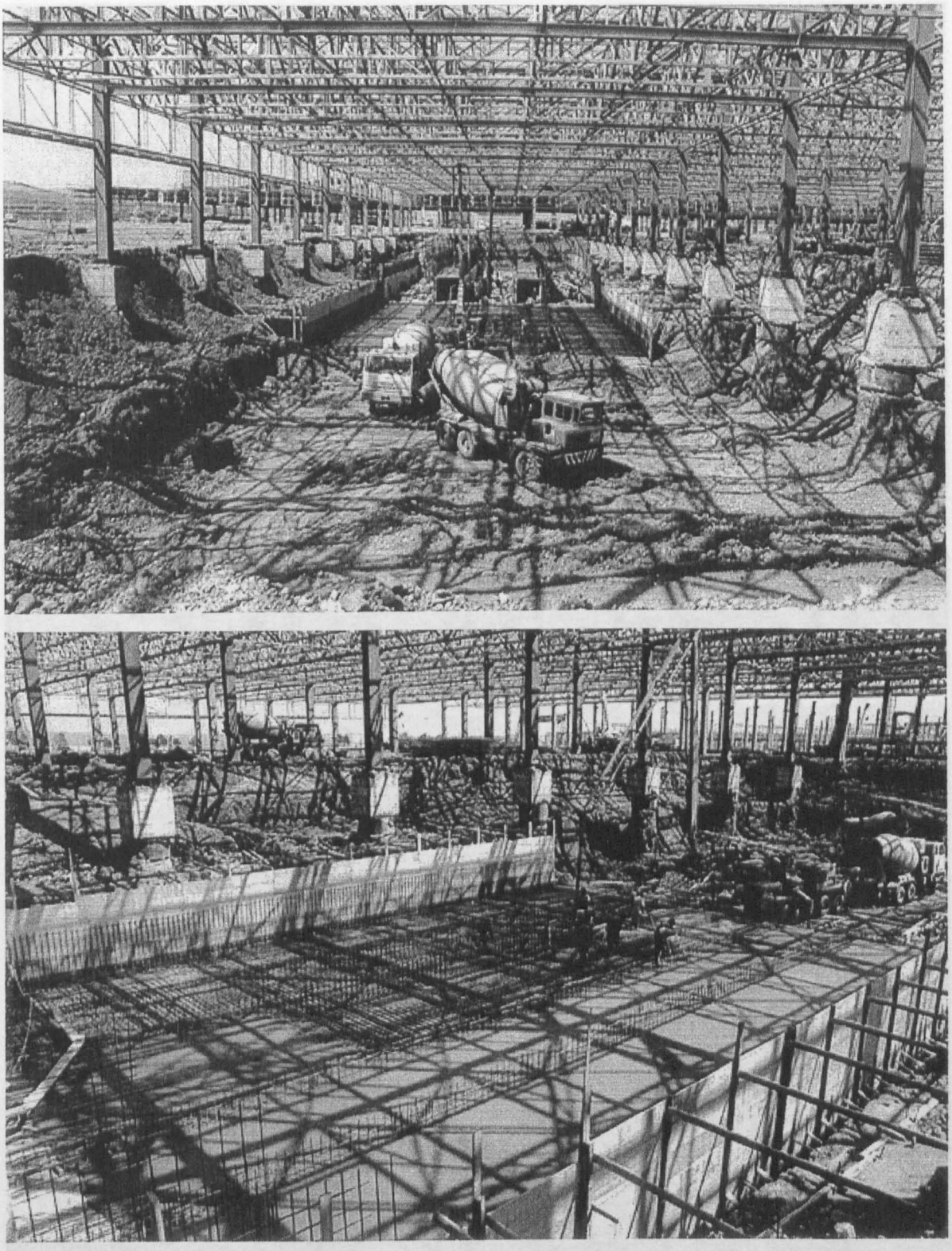

Figure 5. Construction work: the paint shop (April, 1992)

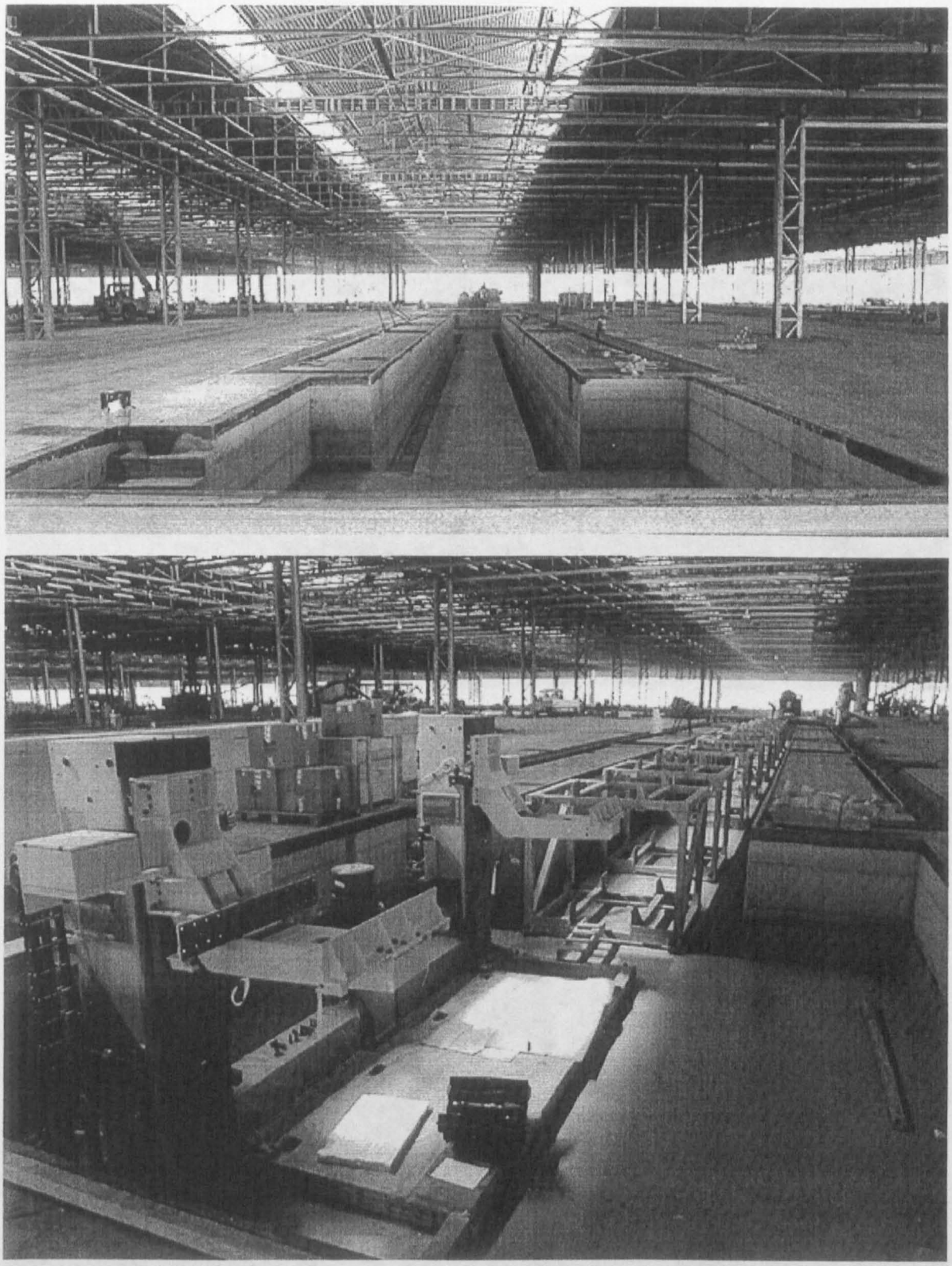

Figure 6. Construction work: the body welding unit (September 1992)

Figure 7. Body welding unit: the production lines (November, 1992)

Figure 8. Body welding unit: overview (August, 1993)

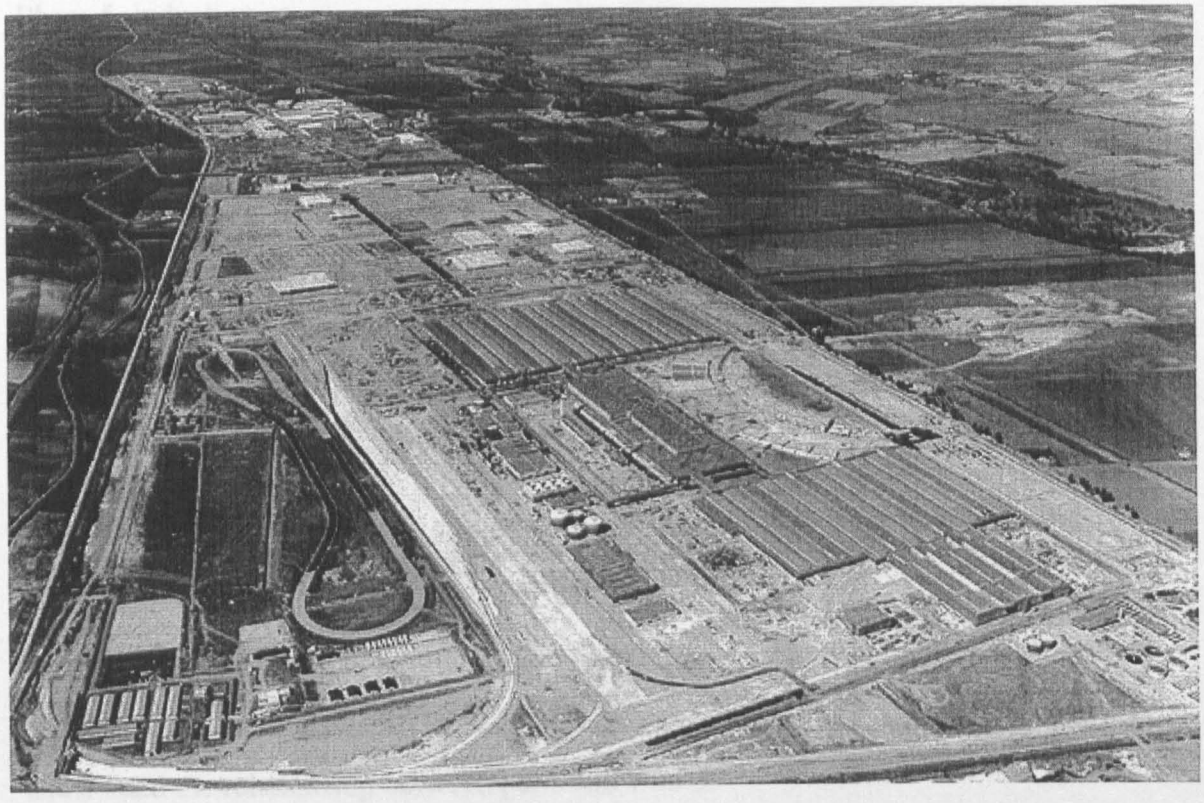

Figure 9. The Melfi plant (September, 1993)

Phase 5: induction

Once the Unit had been "assembled", it was time to make acquaintance with the product and the production process. But how was that to be accomplished? Two managers (see below) came up with a "smart" idea, which would eventually prove to be much more than a simple training exercise. As we shall see, the learning dynamics surrounding the appropriation of the product (ownership) and the cognitive analogies derived from that process still exert a subtle influence on the way operators think on the shop floor:

> A smart idea during our basic training was to disassemble, re-assemble and disassemble again and again a few cars. Can you imagine ? These cars are still laying around somewhere in the new plant. (Head of UTE, Assembly Unit)

Just like a child in front of a new toy, the above exercise emphasises the act of disassembling, conceived as a way of deconstructing the product in order to understand the relationship between parts and whole:

> In order to familiarise themselves with the list of components, the young engineers were asked to develop it *physically*. Basically, they took all the parts of a specific model as listed on the bill of materials, and spread them over a surface of about 800 square metres. Subsequently, they developed all the Punto's product range by separating the common parts from the specific ones (Former Plant Director).

The simulations based on the disassembling exercise were jointly devised by the Plant Director and the Personnel Director as a practical mode of training shop floor operators about the details of the product and the intricacies of the production process. It was in the intention of the designers that the exercise should make operators familiar with at least four aspects of the product: the individual car parts; the interface between one part and the other; the more critical parts; the sequence of operations and the precessions driving the assemblage of a car. At the organisational level, the exercise was integrated within a set of continuous improvement activities (a suggestion system) directed towards the design of the production cycle. The recollection of how operators were made familiar with the product provided by the Head of Production Engineering in the Assembly Unit seems to make this point clear:

> Later on, the UTE leaders arrived, then the technologists and the line workers, all of them after a training period in Turin. Those people were introduced to the product by working on a stock of cars provided by the Mirafiori plant. On those cars we did some training, by disassembling and re-assembling them again and again. We were asked to come up with a "disassembling" cycle for the car. Although those people had already gone through

> operational simulations in other plants, they now had the opportunity to have some "hands on" experience (Production Engineering manager, Assembly Unit).[21]

In a subsequent phase, the "ownership" of the product became a vehicle for transferring a stock of practical knowledge from a core group of knowledgeable workers (namely UTE leaders and technologists) to the newcomers:

> Having learned how to disassemble and re-assemble those cars, the UTE leader and the technologist had become "owners" of the product. They were now in the position to transfer their competence to the line workers. Starting from this training exercise, we moved to the actual production of the car within this plant. Those cars were used to show our people how a car is assembled and produced. Since then we have only built cars that could be sold (Production Engineering manager, Assembly Unit).

Interestingly, the training provided through this type of simulation was centred around the task (building the car bit by bit) with shop floor operators moving from one work station to the next while the production lines stood still. The ensuing introduction of the moving line provided an additional learning setting:

> Then when the first group of line workers arrived, in September (1993), we started working along the production lines. The lines would be much less loaded than now. There was all the time to talk, stop the line, and reflect about how to do things properly. Now when newcomers ask something, we know what to tell them, because we did it before. As you can see I am much slower than they are (Head of UTE, Assembly Unit).

Overall, the induction phase has to be seen as the practical side of the formal training provided by ISVOR leading to the acquisition of a work method as a major learning outcome. During this phase, rules of method were built "empirically" by drawing on concrete occurrences and continuous improvement activities. Typically, rules of thumb had to be formalised in order to incorporate them within a "shared" work method:

> I was terrified that rules of thumb would generate the worst drifts in the production process. For this reason we would encourage the engineers to take the initiative to make improvements, but then we would also ask for a weekly check list of what had been done. The plant director and I would assess the check lists and formalise new rules. Little by little this organisation was constructing its own rules rather than accepting faxes from Mirafiori in

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[21] The disassembling exercise bears interesting resemblance with the method of building the car in the pre-production phase. As Whipp and Clark have pointed out in their study on Rover, method-build and pre-production take place off-the-line, away from the current assembly, using skilled, experienced workers: "The assemblers who rehearsed the tasks involved reported on their feasibility within the time allocated and suggested modifications to task, tools and, if necessary, body dimensions." (p. 161). The interesting variation, within the disassembling exercise, is that that the task is defined "in reverse" so to speak. A second striking characteristic concerns the presence of a "green", non-experienced work force.

order to see how things were done over there (Former Personnel Director).

The above quotation provides a typical example of how knowledge creation processes leading to the production of empirical know-how or rules of thumb were eventually capitalised and crystallised into explicit rules. A crucial feature of the Melfi's generalised work method, at least in that early stage, was the capacity to systematically formalise emerging stocks of tacit, empirical knowledge by letting it come to the surface. Finally, in order to bridge the gaps related to lack of experience of the green work force, a group of senior people was mustered to help out with the training. The role of this group principally regarded the transfer of practical know-how as well as a set of problem solving skills based on common sense:

> During the training phase, engineers and UTE leaders were told to stop the production line whenever a problem occurred. Suppose that for some reason, the supplier did not send the tank lid and, as a result, one operator stopped the production line for lack of materials, bringing the whole assembly unit to a halt. The expert would tell the operator: all that you have been taught on quality issues is right; however if you can assemble the tank lid once the car has rolled off the line, there is no need to stop the production process only because the lid is missing (Former Personnel Director).

The above example is particularly interesting in that it clarifies the role of common sense as a decision-making skill. In the example, common sense tells the operators about the importance of distinguishing between parts and whole, sequential and parallel operations along the assembly line. During the formal training, the knowledgeable engineer had been taught that "one should not cry on quality". The expert had told him that a part like the tank lid is not interconnected with the production process and therefore it could be assembled outside the formal sequence of assembling operations. Furthermore, the lid does not hinder the functionality of the car, and therefore it is even possible to perform the routine functionality tests on the car without it being present. In other words, experience tells the young engineer that some rules can be broken, without questioning their overall validity.

The induction phase of the factory came to an end one year later, with the formal opening of the plant in October 1994. This moment represented the closure of the black box as well as the termination point of our analysis. The factory then gradually moved towards its full production capacity.

4.6 Learning as appropriation: building identity through ownership processes

The chronological advancement of the Melfi project and the knowledge sources associated with it highlight knowledge-specific outcomes related to each phase, which have been described in the previous sections. The results are summarised in Table 6.

	PHASES	KNOWLEDGE SOURCES	KNOWLEDGE OUTCOMES
1	DESIGN CONCEPT	BENCHMARKING, COMPANY VALUES	INTEGRATED FACTORY MODEL
2	RECRUITMENT	SCHOOL EDUCATION, LOCAL VALUES	DEGREE-SPECIFC KNOWLEDGE
3	FORMAL TRAINING	CLASSROOM, ROTATION IN OTHER PLANTS	OWNERSHIP OF THE ROLE (e.g. professional profile)
4	CONSTRUCTION WORK	BUILDING SITE	OWNERSHIP OF THE FACTORY (e.g. activities, territory, equipment)
5	INDUCTION	SIMULATION EXERCISES ON THE SHOP FLOOR	OWNERSHIP OF THE TASK/PRODUCT (e.g. work method)
6	FULL PRODUCTION	FACTORY OPERATIONS	ROUTINES

Table 6. Phases, sources and outcomes of the knowledge creation process

At the outset of the knowledge creation process lies the encounter between the factory's design concept - laid out in detail by the top management of the company - and a group of young and highly educated novices, carrying a stock of core values typical of the area where the green field is located. The recruitment process is instrumental towards the fulfilment of one of the two main assumptions stated in the design concept: to break with the cultural tradition of the past. The second objective specified by the top management, the acquisition of a holistic vision of the work process, relates explicitly to organisational learning, and is to be achieved through an intensive training programme (phase 3, 4, 5). Although the outcomes of the training process are manifold, encompassing both theoretical and practical aspects of work, it is nonetheless possible to identify a pervasive learning strategy underlying the long path preceding the formal opening of the factory. Learning seems to occur as a form of situated appropriation or progressive ownership of different aspects of work: the

role, the task, the product and production process, and most importantly the work place itself. The ownership strategy characterises the overall organisational learning process in at least two ways. Firstly, it emphasises the proactive role of the learners: becoming owners does not imply a sheer knowledge transfer. Rather, it involves filling a gap on the part of the learners, becoming users and accordingly re-inventing the task at hand. In a sense, even the benchmarking activities performed by the company and leading to the design concept of the new factory can be seen as a process of appropriation and re-invention of concepts invented elsewhere, namely in Japan and filtered by US car manufacturers.

Secondly, the concept of ownership is closely related to identity building. When looking at the greater picture, the learning processes described in the previous section depict an impressive socialisation endeavour aimed at the construction of a distinctive identity of the work force as "pioneers and constructors". Entering the work environment implies taking up a role within a community of practice. Accordingly, the training phases described in the previous sections portray the progressive development of individual (role), collective (community) and corporate (product) identities. The evolution of the training process also highlights a move from a narrow focus (the role) to a holistic vision of the production process, bringing crucial implications for sensemaking activities. This is particularly visible in the construction work, where the appropriation of the factory requires the characters involved to relate the task at hand to the broader network of equipment, practices, and institutions. Likewise, the induction phase is concerned with a more focused type of appropriation delimited by the task of building cars bit by bit (this will be discussed at length in the next chapter).

Finally, it is precisely the constitution of a distinctive identity that explains how the work force came to accept the apparently "onerous" deal proposed by the company. In fact, a striking characteristic in the evolution of the Melfi project is the considerably low level of conflict and controversy around the knowledge creation process. For example, how did the company manage to convince the "green" work force to spend a long amount of time on training, away from their home places, and even get involved in the building works of the factory?

A major source of identification of the work force with the objectives of the company

and acceptance of the conditions imposed by the implementation process is certainly the conceptualisation of the factory as a public good, whose construction requires a collective effort. The symbolic value of the involvement of the work force in the construction work is very strong, stressing the sense of belonging and ownership of the workplace. First of all, the young work force is asked to work for a "greater" good, that is to create its own job opportunity in a traditionally depressed area. Secondly, building the workplace is different from just walking into a ready made one. It emphasises the notion of familiarity as opposed to alienation. Within this conceptualisation, the potential sources of conflict are subtly absorbed through a variety of social mechanisms aimed to build consensus around the project, maintain the commitment of the work force, avoid opportunistic behaviours and free-riding: the deal with the Unions, the contextualisation strategy, and the socialisation of the work force as part of the training programme, exemplify some of these mechanisms.

4.7 Specification-delegation chains: planned and emergent factors in the knowledge creation process

Having described the main phases surrounding the coming into existence of the Melfi plant and identified some key learning processes occurring in each phase, this section sets out to review the overall design and implementation process in order to identify some pervasive patterns of knowledge creation underlying it.

The first thing to be noticed is that the process of knowledge creation and transfer is bi-directional. In the recollection of one of the managers involved in the project, the striking characteristic of the decision-making and implementation processes was the degree of discretion left to the decision makers at the lower levels:

> I would say that the ratio between planned and emergent factors in the design of Melfi was 50-50. Based on benchmarking activities and a feasibility study, the headquarters had defined the rationale for a project aimed at building one of the most competitive automotive factories in the world. We were assigned specific key targets and excellence standards (organisational model, production, ergonomy, working time, etc.). However, we were autonomous as far as how those targets were to be accomplished. The same applied to the start up teams that were in charge of the set-up of the production system and the training of the generic workers (about 5000) that were eventually hired (Former Personnel Director).

This finding is consistent with adult learning theories presented earlier for at least two related reasons. On the one hand, the role of the workers' background (including lack

of work experience) is a critical feature selected by the company to implement the training process. On the other hand, the learning dynamics observed on the green field and during the induction phase, seem to possess an element of autonomy and self-directedness stressing a learning by doing pattern.

The implementation process of the Melfi project seems to unfold according to a specification-delegation pattern. On the one hand, the top-down process is encapsulated in the design concept of the factory. Based on benchmarking activities (a knowledge creation process in itself) the company defines the strategic mission of the project (to build one of the most competitive factories in the world), outlines the main specifications of the design concept (location of the plant, nature of the work force) and provides a cutting edge tool kit for the new factory (organisational model, technology, production system). Also the selection process and the initial training of the work force, based on pre-existing training modules, is very much under the control of the company headquarters. However, since the early stages, the implementation of the project is characterised by a considerable degree of delegation and consequently by a significant process of knowledge creation from the bottom. As Donzelli put it, "Melfi has a degree of autonomy, a philosophical independence from the Headquarters, that perhaps escapes even its designers' intentions" (1994: 19). The people chosen to make the project happen are young and highly educated. They can be seen as carriers of "fresh" knowledge and new values. The more the project moves forward, the more the influence of the company values gets diluted. This fact becomes particularly conspicuous once the operations are transferred to the green field site. Here, the Melfi work force— knowledge builders and construction workers at the same time— is actively involved in "making the project happen". The "community of practice" operating on the green field is constantly engaged in a sensemaking activity whereby the cognitive and material resources at hand are assembled in original ways. In other words, the construction site provides the locus for the encounter of formal knowledge and practical one. The factory itself represents the visible and measurable outcome of this collective effort, the hard product born of a process of social construction. In addition, the advancement of the project is not always smooth: the construction site sets out continuous challenges forcing the different teams at work to adapt existing solutions or to devise new ones. The context shaping the development of the Melfi project is constantly shifting (or in becoming)

as the multiplicity of implementation phases, training venues, learning settings, and knowledge sources demonstrate. The dynamic character of the knowledge creation process over the green field has been stressed by one of the managers who took part in the Melfi steering committee:

> The evolution of the training process in Melfi has been incessant. While the factory was growing, the training programmes and methods were constantly reviewed in accordance with the evolution of the context, the suggestions gathered from the trainees, and the emerging training needs (Former Personnel Director).

Furthermore, the scope of the project requires the management of the factory to co-ordinate with the broader network of organisational actors operating in the immediate environment: for example, synchronising the advancement of the construction work with the suppliers who are constructing their own plants; lobbying political actors at the local and national level in order to get concessions and build infrastructures; and dealing with utility companies to get the necessary connections.

In sum, the construction site possesses the characteristics of a "formative context" (Ciborra and Lanzara, 1994) providing a mixture of opportunity structures and structural constraints. At the same time, the advancement of the construction site describes a highly situated process of knowledge creation and accumulation, while emphasising the provisional character of that knowledge (knowledge in the making). The learning process over the green field builds on a collection of multi-faceted sources which are originally combined in the implementation process in order to serve the performance of the new born factory. Training of the work force and investment in HRM are critical factors. Teamwork, socialisation programmes, respect and protection of the local cultural values, and definition of the project as a collective effort are the multifaceted aspects of a human-centred design concept. However, the expansion of the core stock of knowledge governing the functioning of the new factory is based on a pervasive strategy of delegation: knowledge transfer occurs top-down in the form of guidelines and specifications; bottom-up in the form of finished products that can be capitalised as consolidated knowledge assets.

Method plays a major role in keeping creativity on course. On the one hand, it makes up for the lack of experience of the novice work force by providing a common framework:

> The Melfi experience has stressed two things. Firstly, we have proved that it is possible to build a competitive car manufacturing plant in any corner of the world, provided the project is supported by a strong training programme. Secondly, we have made up for the lack of experience by relying on method (Former Plant Director).

At the same time, method provides a strategy for the capitalisation of knowledge, that is its transformation into a corporate asset: knowledge creation must be institutionalised in the method in order for successful experiences to be repeatable. Consider the disassembling exercise. The exercise is aimed at transferring knowledge (top-down) about the product and the production process. At the same time, operators are asked to devise a disassembling cycle and suggest the best way for re-assembling the car. In other words, knowledge appropriation is closely linked to practice and institutionalised in the method. As we shall see in the next chapter the disassembling/assembling exercise also bears important cognitive implications which emerge in the resolution of breakdowns along the assembly line.

4.8 Concluding remarks

The main findings of the above case study highlight the provisional nature of the knowledge creation process, here epitomised by the building site concept. The construction of the plant from the green field represents a unique experience for the original core group of workers. It stands at the heart of a highly situated learning process which carries crucial cultural, organisational, and epistemological implications. Bringing the plant to its full production took two and a half years, which still counts as a significant proportion of time for a young factory like Melfi. Moreover, it consisted in an intense and emotional experience, one which was to remain imprinted in the memory of the participants. Just imagine a group of young people, coming from a rural community to their first work experience, who are actively involved in a major re-engineering process on behalf of the most important Italian company. As we have seen above, the interviewees proudly refer to the green field as a unique experience, emphasising the emotional implications of "being there".

Certainly, this knowledge creation process seems to be characterised by low levels of conflict, thanks to the participatory strategy of implementation promoted by the company. On other hand, the advancement of the Melfi project is controversial in that

it is constantly subject to shifting trajectories and contrasting forces (top-down and bottom-up), albeit within a planned and very structured design concept. In this respect, the "construction site" becomes the emblem of knowledge-in-the-making. It provides a competence/identity building space, characterised by the encounter between the avant-garde design concept of the factory, the company culture and the values incarnated by the green work force. The building site is a learning laboratory, a training yard, where experiments and simulation exercises can be tried out without any pressure stemming from production plans. It also conveys the idea of gradualness of the learning process: like in construction work, competence building takes place step by step, gradually moving the work force towards higher levels of understanding. Yet, this learning process is highly situated and never detached from practice. For the above reasons, we argue that the initial stock of knowledge embedded in the design of the Melfi factory probably represents the most crucial knowledge asset for the company. It can be seen as a distinctive feature of the way the factory operated and therefore regarded as a source of competitive advantage. We have also contended that it is precisely here, in the experience of building the factory from scratch, that a great deal of tacit knowledge lies, and it is here that we need to look in order to explain specific organisational dynamics.

In sum, what emerges from the Melfi building site is a process of social construction of corporate knowledge, rather than a sheer top-down transfer of knowledge. Initially the factory only consists of a few pillars and the roof. But then it gradually takes shape with the fundamental contribution of the work force, which becomes involved in a real piece of craft work. The development of operators' competence goes hand in hand with the physical construction work, highlighting the processual and sedimentary nature of organisational knowledge. Given the peculiar character of the competence building in Melfi, the strategy adopted in the present case reminds one of the work of an "archaeologist of knowledge", engaged in a process of discovery and delayering the multiple strata in which knowledge has been sedimented and institutionalised over time. Our analysis has identified six phases/sources of knowledge creation and institutionalisation of core competencies. By the time construction work is completed and the factory runs at full production, knowledge too seems to become fully institutionalised. The factory and the core stock of knowledge underlying its functioning have finally been sealed, transformed into

black boxes, and manifold secrets have been concealed in a protected nucleus. From now on, it will be more difficult to access tacit knowledge, except on those occasions when knowledge is displaced and somewhat disclosed. In the next two cases, therefore, we will focus more explicitly on breakdowns as a way of exposing the tacit features of organisations.

CHAPTER 5: BREAKDOWNS AND BOTTLENECKS: CAPTURING THE LEARNING DYNAMICS ON THE ASSEMBLY LINE

5.1 Introduction

In chapter 4, we contended that the appropriation of the work place by the novice work force, through progressive ownership processes, was the main outcome of a highly situated learning process occurring over the Melfi's green field. Four years after it was officially opened, the Melfi plant offers a quite different picture. To start with, the complexity of shop floor operations has increased considerably: the factory is now running at full production speed, whereas during the induction phase the lines would only go at half capacity load. Today, given the impressive rhythm of the production lines, and the exceptional levels of productivity, the Melfi plant is often referred to as a "road-roller". Secondly, the "learning laboratory" is facing new challenges stemming from the fact that business operations are now carried out in a competitive environment. Managers and operators in Melfi are confronted with a number of issues related to dealing with changes while keeping the pace of production targets and maintaining the organisational identity, which is increasingly taking shape. A third element of novelty is that the original management group of the factory has been completely replaced. Most of the young managers (today in their early forties) who were in charge of the start up of the factory have followed a brilliant career path at the corporate level, with some of them holding key positions within the company. Paradoxically, while Melfi is attempting to build its past, the competitive challenges and the related dynamics of change seem to keep the organisational context of the factory still "in flux".

More generally, by the time the induction phase is terminated, the factory enters a new phase - one in which knowledge has been deeply transformed and institutionalised. At the shop floor level, the move to full production involves shifting from a non-routine situation to one where work has become routinised. Knowledge has been embodied in standard operating procedures, organisational artefacts and

technology. The factory as a whole has been transformed into a clockwork mechanism, epitomised by the presence of the assembly line and characterised by mechanisms of repetition. Finally, at the cognitive level, the move towards a situation of "business as usual" points to a kind of transparent intentionality, which bears crucial knowledge implications (see chapter 2). In fact, the more one get closer to the clockwork, the less knowledge underlying factory operations becomes accessible.

Taking into account the above considerations, this chapter strives for a twofold purpose. It aims to assess the process of institutionalisation of knowledge (degree of tacitness) within the Melfi factory once the plant had reached its full production capacity. More specifically, the case study presented below attempts to test how the competencies acquired by workers and managers over the green field are applied in the practical context of the production process. Accordingly, the study addresses the following question: how does the knowledge acquisition process over the green field site affect the later behaviour of the work force? At the same time, the case study describes the dynamics of organisational learning and knowledge acquisition in the setting of routinised work. In this regard, the case asks: what is the nature and the process of knowledge acquisition in the new phase? How is knowledge capitalised and crystallised into stable organisational structures?

In order to "scratch" the stock of tacit knowledge that had sedimented within the factory over time, the case relied on the use of breakdowns as a methodological lens to gain empirical access to the dynamics of learning and knowledge acquisition. Detailed observations were carried out on how operators and managers on the shop floor were performing when faced with a variety of minor and major breakdowns, by enacting different sorts of problem-solving, computer-mediated communication and learning strategies. The analysis revealed a widespread isomorphism between the physical infrastructures through which factory operations are performed (e.g. layout and assembly line), and the cognitive frames governing the execution of those operations. More specifically, we found that the standard problem-solving routine applied on the shop floor was based on a generalised capability to (manually and mentally) disassemble/re-assemble (D/A) the car. As a consequence, the D/A analogy seemed to connect the way operators think at work with the piecemeal nature of the task (building the car bit by bit) and the assembly line concept. At first glance, this

may appear an obvious finding: it could be argued that a factory like Melfi ultimately incarnates the old principles of mass production here revived in the traditional image of the assembly line concept. However, a careful consideration of the Melfi work force and the core capabilities underlying the factory operations highlights profound discontinuities with respect to the old production paradigm. A first point of divergence concerns the nature of the Melfi work force and the intense training process that it underwent during the green field phase of the factory. Unlike the traditional unskilled Fordist workers, the Melfi work force consists of knowledgeable workers, highly educated and highly trained. Secondly, the capacity to disassemble/re-assemble the car as a problem-solving strategy seemed to be grounded on a holistic picture of the product and the production process. In particular, evidence suggests that the cognitive analogy detected in Melfi was directed at capturing the fundamental relationship between parts and wholes by conveying a virtual image of the production process. As a result, the systemic features of the assembly line concept (the chain of transformations along the production process) are emphasised rather than the narrow focus on the single operation, characterising the traditional Fordist "formative context". Finally, in accordance with the company's commitment to quality, the task of building the car bit by bit—at the core of the assembly line concept— is redefined as a piece of craft work, carried out by semi-autonomous teams, and sustained by a general capability for tinkering.

This chapter contains 8 sections. Section 2 outlines the production process within the body welding unit, where observations were carried out, and describes in some detail the sophisticated information system that controls production operations along the assembly line. Sections 3 and 4 depict a number of scenes observed on the shop floor in relation to the solution of breakdowns and bottlenecks, stressing the knowledge implications underlying the way operators deal with disruptions. Drawing on the above episodes, section 5 and 6 highlight the main learning processes dedicated to the control of local and systemic breakdowns. Section 7 identifies the main outcomes related to the above process. The learning dynamics observed on the shop floor highlight the distinctive features of Melfi's production system as opposed to the traditional Fordist model. Crucially, this distinction is grounded on knowledge-based rather than technology-based factors. More general conclusions on cognition and the

organisation of work in advanced manufacturing follow.

5.2 The body welding unit

The body welding unit within the Melfi plant is a small technological jewel, worth more than 1,000 billion lire (about $ 600 million), and featuring the most advanced technology available today in car manufacturing. With 100% of automation and 233 robots it is the epitome of the concept of the high-tech factory. The body welding unit consists of seven UTEs (1 to 7) integrated according to the internal customer logic and linking the stamping shop with the paint shop. Car bodies flow along 19 automated lines stopping at the different work places, where robots perform most of the operations. The workers' role, in most of UTEs, is to monitor the process through information systems and visual control tools. The skills required by operators are mostly technical and concern the governance of machines. The UTEs are small and there are few blue-collar workers.

The work flow is characterised by the presence of two kinds of lines: production lines on the shop floor are utilised to assemble the car body; overhead conveyors consist of a sequence of aerial hangers on which car components are accumulated and transferred from one process to the following one. Aerial lines have a dual purpose: besides moving car parts between processes, they serve as dynamic inventories where parts are temporarily stored before reaching the next process. A system of elevators, situated at the extremities of each production line, makes it possible to load and unload the car components and to transfer them between production and transportation lines. The final assembly of the car body is the result of three synchronised flows (underbodies, sides and roofs) joining in a specific work place of UTE 5, where a "robogate" performs the "marriage" between the three components. The "marriage" of the car body is the most spectacular operation inside the unit, requiring a high level of synchronisation between different production processes. In order to be successfully assembled the components must have the same sequence number, i.e. they must belong to the same customer's order.

When entering the body welding unit, the first question that a visitor may ask himself/herself is "where are the workers?" In fact, a visitor is shocked by the fact

that there are no workers around, the UTE offices are usually empty and one just sees the car bodies flowing along the lines and being assembled by robots. Occasionally, some workers appear moving by bicycle along the flow; another small group goes back to the UTE office and does some work on PCs, or controls monitors, or fills charts, or makes a call. Other small groups talk along the lines, then go back to work. The body welding unit is the realm of machines and geometry, of measurement and exactitude. Technology plays a dominant role. As the head of the OU put it: "technology provides visibility". The seven UTEs in the unit have been designed according to a clear-cut definition of the boundaries between semi-finished products which compose the car body. In this regard, boundaries promote an unequivocal demarcation of responsibilities in case of anomalies or breakdowns. The idea of a product which consists of assembled parts and a process which unfolds according to a sequence of operations allows shop floor operators to trace back systematically the source of any anomalies related to the product/process and attribute the responsibility to a specific work station within the UTE.

The capacity to govern the technological system and keep the production process on course is crucial. Unlike the assembly unit, where the bulk of car parts are assembled, here the knowledge of the process (the sequence of operations) is more important than the knowledge of the product (the different car sub-components). In fact, only 200 parts out of about 10,000 are assembled in the body welding unit. Machines provide automatic measurements and reports about the state of production and the quality of the product. Echoing Zuboff (1988), it is possible to say that they automate the production process as well as "informate" it. The task of operators involves making sense the data provided by machines and using them in a purposeful way. Accordingly, knowledge of the machinery, method, and inferential capabilities is very important. Also, taking care of machines, by performing constant maintenance operations accounts for a substantial part of the routine within the body welding unit. The production process is backed up by sophisticated information systems, which are supposed to "textualise" work and render it transparent (Zuboff, 1988). The information system architecture in Melfi is articulated according to three levels, mirroring the production process described above. Level 1 refers to machine software or task automation. Each machine on each workstation is operated and controlled by a specific piece of software which recognises the local operation to be

performed in that work station. Level 1.5 controls the system of elevators, located at the beginning and at the end of each line, which lift up the semi-finished products from one process and unload them to the next one. Level 2 is responsible for workflow management, highlighting the interdependence between different UTEs. Basically, this level controls the flow of the overhead conveyors which transport car parts in the form of semi-finished products from one process to the following one. Level 2 refers to the systemic level of automation, governing the synchronisation of the different processes and the consistency of the different parts composing the car body. A typical example of level two in action is the "marriage" between underbodies, sides and roofs which implies ensuring that all the components assembled belong to the same customer's order. Level 3 controls the mix of orders from the customer and sets the production sequence. The system is connected to the network of Fiat dealers and to the Headquarters in Mirafiori. A fourth level should be added to the three above and should be seen as a sort of metalevel which makes the Melfi plant visible to the Fiat headquarters.

The three levels described above reflect the hierarchical division of labour within the plant, i.e. "where is control located?" Level 1 is visible at the UTE level: UTE members are entitled to perform modifications on the machines' software whenever that would improve the production process. For instance, UTE members could decide to modify the production cycle by eliminating a superfluous operation. Level two is still visible at the shop floor level, but any modification of the software is entrusted to specialised offices (e.g. production analysis); level three is operated at the plant level (top management). In organisational terms the three levels can be named as local, systemic and strategic reflecting both the division of labour and the articulation of knowledge within the plant. In other words, the system's architecture mirrors both the organisational structure and the knowledge architecture of the plant.

5.3 Men and machines

The concept of automation is conventionally defined as the substitution of human labour with machines. Although this definition is certainly correct, it seems to overlook some important aspects of human-machine interaction. For the purpose of our analysis, and in order to reach a better understanding of the knowledge

implications of technology, we will conceptualise automation as the delegation of certain functions normally performed by humans to non-humans actors. From this perspective, automation appears as a modification in the pragmatic relationship between humans and equipment. Delegation to non-human actants (Latour, 1993) pinpoints the notions of knowledge transfer and knowledge embodiment. As for humans, automated tasks are grounded on a stock of knowledge that has been delegated to machines and that is embedded in the software in the form of a set of operating instructions. According to this perspective, machines are not mere objects; rather they are enabled to perform actions. When a breakdown occurs not only is the functionality of the machine questioned, but also the original delegation mechanism gets disrupted. Humans need to re-appropriate the machines in order to be able to restore a situation of normality. In other words, recovering from disruptions implies a re-appropriation of the task out of technology. When applied to the Melfi factory, the above definition brings about important considerations concerning the nature of existing knowledge.

As mentioned earlier, the body welding unit is the realm of automation and machines, while the role of humans is closely related to the governance of the automated work flow. Shop floor operators are separated from machines along the lines by means of transparent gates which are supposed to render the production process visible at any moment and allow the human eye to follow the car bodies along the lines. In addition, the work flow is monitored through the data produced by the sophisticated information systems attached to machines. The ability to make inferences from numbers appearing on print-outs in order to monitor the "drifts" of the production system is part of the routine work in the body welding unit.

As we saw in the previous chapter, the training of the work force during the induction phase played a crucial role. Core competencies were transferred through the active involvement of the new work force in the physical construction of the unit, the set up of machinery (under the supervision of the technology supplier, KOMAU), and a set of "hands on" exercises on real cars. Besides the disassembling exercise, the latter included dissecting the first set of cars produced on the assembly line by performing a sort of appendectomy on each of them. The principal aim of the "dissecting" exercise was to transfer diagnostic skills to technologists, UTE leaders and other

technical figures within the unit. The pervasive influence of the induction phase of the factory and the importance of diagnostic skills becomes apparent in the way operators deal with defective components. Within UTE 5 there is a small display area where defective car bodies are exposed in order to perform in-depth analyses of anomalies generated by the body welding unit in the production process:

> This is the display area where we look over the waste generated in the production process. Typically this is a gathering point where UTE members or external suppliers convene to take note of waste generated by them. There you see two of our suppliers who are examining some waste for which they are responsible (UTE technologist).

The area resembles a "mortuary", where "dead" car bodies are waiting to be dissected before being definitively discarded. Not surprisingly, the role of the technologist within the Fiat world is defined as that of a "physician" who is in charge of detecting anomalies, working out the causes, and coming up with solutions:

> We have had to discard this one (car body)... Now it is going to be dissected and opened; basically we perform a few cuts in order to understand what happened (UTE technologist).

The car body mentioned by the technologist has been sent back by UTE 6, which had discovered the anomaly while operators were performing a particular welding operation. The body presents a fault on the left side, which is one millimetre lower than the other one. Although the entity of the default could make it acceptable, the car body has been discarded in order to perform a diagnosis of the problem. The problem looks quite peculiar because it did not repeat over time. This fact makes the diagnosis particularly difficult and leads to a dispute over the attribution of the anomaly to a particular UTE. At a first glance the source of the anomaly may derive from UTE 1 (sides), but this hypothesis has already been discarded. Also the UTE 5 has been exempted from any responsibility. The candidate "culprits" appear to be the UTE 2 and UTE 3 :

> The only thing that can give us a response is to dissect the body, i.e. take out the side and analyse it; if that is not sufficient we will have to disassemble the car bit by bit (UTE technologist).

The dissection of car bodies possibly represents a variation of the "disassembling" exercise (see previous chapter) and accordingly carries important knowledge implications. Dissecting bodies is a way of dissecting knowledge; it is a fundamental diagnostic practice underlying the way operators make sense of disruptive

occurrences within the body welding unit.

The case reported above portrays an unusual situation, where an anomaly eludes both the automatic measurements (because a small deviation from the standard is tolerated by the system or because the point of anomaly is not subject to measurement) and the human control. Interestingly, it is precisely automation which makes it difficult to "see" the problem; as a consequence the anomaly can be detected only when the car body re-emerges from the automated flow and reaches a point where manual operations are performed (UTE 6 in the above case). In general terms, problem-solving activities are triggered by the appearance of anomalies which can be detected either by human or non-human actors. When a breakdown occurs the interaction between man and machine is called into question, and humans are confronted with the complexity of machines:

> The first thing we do when an anomaly is detected is to stop the line and go to see. If the problem is serious, we open the gate, enter inside the line and perform the operation manually in order to make sense of the problem. The problem could be related to the wear and tear of machinery (e.g. a broken wedge, or a worn out component). Normally we try to repair the machine, if that is feasible; otherwise, we perform a "quick and dirty" intervention and postpone the repairing to the end of the shift. As a general rule, we try to avoid "quick and dirty" solutions because with three working shifts there is not much room left for maintenance or repairing interventions (UTE technologist).

The definition of the product as an assemblage of parts makes cause detection quite straightforward. Furthermore, the product is not too complex at this stage. Typically, operators in the body welding unit are confronted with dimensional anomalies, i.e. problems related to the geometry of the car body, which are detected by automated measuring devices (MAC). The MAC operates as an electronic finger, touching the car body in different areas and comparing the values detected on each measuring point with standard quality values predetermined by the company. Whenever there is a deviation from the standard, the MAC people inform the UTE responsible for the anomaly detected. The measurements are performed every hour or every 50 car bodies produced and take about 20 minutes. However, anomalies which elude measurements, as in the case reported above, are difficult to detect.

As shown by the episode described above, automation may render the production process quite opaque since the complexity of the task is hidden in the complexity of the machine. As a consequence, when things go smoothly the task is transparent

whereas when machines break down, humans are confronted with the complexity of the task. In order to perform a diagnosis of a problem, operators are often induced to stop the lines, open the gates, perform operations manually, and dissect car bodies. In other words, recovering from disruptions implies a re-appropriation of the task out of technology. Furthermore, by temporarily excluding the mediation of technology, disruptive events emphasise the role of the body since they restore a physical contact between workers and product. In dissecting car bodies or performing operations manually, operators act as craftsmen (physicians, surgeons, mechanics, and so on). On the basis of our pragmatic definition of technology, we argue that operators in Melfi show a considerable confidence in problem-solving precisely because they are the "owners" of the machines (no panic reactions, emotions under control). Mastering the machines means being able to establish a sort of "dialogue" with them. In other words, machines need to be humanised in order to be harnessed and mastered. Knowledge of the machines is developed through practical involvement with them and through the experience of successful problem-solving. Another important source of appropriation is the knowledge of the "non-visible" aspects of machines (history, design) In Melfi this appropriation occurred through the active involvement of the work force in the setting up of machinery. In this respect, the behaviours observed above seem to be consistent with the findings presented in the previous chapter, highlighting the effectiveness of learning based on ownership processes.

5.4 Breakdowns and Bottlenecks

In the best of all worlds, the line never stops. Unfortunately, the lean production concept is a source of unexpected events. At any moment the mechanical synchronisation of the operations can collapse for various, unpredictable reasons: process/product anomalies, machine breakdown, lack of materials, quality problems, lack of work force, and so on. As the line stops work-in-process piles up quickly, bottlenecks may occur, and UTEs can be kept on hold, unless workers intervene. In some cases the causes of bottlenecks can be very complex, since they are related to the constantly changing product mix, and not to a specific breakdown. That is, even if the factory as a whole might have enough capacity, there is a mismatch between

the line balance and the product mix being pushed through. Such bottlenecks highlight the key role of capacity planning.

Bottlenecks may also have a more "abstract" origin related to the opacity of human behaviour, to the tendency to focus on individual interests and to "manage one's own position" (Senge, 1990). For example, the customer-supplier concept implies that UTEs co-ordinate activities as transactions between semi-autonomous units. In this "co-ordination game", instances of "local sub-optimisation" and opportunistic behaviour may arise, that is activities are executed in order to optimise a given UTE's performance rather than the plant production. In its turn, local-sub optimisation may lead to the building up of inventories along the lines. Often, opportunistic behaviour may be fostered unwittingly by company values. For example, in Melfi *quality* is a pervasive concept throughout the production process, manifest in multiple organisational artefacts. Quality is both a *technical requirement* (absence of faults; reduction of waste and demerits) and a *cultural value* (responsibility; collaboration; commitment and motivation; identification with the customer, the product, and the company). In order to 'measure' it, quality has been defined in terms of 'demerits' (i.e., number of faults). The demerits system sets visible targets for continuous improvement and enhances the levels of care and attention to the product and the process. However, as each demerit is ascribed to a UTE (or better, a work station), supposed to be at the origin of that demerit, the negative measurement may be perceived as a punishment and be frustrating for particular individuals and UTEs. As a result, the demerits system may represent a barrier to the achievement of full transparency of behaviours, since it induces workers to enact defensive behaviours, face-saving, scapegoating and other tactics that ultimately interfere with effective problem-solving and learning (Argyris, 1993). Finally, bottlenecks can be traced back to the coupling between the sheer complexity of the production system and the actors' bounded rationality. The new assembly line and the system of exchanges between customers and suppliers can be compared to a network of concurrent events, which is impossible to fully control, as opposed to the traditional, sequential assembly line. Sometimes a corrective action performed in one point of the system can generate a problem in another (distant) station along the line. As the relationships between different processes are very complex and cannot be properly handled, bottlenecks can be generated without awareness as a result of a

lack of "systems thinking" (Senge, 1990). At the same time, bottlenecks also present opportunities for problem-solving and learning. Effective intervention requires an ability to discern their sources and causes, lest corrective routines be adopted that lead to further propagation of mistakes and disruptions, and to very little learning.

5.4.1 Systemic breakdowns: analysing bottlenecks

Bottlenecks are the most frequent manifestation of both local and systemic breakdowns. Car bodies which have undergone a certain processing are lifted up from one production line and moved to the next stage. Overhead conveyors serve as dynamic points of accumulation, where the car bodies in transit, waiting to reach the next process, are stored. Given the tight nature of the production flow, the aerial inventories can be seen as buffers. If a line stops as a result of a breakdown, the upstream processes keep going until the inventory closest to the problem is full. At this point a bottleneck may arise and the upstream lines must be stopped (thus creating work-in-process inventory). The downstream processes, in turn, stop receiving cars and, once their upstream inventory is emptied, they must be halted too. When the problem causing the bottleneck is solved, the line is able to receive the bodies and the flow can restart. If it is solved before the formation of bottlenecks along the line, it will remain at a local level. Otherwise, it will affect the whole system. The longer the duration of the halt, the higher the number of parts accumulated and the greater the imbalance caused to the flow. Keeping the "metal" moving is a matter of line balance and absence of breakdowns (see crystal pipeline). Furthermore, the customer-supplier model requires having a general knowledge of the upstream and downstream processes in order to make sense of the unfolding of the production flow and figure out the potential causes of a problem when breakdowns occur.

A new "radar system" has been installed for workflow management (level 2 of automation). It consists of electronic boards displaying data about the amount of parts produced, the daily production target, and the inventory build-up in the upstream and downstream flows (customers and suppliers' inventories). A number of coloured lights provide additional real time signals about the current status of the production process: a green light stands for "in production" and indicates absence of

problems; a red light signals machine breakdowns; a yellow light followed by the message "loading/unloading failure" indicates the presence of a bottleneck. More specifically, it refers to two possible scenarios: either the upstream inventory is empty and parts cannot be loaded on the line (loading failure), or the downstream inventory is full and parts cannot be unloaded on the line (unloading failure). Electronic notice boards provide shop floor operators with a rich, albeit stylised, description of the current status of the production flow. Furthermore, they are conceived as predictive tools: by reading the electronic boards UTE members are in a position to make inferences about the immediate future and the possible developments of the current production situation. Therefore, the radar system can arguably be seen as a decision-making support system based on IT.

The following episode depicts the UTE 5 in its interaction with customers (UTE 6) and suppliers (UTE 1, UTE 2, and UTE 3). More specifically, the scene portrays the UTE leader in the attempt to explain how to read the data displayed on the electronic board. By "reading" the board, the UTE leader detects a breakdown in the upstream process (sides) and makes conjectures about what might happen next:

> Let's start from the left side of the board. That number refers to the pairs of sides which are flowing towards our UTE from UTE 1, in this case there are three of them; the number below refers to the underbodies which are in the queue, 22 on the left production line; next we have the flow of roofs; and finally the flow of assembled bodies which indicates the number of car bodies, 30 at the moment, which are flowing in the downstream production lines (UTE 6). The current situation indicates that the UTE producing the sides is experiencing some problems. However the problem should not be serious, otherwise we would have been informed over the phone.

The current display also highlights a line imbalance, which means that UTEs are running at a different pace. It is precisely the lack of balance between production lines which eventually generates bottlenecks:

> In a few minutes we are going to see a loading failure, because of a lack of sides... In this situation we normally go to have a look at the problem upstream (sides) in order to assess the exact nature of the problem and, if the problem is serious, possibly exploit the line stoppage to perform short maintenance works. It's one of the few moments we can really exploit.

However, from the interviews and observation carried out on the shop floor, it seemed that team members seldom rely on electronic devices in order to act and take decisions. Rather, most of their job consists in walking along the lines, and listening to unusual noises. As the UTE leader put it:

> We prefer to walk along the lines in order to understand in real time what's going on. Data displayed on electronic boards is generally reliable, but walking along the lines gives you a better picture of the situation.

The above quotation is promptly supported by a concrete case:

> Now we should have a loading failure (meaning problems in the upstream UTE), but that is not displayed on the board. Shall we check whether that's true? Here you are. My machine is waiting for the sides... So there is an inconsistency with the system... Basically the upstream inventory (UTE 1) has been emptied and we are now emptying our production lines... Now the loading failure has appeared on the notice board. Typically the system would wait for a few minutes before updating the situation, whereas we had already detected the loading failure.

Despite the presence of sophisticated information systems, UTE members prefer to spend most of their time walking along the lines and watching the car bodies moving in an attempt to detect any possible disturbance. Even sounds or silence over the shop floor are taken as clues to the smoothness of the production flow or, conversely, point to production breakdowns. In other words operators on the shop floor seem to have developed a certain sensitivity towards the subtle functioning of the assembly line. This highlights the role of perception and the importance of craftsmanship as necessary complements to high-tech devices.

> Despite the fact that we have no inventory of sides, the pieces produced have gone from 45 to 50. It means that we are emptying the line. We still have about 30 bodies to send forward. Once our line has been emptied we will probably have around 80 bodies in our inventory. That will take about 15 minutes if things go smoothly. If the problem upstream is not solved within this lapse of time, the production level will start to decrease since we won't be receiving components from the upstream processes (in this case sides from UTE 1) (UTE leader).

The UTE leader casts a glance at the aerial lines:

> Look there are two more pairs of sides arriving, let's go to check what's going on at the UTE 1... You see, it's the left side which is in trouble, but now the line is producing... there are nine sides in transit... now look at our production level, we have reached 55 pieces, despite the lack of accumulation in the upstream inventory.

The problem at UTE 1 during that day persisted for a whole shift. The UTE was beset by an impressive number of micro-stoppages. This type of breakdown is very difficult to handle and does not leave any room for performing alternative operations (e.g. maintenance). Micro-stoppages normally last for less than three minutes but nonetheless they disrupt the smoothness of the flow and are difficult to diagnose:

> Micro stoppages refer to problems which are not real problems. They take up a lot of time. If you have a breakdown, you can understand what is causing it and therefore perform an

> intervention and solve the problem. With micro-stoppages you are always short of breath, it is not easy to recover from them...

Despite this problem, the UTE 5 was able to carry on without particular problems and meet the daily production target.

Once again, the above episode suggests some important implications about the nature of existing knowledge in the Melfi factory. Notice boards can be seen as sensemaking devices. As it is apparent from the description of the way operators use the system, electronic boards act as systemic maps, enabling operators to make sense of what is going on in the immediate surroundings of their UTE, and to take action on the basis of if-then inferences. In other words, the numbers and messages displayed on electronic boards bring about important cognitive implications for shop floor operators. The capacity to read the data displayed on electronic boards and make inferences out of it, indicates the presence of systemic maps at the cognitive level. However, as the above quotes suggest, these maps seem to have been acquired through experience rather than derived from the information systems architecture. Operators do not trust (or rely on) electronic devices. As a consequence one may wonder: are electronic "notice" boards there to be noticed? The radar system seems to be there to reinforce rather than to guide the way people think. In other words, notice boards seem to expose the systemic features of the production process and the assembly line rather than provide handy information. As an artefact, they convey the idea of transparency and systemic visibility of the production system.

5.5 Trouble-shooting at Melfi

The problem-solving routine most frequently observed in the plant operations is based on an incremental feedback model. Whatever the breakdown, the routine seems to consist of the following "moves" (Pentland, 1992):

- "see" a problem (e.g. building up of work-in-process inventory);

- mentally "search" for the station where the cause of the problem may originate, based on the previous knowledge of past bottlenecks; work stations and relevant operations characteristics; information received or gathered from other points on the

line;

- "go to" the station held responsible for the breakdown, or communicate with operators there (depending on proximity of the station);

- "disassemble/reassemble" a part or a component of the car or the production machine in order to fix the problem (e.g. dissect a car body, perform automated operations manually);

- register intervention and solution for future memory.

The striking characteristics of such a problem-solving procedure, which we have called the "Disassembly/Assembly"(D/A) problem-solving routine, because of its "routinised" or repetitive nature (Pentland and Reuter, 1994), are its ubiquity, concreteness, "situatedness", and high level of consistency.[22] Namely, as our previous analysis of the building site illustrates, we found instances of its application even in areas distant, at least conceptually, from the car manufacturing process. The construction of the UTE offices using pieces of iron that were lying around and, above all, the "game of disassembling" played on the original stock of cars received from Mirafiori are among the most emblematic examples. Today, the application of the D/A routine is evidenced by a number of problem-solving activities, from TQM to phasing of new car models, where the D/A analogy works as a sensemaking technique:

> The final quality control procedure performed on each car and the demerit system are based on a retroactive mental process, whereby defects (in the form of demerits) are assigned to a specific UTE (Quality manager).
>
> During the phasing of the Lancia Y we would invite our operators to disassemble a car that had just been completed on the line and to re-assemble it. Then we would ask them which was the best method for re-assembling the car and which were their suggestions about the method (Former Plant Director).

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[22] A typical instance of this attitude towards disruptions is the very popular problem-solving procedure imported from Toyota and known as "the five why's". Production workers are taught to systematically trace every error back to its ultimate cause (by asking "why" as each layer of the problem is uncovered), then to devise a solution, so that it never occurs again. This strategy, which is widely adopted in Fiat factories, most of the times leads to good and "clean" solutions, since it tackles the causes generating the problem. The five why's procedure presents many similarities with the D/A routine since both are based on a retroactive mental process aimed at detecting the source of a problem. The efficacy of the latter, however, seems to derive from its level of situatedness and consistency with the assembly line concept.

The D/A analogy is sustained by a generalised ability for crafting and tinkering and by a high degree of sensitivity towards work operations. Problem-solving must be concrete, "hands on" a machine:

> It is more effective to hold a meeting in front of a problem than in front of a desk... To start reasoning in front of a drawing is one thing. To be directly in front of the machine is a totally different thing... We need to transfer the problem (solving procedure) from the desk to the operations point... We need to work as a team in front of the problem (the machine) (Production Engineering manager).

And although a need for a "global vision" of the production flows is strongly needed, the way suggested by the UTE leaders as to how to acquire such a vision is quite concrete:

> We convey a global vision by having workers learn something new all the time through job rotation. The worker acquires more confidence with different production phases and operations... He learns to "see" new things and gets a global vision of the process (Head of Unit).

The analogy of disassembling is "exposed" in a variety of organisational artefacts making up the so-called visual control system: notice boards and panels on the line display the sequence of operations composing the production process, the details of the car components and even the tools that operators are supposed to use in order to carry out their operations. The computer-based information system also reinforces this way of solving problems. In each UTE office, a PC shows screens which portray the relevant segments of the production lines, listing for each work station the number of semi-finished cars entering and exiting the station, together with the levels of in-process-inventories. Other screens offer the data in a more aggregate form by identifying the quantitative flows between UTEs. The same network feeds into the big electronic boards (the so-called "radar" system) which show production data for each UTE and all the related alarms. The radar boards reproduce at a higher level the idea that you have to "see" and "feel" a problem in order to make it "really true", and amenable to a "go to" and "hands on" solution. Finally, the routine allows for variations, though within the boundaries set by the D/A metaphor. At a cognitive level the whole production process is perceived and thought of as a sequence of operations, the product as an assemblage of parts (see Figure 10-11). Although knowledge of the global process and product is sometimes necessary to solve "local" problems or take care of the ramifications of local breakdowns, the procedure followed consistently implies the deconstruction of global problems into lower level

ones, capable of being resolved through a local D/A intervention. We have observed various instances when a breakdown occurs, or a bottleneck is perceived, in which the worker or the supervisor goes back through the working cycle and through a *gedanken* experiment disassembles the car in order to search for and identify the potential source of the default, i.e. what operation might not have been carried out in the proper way. Thus, once the mental search results in a physical identification of the problem, workers propose a local intervention, try it out and learn: (background noise; line-stop alarm ringing because of an inventory build up):

> It's four screws. You slam it down, re-screw and streamline (the body of a car). You know it better than I do! It is just four screws (Head of the UTE to a line worker) .

To conclude, an analogy emerges between the physical layout and workflow in the integrated factory, and the cognitive strategies present in the problem-solving routines. The way operators think is linear and sequential, thus reflecting the organisation of the physical flow of cars along the line.

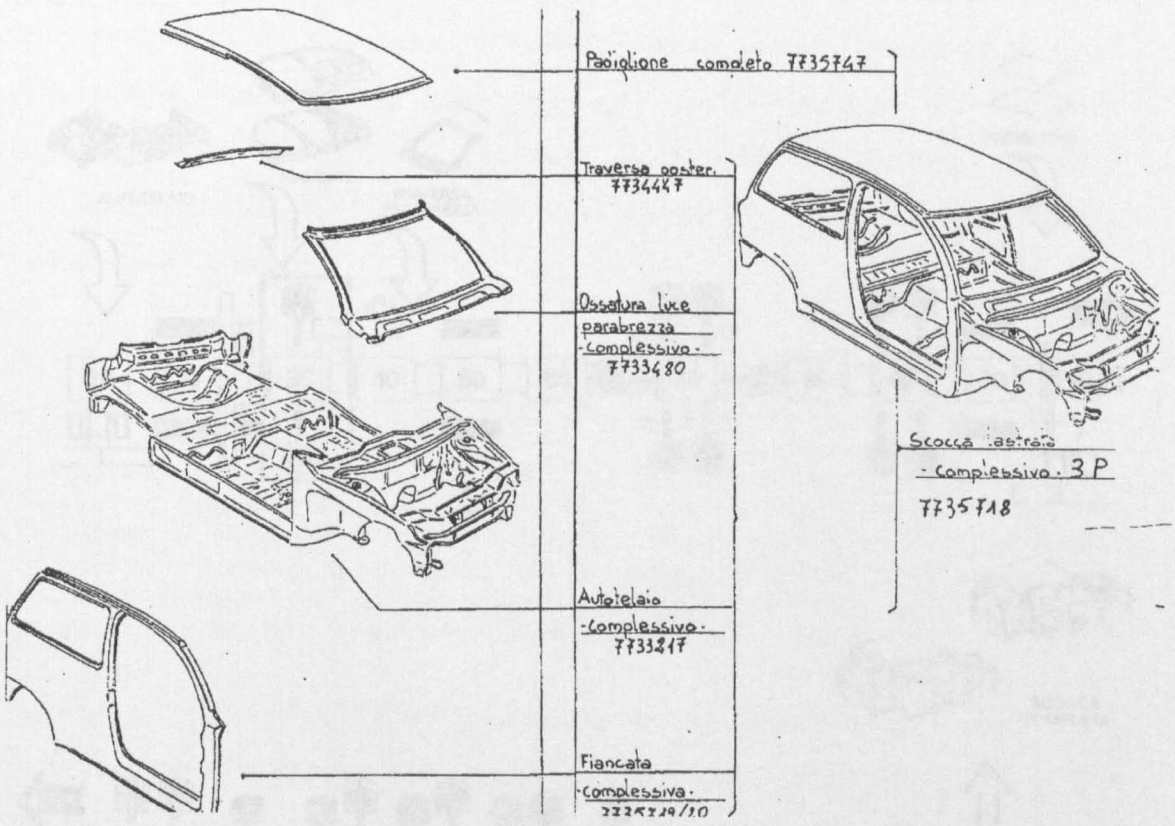

Figure 10. The D/A analogy is reflected in the definition of the product as an assemblage of parts

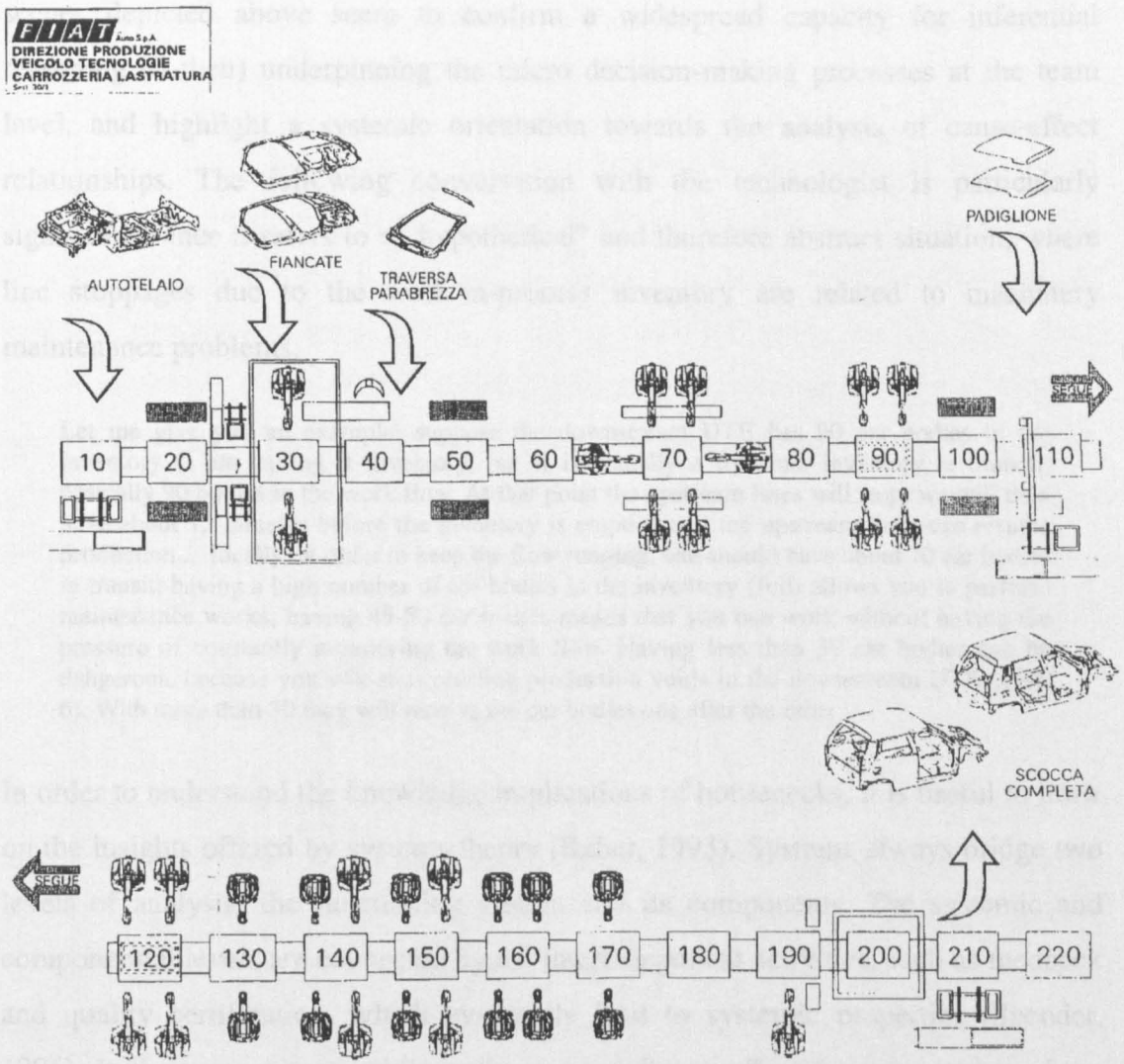

Figure 11. The D/A analogy is reflected in the definition of the production process as a sequence of operations along the assembly line

5.6 Local and systemic breakdowns: cognitive implications of the D/A routine

The cognitive connotations of the D/A routine became apparent through the observation of those situations related to the building up of in-process inventories. As explained earlier, their causes are often of a "second order" nature as they may stem from local sub-optimisation strategies carried out by some UTEs, or unintended side-effects due to the application of a local D/A routine to fix a problem somewhere along the line, or "systemic" causes linked to the production mix and capacity load. In this respect, bottlenecks confront the work team with crucial cognitive challenges, emphasising the need for systemic understanding and capability for abstraction. The

scenes depicted above seem to confirm a widespread capacity for inferential reasoning (if-then) underpinning the micro decision-making processes at the team level, and highlight a systemic orientation towards the analysis of cause-effect relationships. The following conversation with the technologist is particularly significant, since it refers to a "hypothetical" and therefore abstract situation, where line stoppages due to the work-in-process inventory are related to machinery maintenance problems:

> Let me give you an example: suppose the downstream UTE has 90 car bodies in the inventory (I am calling it inventory, but it is actually a dynamic inventory, a transit), basically 90 bodies in the work flow. At that point the upstream lines will stop; we will then have about 15 minutes before the inventory is emptied and the upstream lines can resume production... Ideally, in order to keep the flow running, one should have about 70 car bodies in transit; having a high number of car bodies in the inventory (full) allows you to perform maintenance works; having 45-50 car bodies means that you can work without having the pressure of constantly monitoring the work flow. Having less than 30 car bodies can be dangerous, because you will start creating production voids in the downstream UTE (UTE 6). With more than 30 they will receive the car bodies one after the other.

In order to understand the knowledge implications of bottlenecks, it is useful to draw on the insights offered by systems theory (Reber, 1993). Systems always bridge two levels of analysis: the functioning system and its components. The systemic and componential levels are connected by the intercomponent activities, such as feedback and quality certification, which eventually lead to systemic properties (Spender, 1996). In the present case, while ordinary breakdowns affect the components of the system (the single operation), bottlenecks disrupt the functioning of the system as a whole since they emerge from a network of concurrent events that define the system's activity.

As a cognitive resource, the D/A analogy provides operators with a virtual map of the assembly line and of the division of labour on the shop floor. As we have seen in relation to problem-solving activities, the mental process underpinning the application of the D/A routine, instantly tells operators where certain things are happening (e.g. where problems are arising), why (diagnosis) and who is responsible for them. In other words, the D/A analogy captures the fundamental relationship between parts and the whole, components and systems, which governs the execution of operations on the assembly line. Furthermore, the cognitive analogy seems to possess an important spatial connotation; it provides a map of the whole production process and at the same time it says: "you are here". Finally, it offers a

conceptualisation of the assembly line as a chain of transformations of the product along the production process (building the car bit by bit).

On the other hand, as the above analysis of bottlenecks illustrates, the background knowledge required for the resolution of bottlenecks is highly situated and grounded on perception. Electronic boards and IT based resources provide systemic maps enabling operators to get a snapshot of the current situation on the shop floor. However, the sensemaking activity related to the potential building up of work-in-process inventories seems to be based on a deep-seated form of "circumspection", grounded on the ability to "see", "feel", or "listen". While notice boards display numbers about the status of the production process, the overhead conveyor—the impressive mechanical infrastructure that dynamically links the different production processes—provides a much more concrete picture of the situation. Likewise, sounds tell operators whether production lines are moving or being idle.

The above analysis shows how, within the notion of an assembly line, hard concepts and soft ones are inextricably intertwined. From a technical standpoint, the assembly line is the basic infrastructure through which the plant organises its activity. However, the peculiar division of labour underlying the operations on the shop floor (assembling the car bit by bit) is subtly reproduced in the background knowledge (the D/A analogy) that governs the way operators deal with routine and breakdown events. Thanks to its situatedness, the assembly line becomes part of the background of "readiness-to-hand" that is taken for granted by the users without explicit recognition or identification as an object. It lies at the heart of the cognitive, social and material background by which people interrelate with organisational practice.

Finally, if we are to understand the interplay between systems and components, we need to consider the socio-organisational elements which shape them. For instance, the task of building cars bit by bit on an assembly line (governed by the technical sub-system comprising machines and equipment) acquires different meaning according to the underlying production system (e.g. mass vs. lean production), the organisational model (e.g. hierarchical vs. team-based), the cultural values (e.g. quantity vs. quality and the demerits system), the capabilities required (e.g. local vs. systemic), and so on. The lean production concept as applied in the Melfi plant generates an integrated dynamic system connecting interdependent stations, which

have a certain degree of autonomy in carrying out operations (the customer-supplier model). Accordingly, the smooth functioning of shop floor operations becomes not only a matter of mechanical synchronisation, but depends crucially on human behaviour: the trust relationship between internal customers and suppliers, co-operation between teams, the attitude towards the demerits system, and so on. The latter emphasises the importance of the core values incarnated by the Melfi work force, which have been discussed in the previous chapter.

5.7 Digging into tacit knowledge

The pervasive influence of the D/A analogy is apparent at different levels of the organisational knowledge system:

- work practices, both individual and team-based, are aimed at building the car, or deconstructing it in case of breakdowns, bit by bit;

- capabilities: the D/A work practice becomes a generalised problem-solving capability in use across the whole plant. It is applied to whatever problem emerges along the line. Where distance impedes a direct presence "in front of the machine", appropriate communication and information mechanisms are set up to handle the problem in a distributed way while preserving the basic approach. Finally, and more importantly, the "skills without a place" character of organisational capabilities is apparent in the conceptualisation of the D/A routine as part of a work method.

- core capabilities: the strategic value of quality of the final product is also supported by the D/A capability. For one thing, analytical attention to the detail is essential to the implementation of quality management throughout the plant ("*Quality is there in the smallest assembly operation....Quality is not something pompous; it is doing things well according to the rules, and doing them in the same way over and over again*"). (Head of UTE)

- the formative context: the piecemeal character of the D/A analogy is very much alive in the design and implementation of the Melfi project, which have been discussed at length on the previous chapter. The construction process of the factory and the simulations carried out during the induction phase over the Melfi building

site, seem to rely on the same core stock of knowledge which today governs the execution of routine operations on the shop floor.

- the computer-based information system is designed to convey and register all the quantitative data regarding actual vs. planned production, with the smallest detail for each work station along the line.

The above considerations invite a thorough reflection about the meaning of technology, the task, and the role of human skills in the setting under study. So far, the findings of the study seem to point out that core capabilities observed on the Melfi shop floor have been developed through a historical process originating from the green field experience, rather than being a mere reflection of the production system (i.e. the Fordist assembly line). This begs two critical questions: Where does the knowledge template (D/A analogy) come from? What is the meaning of assembling?

As we have seen in chapter 4, the appropriation of the assembly line in Melfi occurs around the task rather than the technology. The so-called disassembling exercise precedes the introduction of the assembly line and emphasises the craft of building the car bit by bit. Under these circumstances, the role of the technology emerges only later, when the factory becomes operational and the moving line is brought into the picture. Indeed, assembling is not about craft; it is about speed, time and motion (Benyon, 1973; Adler, 1993).

The learning process developed around the task of disassembling, and eventually institutionalised in the D/A analogy, highlights an important knowledge-based distinction between the traditional mass production system and the new post-Fordist paradigm developed in Melfi.

The Fordist model integrates task and technology in the assembly line concept. The skills necessary to perform the task are built in the technology. The Fordist assembly line is based on alienation of the task and the substitution of human labour with machinery. Accordingly, the job of shop floor operators is defined by the moving line. On the other hand, the induction phase observed in Melfi seems to emphasise a tension between task and technology. The initial experience of assembling a car takes place off the line. Certainly, production lines have been set up, but they are idle.

Operators and not the technology are physically moving on the shop floor and this clearly indicates who "owns" the task. In a sense, competence transcends the technology because the task is "bigger" than the technology: it encompasses quality, problem-solving, coping with disruptions, and so on.

Finally, even when the technology is operational, the job of shop floor operators seems to be defined by the tension between routine and breakdown events, between separating from and re-appropriating the task of building the car bit by bit according to the changing circumstances on the shop floor. In this sense, we define technology as a mechanism of delegation of the task.

To sum up, the distinctive features of the production paradigm applied in Melfi can be reconnected to a different conceptualisation of the relationship between four related systems with respect to the traditional Fordist model. These are: the task, the technology, human skills, and the division of labour. Crucially, this is a knowledge-based rather than technology-based distinction. In the Fordist model, the *assembly line* acts as an independent variable driving the execution of the task and dictating the division of labour. The assembly line is a social system in which the distinction between task, technology and human labour has been somewhat blurred. The model stresses precisely the concept of automation, defined as the substitution of human labour with machinery. Conversely, in the post-Fordist environment observed in Melfi, competence seems to be built around the task. Accordingly the *task* mediates between human labour and technology. Figure 12 illustrates this main distinction between the two production paradigms.

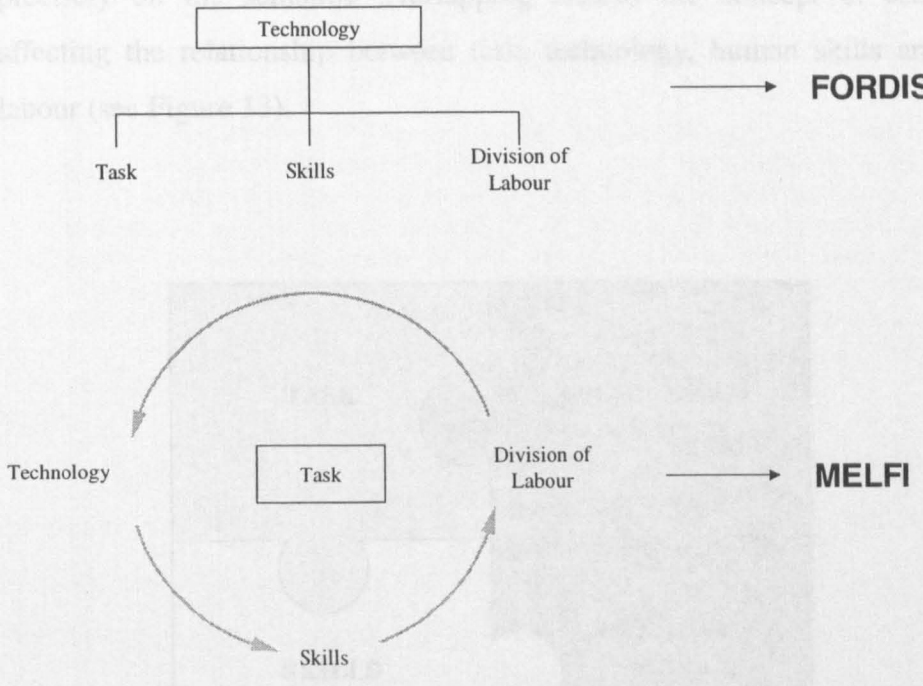

Figure 12. The knowledge implications of production systems

Competence in Melfi is developed around a redefinition of the organisational socio-technical system. On the one hand, the D/A routine is so powerful in shaping problem-solving and learning throughout the plant, because it embeds the "archetype" of the assembly line (Greenwood and Hinings, 1988). The D/A metaphor apparently has been transferred almost intact from the slaughter houses in Chicago, where Ford had the first idea of the assembly line, to the avant-garde plant in Melfi. At the same time, the knowledge template based on the D/A analogy is developed through a historical process related to the green field experience. In fact, a crucial knowledge transfer occurred during the intensive training period over the Melfi green field, where the capabilities of the future work force were developed and fine-tuned, especially during the hands-on sessions that included building off the line a real car "bit by bit". The D/A metaphor remains at the heart of Melfi's formative context and exerts a strong influence on the vast array of learning processes which take place in the plant. From the above considerations, we can draw the following conclusion: the D/A analogy does not reside exclusively in cognition, technology, the task or the skills related to its execution. Rather, it can be seen as a distributed knowledge system linking different variables in a coherent whole. The D/A analogy draws

precisely on the semantic overlapping around the concept of assembling, and affecting the relationship between task, technology, human skills and division of labour (see Figure 13).

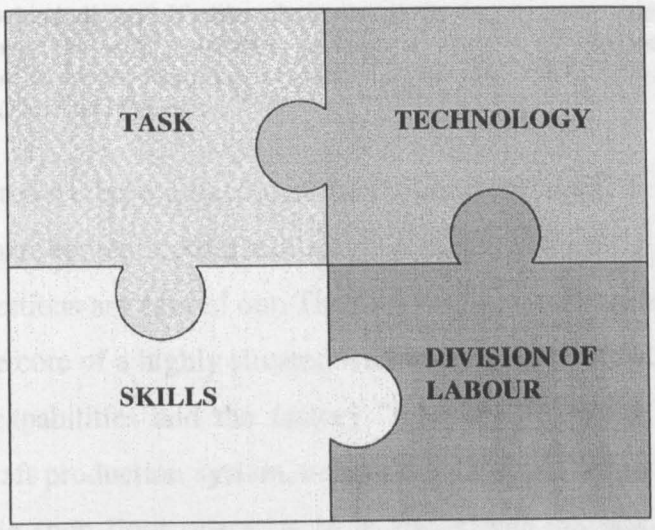

Figure 13. The D/A analogy as a knowledge system

It is this holistic dimension of the analogy which makes it work. In this respect, the D/A analogy does not "drive" work operations in a strict sense, it is not an independent variable. However, it provides meaning to factory activities, which become part of a distinctive organisational "cosmology" (Weick, 1993), and thereby acquires both a descriptive and prescriptive value.

5.8 Conclusions

Before the assembly line was invented, cars used to be hand built in small numbers by skilled craftspeople (Womack *et al.*, 1990). When the mediation of the assembly line was brought into the picture, the basic task of building the car bit by bit was simply delegated to the technology. Today, despite revolutions and paradigm shifts, the functioning of modern car manufacturing systems is still based on assembly lines,

although the heavy reliance on computer mediated devices to control the production process has rendered the basic task of building the car bit by bit more transparent:

> The D/A exercise provides knowledge of the product, the work method and, ultimately, the production process. Correspondingly, it provides knowledge about those processes that have been automated through IT and therefore can only become manifest through a mechanical scheme. Let me give you an example. JIT is run through computer based systems which ensures the co-ordination between UTEs and suppliers and between different UTEs. But what is behind all this? It's like administering the double entry: today you buy a computer that includes an admin software package, a ready-to-use product. However, the real accountant is the one who, having performed the job manually, knows what is inside the package (Personnel Director).

In this chapter, we have argued that the D/A exercise carried out by the Melfi people as part of their apprenticeship still exerts a subtle, far-reaching influence on the way factory operations are carried out. The D/A analogy, derived from the above exercise, stands at the core of a highly situated learning process which connects work practices with core capabilities and the factory "formative" context. The analogy enacts a powerful craft production system, emphasising the task of building the car bit by bit and allowing shop floor operators to re-appropriate the task whenever a disruption occurs or machinery breaks down.

Thanks to the D/A analogy, the complexity of a modern production process based on assembly lines can be unpacked, reconnected to mechanical operations, pinned down to the smallest detail. Likewise, the finished product, far from being treated as a black box, is broken down into its components and explored again and again. Put another way, the craft work of building the car bit by bit is what comes to the front of the stage when technology is bracketed out (e.g. in the case of breakdowns).

We can consider the various UTEs as "communities of knowing" (Boland and Tenkasi, 1995), engaged in learning and problem-solving about minor and major breakdowns of production. Our analysis has shown that each time a breakdown occurs, the existing formative context triggers interpretative schemes and organisational routines which are driven by the D/A metaphor. In other words, when facing a problematic event, both improvisations and planned interventions are performed by members of the community taking a special perspective, present both in the traditional concept (and technology) of the assembly line and in the new concept of "artisanal, quality work": building the car bit by bit. The existing information systems support this kind of "perspective taking". We have also seen that

individual and collective learning processes are heavily influenced by such a perspective. Specifically, we have discussed the variety of breakdowns which plague the production process whilst pointing out the cognitive implications of technical disruptions.

Our empirical observations of breakdowns and the ways in which they are tackled indicate that the D/A problem-solving routine works efficiently for the large majority of technical breakdowns occurring along the lines. That is, workers have acquired and internalised the procedural skills and competencies necessary for dealing with most breakdowns. Problems involving fixing the car along the line are solved with dexterity and speed; solutions are stored and made accessible for the work teams through the visual control system; artefacts are available to capture in written form such solutions and the network infrastructure is used to communicate in relation to such activities.

To conclude, the main findings of the case study highlight the strengths of the theory and practice of disassembling. The generalised D/A routine seems to encapsulate the concept of the "mechanical", rigid sequence of operations on the traditional assembly line, while defining the worker as a mechanic-bricoleur, able to make effective use of material, social and experiential resources available in the work environment. The socio-technical validity of the D/A routine is reinforced by the original design concept of the avant-garde factory. Finally, the above findings seem to point to a redefinition of the assembly line concept in a post Fordist environment, one that is aimed at yielding outputs comparable to mass production factories while ensuring the high quality of the finished product.

CHAPTER 6: SENSEMAKING ON THE SHOP FLOOR: THE NARRATIVE DIMENSION OF ORGANISATIONAL KNOWLEDGE

6.1 Introduction

This chapter analyses the processes of organisational learning and knowledge acquisition in the setting of a traditional pressing plant within the same company. In contrast to Melfi, the Mirafiori pressing plant incarnates a highly institutionalised context, characterised by experienced work force, consolidated and often opaque work practices, and distinctive cultural tradition. In trying to penetrate such a deep-seated knowledge base, the technological discontinuities inherent in the nature of the task and the batch production system provide a fundamental entry point. A typical day on the shop floor seems to be punctuated by the occurrence of interruptions and disruptive events which prompt operators to make sense of the situation and respond through different types of interventions. Precisely because the line between routine and breakdown situations - the cleavage between organisation and disorganisation - is very thin, the above context offers a privileged observational perspective. Based on thick description of how a best performing team engage in the resolution of disruptive occurrences, the case described below attempts to identify the distinctive knowledge acquisition processes underlying the team's work practices.

In line with the attempt to describe organisational knowledge as an empirical phenomenon, the present case follows the fundamental sensemaking processes leading to the enactment, punctuation and retention of organisational action (Weick, 1977). In particular, the construction of narratives in the work setting is reconnected to the process dramatisation of disruptive occurrences. The latter emphasises the emotional content of breakdowns, linking the presence of a problem and the quest for a solution to the social relationships between the characters involved. The main findings of the study seem to be consistent with the existing literature. Narratives appear to be fundamental diagnostic devices, enabling operators to perform a coherent description of troubled machines (Orr, 1996). Furthermore, they provide

operators with guides to conduct (Weick, 1995) or cognitive maps based on the recurrence of histories of disruption. Finally, narratives act as storage devices, providing receptacles for organisational memory. In so doing, they maintain the stability of the work setting by fostering the circulation of organisational knowledge within the community of workers.

The main contribution of the study concerns the role of narratives for a theory of organisational knowledge. Specifically, the present case attempts to explain how knowledge is capitalised in a narrative form, and thereby explicitly links narratives to the dynamics of knowledge creation, utilisation and institutionalisation. Evidence collected considers both instances of sensemaking in action occurring in the "here and now", and completed episodes that have been somewhat elaborated and "metabolised" by the team members. The first disclose a controversial process of knowledge construction, whereby operators attempt to make sense of disruptive occurrences by turning them into detective cases. Detective stories provide operators with a connecting narrative whilst acting as "templates" for the resolution of future cases. The second highlights issues of memory and collective remembering in relation to learning processes. The juxtaposition of present occurrences to notable experiences of the past qualifies the process of knowledge acquisition over the Mirafiori shop floor as "learning by examples".

This chapter contains 9 sections. The next section provides some background information about the factory and the production system. Sections 3 and 4 present vignettes of the field in which the team members engage in the resolution of disruptive occurrences on the shop floor. In section 5, the sensemaking dynamics underlying problem solving activities are reconnected to a distinctive narrative-based process of investigation, conceptualised as "detective stories". Section 6 shows how sensemaking is grounded on the core values of the team and how those values affect collective learning processes. Section 7 analyses the theory underlying the detective's method in the attempt to define the nature and content of existing knowledge. The analysis qualifies the method as an emergent epistemological archetype similar to what Ginzburg (1990) calls the "evidential paradigm". The paradigm stresses the importance of conjectural knowledge and the value of commonsensical wisdom. Section 8 brings the main findings to a synthesis by presenting a model of knowledge

creation, utilisation and institutionalisation based on the resolution of disruptive occurrences. The concluding section contains some general considerations about the narrative dimension of knowledge in organisations.

6.2 The Mirafiori Pressing plant

The Mirafiori Pressing Plant (Figure 14) is one of the largest in Europe, covering an area of 233,000 square meters with about 3,000 employees. It is housed in buildings constructed in the 50s during an extension of the Mirafiori industrial district. The shop floor consists of 15 UTEs distributed across two Operational Units. The large presses unit utilises large size technology to produce large parts such as roofs, doors, and panels. The medium presses unit deploys medium size technology to produce smaller components for the car body. The production process is organised in lots, scheduled according to the customer's demands. The process starts with a large roll of sheet metal. This sheet is run through an automated "blanking" press to produce a stack of flat blanks slightly larger than the final part that needs to be produced. The blank is then inserted in massive stamping presses containing matched upper and lower dies. When these dies are pushed together under many tons of pressure, the two-dimensional blank takes the three-dimensional shape of a car component (Womack *et al.* 1990: 51-52). Depending on the part that has to be processed, the workflow is organised either around single-shot presses, or a sequence of presses and dies forming a production line (see Figure 15). Once each lot is completed, dies are replaced and the presses can start processing a different part. The plant receives about 2,000 tonnes of sheet metal rolls per day. It includes 25 large press lines (15 of which are automated), 30 transfer lines, 9 shearing lines, 67 traditional presses and a sheet working shop for the mobile parts of the Panda.

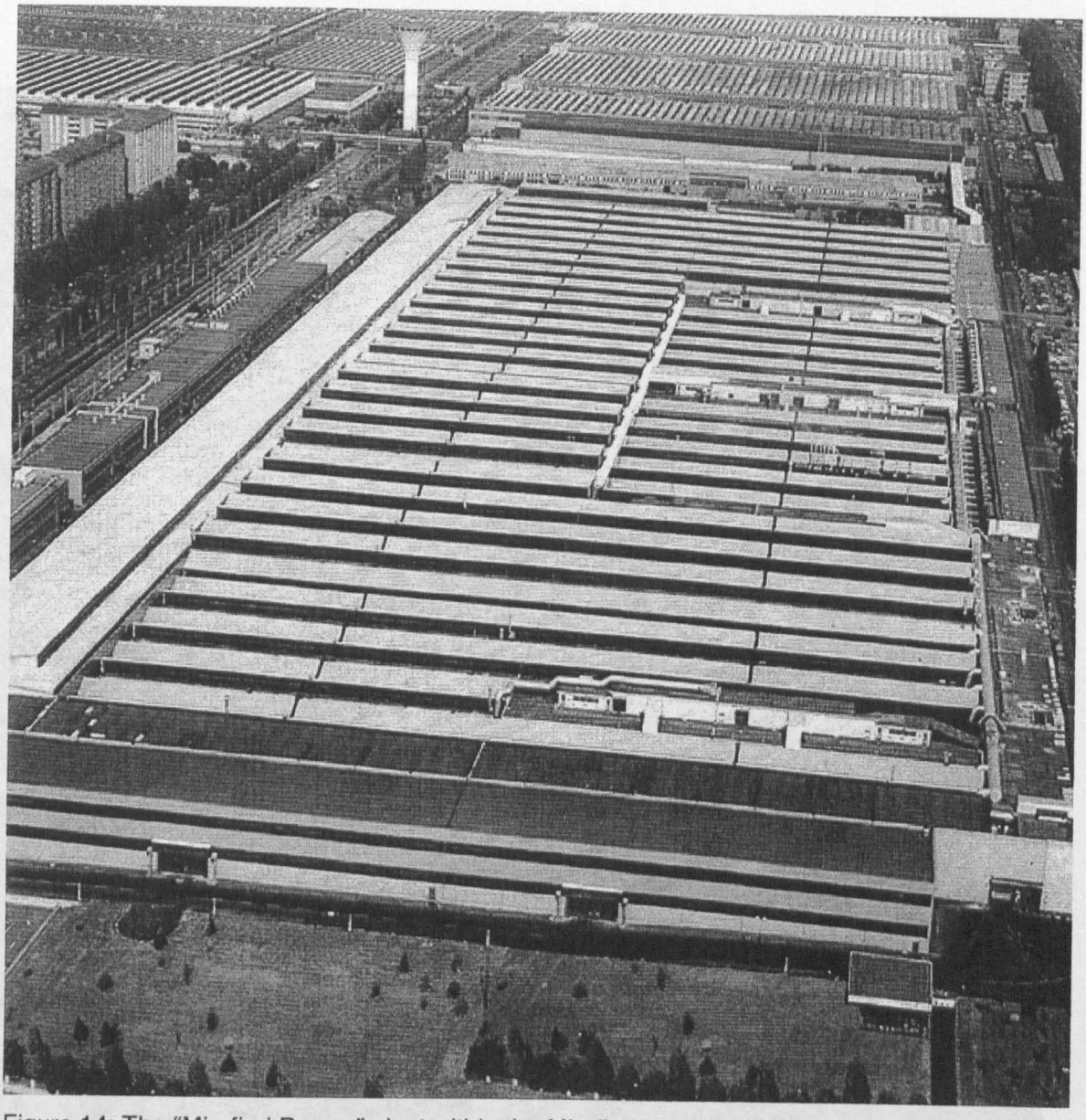

Figure 14: The "Mirafiori Presse" plant within the Mirafiori industrial district

Figure 15: A traditional production line

In a pressing plant, die change can be seen as the bottleneck in the system. Time for this operation is idle time, thus the shorter it is the better. By shortening set up time it is possible to minimise lot size and therefore reduce stocks. The latter is a basic requirement of lean production and JIT. Through small lot production, the production lead-time of various kinds of products can be shortened, and the company can adapt to customer orders and changes in demand very promptly (Monden, 1993). Although fast set-up techniques (e.g. Shingo, 1989), make it possible to standardise operations to be performed during a die change, this event still presents a good deal of uncertainty. Electrical or mechanical problems may occur during the internal set-up slowing down the whole process. A die change requires precision, concentration and group concord. A recurrent analogy for changeover operations, to which workers generally refer, is that of Formula 1. In fact, die change looks very much like a pit stop: on the one hand, it is part of an established routine (dies are changed everyday); at the same time it is a critical event for the overall factory performance and therefore presents the typical emotional dynamics associated with risk. In a batch production system, time seems to be punctuated by the succession of production lots with changeover operations providing major points of discontinuity (discrete events): a batch is not simply a production unit, but also a time unit. For that reason die change is perceived as a major technological perturbation, bearing important consequences in the punctuation of organisational action and the perception of time. Significantly, one manager remarked that "each lot tells a different story".

Although derived from the general model of the integrated factory, the work organisation of the Mirafiori pressing plant is somewhat peculiar. In fact, given the nature of the batch production process there is little interdependence between the different UTEs, and the internal customer model is rather loose. Virtually all the UTEs (except the UTE dedicated to blanking which supplies all the other UTEs with raw materials) work in parallel and interact directly with Fiat's assembly plants. The UTE I observed is located in the large presses unit and characterised by automated operations. The UTE controls three production lines. Typically, the stamping cycle involves a range of 4 to 7 machines depending on the part that has to be processed. Along the automated lines all the operations, including line loading and transfer of a part from one work station to the other, are performed by robots. Given the high level of automation, the UTE employs a limited number of people (about 16 generic

workers per shift). Only four operators work on each line: two line conductors at the beginning of the line are in charge of loading the pieces, while two operators at the end of the line monitor and certify the quality of each component produced. The UTE produces components for different car models and has a daily output of about 30000 pieces (the UTEs where work is performed manually produce 5000-7000 components per day). The presses of the robotised lines hit 8-12 strokes per minute. It means that the line has a capacity of 480-720 pieces per hour at 100% efficiency.

As stated in the introduction, the production system in Mirafiori provides a crucial entry point for the observation of knowledge in the making. In fact, technology defines a set of cognitive models and sensemaking capabilities allowing the users to represent and understand events associated with it (Weick,1990). More specifically, batch production systems seem to be particularly subject to technological discontinuities which, to a certain extent, are harnessed in organisational routines (see die change as an example). In this regard, a batch production system falls only partially within the class of events that Weick (*ibid.*) defines as "stochastic", since the very distinction between predictable and unexpected is problematic. However, the repertoire of skills defined by such a production system are indeed those typical of a stochastic environment: "people are usually on standby, giving special attention to start-up and to anticipating faults that may lead to downtime; the distinction between operations and maintenance is blurred; skills in monitoring and diagnostics are crucial; people must be committed to do what is necessary on their own initiative and have the autonomy to do so; and people have now assumed the role of "variance absorber", dealing with and counteracting the unexpected" (Weick, 1990: 9).

6.3 Encountering the team members

It is my first day on the shop floor. A one-day meeting with a best performing team in the large presses unit has been arranged for me by the HRM manager. The first event I am supposed to observe is the institutional UTE meeting which takes place daily around 10 a.m. The general purpose of a UTE meeting is to plan the activities of the team and possibly discuss issues and problems inherited from the previous shift. The meeting has a variable duration ranging from 5 to 30 minutes, depending on the issues at hand. Typically, it involves the core members of the team plus a number of

ad hoc people who are called on the basis of the issues to be discussed. Unfortunately, that day the meeting has been moved to an earlier time and when I arrive at the UTE box, it is too late. Nonetheless, I take the opportunity to interview the team members who are still there, namely the UTE leader, the technologist and the scheduler. Other participants involved in the meeting included the operations manager, the die maintenance leader, the machinery maintenance leader, and one electrician, all of whom have now left. Other operators will join the interview afterwards.

Before going into details we start off with a round of introductions so that I can become acquainted with the team members. Then we review the issues that have just been discussed, by going through the agenda of the meeting. The first point in the agenda concerns the planning of extraordinary maintenance work to be performed during the summer holidays (traditionally Fiat shuts down all its factories for three weeks during the summer). Unlike day-to-day maintenance of machinery, these types of intervention require stopping production for some days and therefore cannot be performed in periods of normal work. Next, comes the modification on a part of the Punto's body following a customer's complaint from one of Fiat's assembly plants:

> The modification requested by the customer has been made. Today we have discussed this work that required re-centring two holes. The maintenance leader took part in the meeting and said that the intervention had been performed successfully. We have controlled the part with a gauge. The part looks in order, but we want further confirmation when the line starts producing that part again. We want to check the recurrence on 1000-2000 pieces in order to be absolutely positive (UTE leader A).

Batch production requires removing the dies from the line in order to perform maintenance works. In order to do that, it is crucial to exploit the inter-lots, that is the lapse of time between two lots of the same part. The scheduler hands me a production sheet with deadlines, ID numbers of parts, production volumes on each line, etc., and clarifies what the UTE leader has just said:

> This is my production plan for the next two months. Information is provided by a centralised information system on the basis of the customer's demands. The problem he (the UTE leader) was mentioning concerns line 24. The part he is talking about is this one, number 6. Once we have completed this lot of 15,000 pieces, the stamping of this part is re-scheduled down here. It means that from 19 July until today (25 July), he has had the dies off the line because he has produced a different part. In the meantime those dies have undergone maintenance works and have been tested on a different production line. Once the dies are set up on the line again, and the part is produced without any defect, we will inform the customer that his request has been fulfilled.

The UTE leader goes on to explain that interventions on the presses or other machinery require having the lines idle. This implies scheduling production voids in order to perform these interventions. Once again his words are echoed by a concrete example provided by the scheduler:

> What he is mentioning now is the case of line 22, where specific maintenance works need to be performed. Whenever he wants to make some interventions on the machinery I have to plan some production voids on the line concerned, so that the line remains idle for a while without affecting the customer's demands. For the same reason I also need to envisage a greater volume of supplies in order to keep the line idle for some days, without producing, and then resume production (thus recovering the number of pieces to be produced).

Moving forward, we encounter the problem of machinery overhauling on line 24, where equipment for the automatic loading of the pieces is under repairing. As this intervention requires more than one month, work has started before the holiday break. Operators are now loading the pieces manually, and that is causing some difficulties. During the meeting, this issue has been checked with the maintenance leader. We keep reading the minutes of the meeting. The next issue covered by the discussion is the UTE performance as far as waste is concerned. Each UTE must meet specific objectives, and one of them concerns the level of waste. Waste is a web embodying several activities. In fact, a wasted product could arise from faulty machinery, a defective blank sheet, a stamping problem, or a wrong decision at the organisational level. Therefore, information about waste (daily data is available to the team), provides the team with a good indicator of the gap between current performance and the team's production target. It also informs the team members of the factors that might cause a drift from those objectives. The last point in the agenda concerns the start up of a Total Productive Maintenance activity (TPM) involving all shop floor operators. TPM is a methodology for the activities of self maintenance and preventive maintenance and it is aimed at the detection of possible malfunctions within the production process:

> It involves specific interventions such as controlling or restoring the oil level, tightening a bolt, etc. These interventions are performed whenever the line gives you the opportunity to make such checks (both when the line works and when machinery is idle). The line stops because a die breaks down, the machinery will be idle for one hour, it is the right moment to do maintenance work on the machinery. The machinery is working: I check the oil level and eventually restore it. Before the integrated factory, these interventions were left to the inventiveness and improvisation of the individual. Through these methods we try to reduce the number of variables involved as far as we can (Technologist).

6.3.1 Sensemaking as anticipation

The above sketch of a conversation highlights the pervasive presence of machines in the daily talks of the team members. For example, all the issues included in the agenda of the team meeting refer to actions aimed at responding to or preventing the occurrence of technical breakdowns. The vulnerability of machinery and its tendency to break down expose the fragility of the work setting. A team meeting can be seen as a moment in which the team members collectively attempt to make sense of disruptions. The "presence" (real or impending) of a disruptive event emphasises the constraints typical of a batch production system. Batch production is based on intensive exploitation of the machinery and therefore, at completion of a production lot, dies and machinery tools are worn out. Accordingly, product quality is heavily dependent on repair and maintenance activities. Die change punctuates the sequence of different lots bringing a major technological discontinuity in the system. On top of that, things seldom unfold according to plan and accordingly the production system imposes heavy cognitive demands on the team members. The need to respond to frequent breakdowns, interruptions and unexpected events emphasises a dual challenge for sensemaking: planning (dealing with the unexpected) and diagnosis (dealing with the equivocality of action). The two activities point to the interconnected processes of anticipation and retrospection, which stay at the core of any sensemaking endeavour (see Weick, 1995). This section considers the organisational and cognitive implications of planning and anticipation, while an in-depth analysis of diagnostic activities will be conducted later in the next sections.

Planning can be seen as a variance absorption activity. It emphasises the ability to anticipate deviations from the standards. At a macro level, this competence is reflected in the ability to manage the trade-off between efficiency (maximise production) and floating capital (minimise the level of inventory). At the micro level, it can be conceptualised as an emergent activity of re-adjusting, re-scheduling and opportunistic use of interruptions. In the following example, the occurrence of a disruption during the night shift leads to the anticipation of a die change:

> *UTE leader B*: During the night shift a coil has been discarded because it was defective. For this reason we will not be able to meet the target lot on line 24. Consequently, we will produce a smaller lot (about 1000 pieces less) and then recover the missing pieces with the next lot. Since the lot will be completed earlier than expected, the die change has been moved forward and will take place in about an hour.

A similar conversation highlights the importance of anticipation in the interaction between production and maintenance activities:

> *Technologist*: In order to perform maintenance work, modifications, improvements, etc. we can only play on the anticipation of a production lot (if things go smoothly) or on a decrease in the customer's orders: suppose that a customer has requested 2000 Puntos for tomorrow and, for some reason, he is able to produce only 1500 cars. At this point I have gained an advantage on the customer's demand and I have a production void available. Handling a line stoppage is easier for an automated line since it employs only four people. A manual line is more critical, because when the line stops you must re-allocate 40 people.

Technological discontinuities, and deviations from routines produce a switch in cognitive gears (Luis and Sutton, 1991) and thereby prompt shop floor operators to engage in active thinking (re-scheduling the production plans, carving out production voids, switching from production to maintenance, performing continuous improvement activities). The alternation between production and maintenance activities epitomises this switch according to a "stop and go" or "on and off" pattern. Interruptions, as it were, serve as fundamental triggers for knowledge creation and utilisation. On the other hand, as the above episodes illustrate, disruptive events and critical incidents can be seen as "moments of truth", bringing to the surface the distinctive sensemaking activity of shop floor operators. Specifically, sensemaking seems to be based on inferential reasoning (since, in-order-to, because, if-then) and associated with the conceptualisation of disruptive events as emblematic situations (real or hypothetical).

More generally, the above episodes indicate that planning activities within the UTE are continually subject to disruptions. Organisation seems to provide a relatively stable background for the local, often improvised practices of the team members. Disruptions, on the other hand, bring elements of equivocality in the team's cosmology (Weick, 1993), thus highlighting gaps to be filled through sensemaking activities. Dealing with the unexpected is part of the everyday life of the team members, but also something on which they can deliberately play in order to gain flexibility and discretion:

> *UTE leader B*: The only organisational constraint is to match the production plans. On the basis of the line performance the scheduler is able to detect where my production voids are. If the line keeps working smoothly, I will have two idle shifts by next Monday; the supply of components is in order. So I can exploit these voids in order to perform maintenance works.

Technologist: All that is planned is organisation. Faced with a concrete problem we have full liberty.

The above quotes illustrate in a very effective manner the interplay between team activities and organisational constraints. At the same time, they provide an insight into the nature of existing competence. What stands out is the divide between organisation as a machine, whose functioning is based on the existence of plans, routines and division of labour, and the competence of middle managers on the shop floor, which allows them to act within considerable margins of discretion. As we shall see in the following sections, the type of competencies detected on the shop floor is related to the strong professional identity of the team members (especially the senior ones) which allows them to base their decisions on common sense rather than what is formally prescribed by the organisation. Despite the complexity of the work setting, sensemaking seems to draw on minimal organisational structures. In this regard, common sense and experience-related knowledge seem to be bigger than the technology.

6.4 Breakdowns

The following section depicts two scenes referring to the resolution of anomalies on the shop floor. These episodes exemplify a process of investigation, again a sensemaking exercise, here conceptualised as detective stories. The problem solver (sensemaker) is portrayed drawing upon the metaphor of the detective who treats breakdowns as ordinary "murder cases". In the first "story", the detective is shadowed along the investigation process which leads to the resolution of a "real time" breakdown. More specifically, the case focuses on the lapse of time that runs form the emergence of a breakdown (the discovery of a stock of defective components) to its solution. The episode is subsequently reconstructed "after the fact", in a retrospective way. The second scene portrays a disruption case of the past through the recollection of a team member. In both cases it is the retrospective account that helps actors shape the contours of action.

6.4.1 The Panda's dashboard

I am with the UTE technologist. Yesterday the Mirafiori assembly plant detected a hole off centre on the Panda's dashboard and reported the problem to our UTE. Although the anomaly is limited to 156 pieces, the problem remains quite important because it has been detected by the assembly plant, at an advanced stage of the production process, and the consequences may well have been more serious. Together with the UTE leader and the technologist we walk to the repair area where the chief repairman, the die maintenance leader and one die operator are waiting for us. We take out one of the defective parts from a container where the faulty pieces are stocked. The group begins to examine the anomaly by touching the component in the point of anomaly.

Since the parts have been returned by the customer, there seem to be only two possible explanations for the problem, both related to a quality control procedure and both involving a human error (although to a different extent): the anomaly could be related to the completion of the lot. Anomalies towards the end of a batch are very common due to the wear and tear of machinery tools. In this scenario, operators had completed the lot without noticing the problem (an oversight on the part of end of the line workers who did not properly check the parts produced). Alternatively, it could be that team operators had performed a corrective intervention on the dies without clearing up the faulty parts and therefore the defect was passed on to the downstream process. Again, they did not follow the procedure for correcting defects which implies going backwards through the lot produced in order to detect the first non-defective piece, and sending all the faulty parts to repairing. Now, in order to perform a diagnosis, we need to go backwards: the die maintainer is going to examine the die that performs the faulty operation. He is going to open the die and check the "blue print". If the blue print is broken, it means that the problem was related to the end of the lot and nobody noticed it. Conversely, if the blue print is in order, it means that a corrective intervention was performed, but without amending the faulty parts.

Before proceeding to the die area, we decide to check the position of that part on an assembled car. Bringing the defective dashboard with us, we walk to another area where a sample Panda is on display. We match the part with the car body in order to assess the deviation of the hole and establish how to perform the repair job. Now the

chief repairman knows how to repair the defective parts, but we still need to understand what generated the anomaly in the first place. We move to the die area, still bringing the component with us. The die maintenance leader and the die operator open up the die that has produced the component in order to check its integrity. The blue print of the die looks in order. This means that it had been replaced before the target lot was completed. This fact seems to exclude one of the two hypotheses, but at one point the die operator comes out with a third hypothesis, that virtually attributes responsibility to workers at the assembly plant. Basically, there is a possibility that the anomaly was generated in the body welding unit, before reaching the final assembly stage. The group seems satisfied with this new possibility and decides to visit the assembly plant the following day. I go back to the UTE box with the technologist. While the solution is still pending, I ask him to reflect back on the episode. As we shall see, the language and the narration style are particularly relevant:

> The anomaly was reported yesterday to the chief repairman, who had passed the information to us. The customer had returned five containers of defective parts, 156 in total, because they presented a deformed hole. We took the faulty component from the repairing team, it was about 3 - 3.30 p.m. Together with the UTE leader of the second shift, I had a look at the anomaly. We consulted the maintenance person who was on duty when the lot was being produced. He said he did not perform any intervention on the machines. Then we had a word with the die maintenance leader and with the line conductor of the second shift because they had completed the lot. Basically they had worked for three hours on Monday afternoon - *because the problem occurred on Monday afternoon* - before exchanging the dies. At 6 p.m. they performed the die change. I wanted to find out whether they had noticed any problem. They mentioned to me that, indeed, they had not noticed any problem nor had they performed any intervention. What they say is confirmed by a line conductor, who had called me for a different problem, around four o'clock. Meanwhile we had a look at the component, and the anomaly was not there, it did not exist at four. The die change took place at six. I do not know what happened between four and six, but the problem must have occurred within that lapse of time. Yesterday when I took the part and saw the anomaly, the first thing I wanted to establish was who had caused the fault. I wanted to establish whether it was a problem related to the end of the batch, or if an intervention had been performed, without amending the faulty parts. Yesterday I was not able to solve the puzzle. I went home without having solved my problem. This morning I arrived in the office and I saw a sheet reporting the 156 defective pieces. I asked the UTE leader whether any intervention on the machines had been performed on Monday morning. He replied no. We decided to investigate further the problem and we did what you have just seen.

Later on, a phone call informs the technologist that the puzzle is solved, revealing yet another possibility that had not been envisaged. The defective parts returned by the assembly plant do not belong to the lot that had just been completed on Monday, but to the previous lot of the same component, produced a few days earlier. The problem had occurred during the second shift and the die change had been brought forward

because there was a broken blue print on one die. Thus, the operators had detected the defect on the components, but had not performed the check backward on the containers that presented the anomaly:

> They had detected the anomaly; accordingly they had brought forward the die change and started processing the next component; the next step would have been to clear up the faulty parts in the previous containers. They did not do that because they thought that the problem had just occurred, without realising that they had already produced five containers of defective parts. Thus the anomaly refers to a previous lot and the intervention (substitution of the blue print) has been performed on the die.

Now that this problem has been finally resolved what will remain of the above episode? Is it an event that just ends in its resolution? The interview with the technologist reveals some interesting considerations about the experience-related nature of learning, the professional identity of middle managers and the division of knowledge between different roles:

> We are left with the direct experience of something we have lived through. To *them* (the line workers) it means that they have to pursue a further understanding of the method and thus to consider it useful, because, at the end of the day, the line conductors are those who produce. *We* do not need as technicians or chief of the UTE to experience this problematic event. For *us* it is important to know that this experience is part of a method, it is part of some occurrence we have faced and thus if we had acted according to some written procedure, we would have avoided the problem in the first place.

The failure in applying the procedure also characterises knowledge creation and utilisation as value-driven processes, stressing the definition of knowledge as "justified true belief":

> A procedure is what we have in this case because such a procedure was already identified and written and therefore we are confident on *our side*.[23] In fact, this is a problem that we have already seen many times, it is not the first: we have deformed holes, damaged ones, missing ones. It is just a matter of understanding that we already have a procedure to tackle the issue, and that has been overlooked. For *them* (the line workers) it is much more important since everyone does a job if he is convinced of what he does, I believe that is the drive. I can come to you tomorrow and tell you that you have got to do things in that particular way, but you may reply: why do I have to do it in this manner? Then you may

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[23] The procedure in question is one related to quality control. Typically continuous defects are discovered through sampling inspection, performed by the line conductor every hour or every 500 pieces produced. When one is found, the machine is stopped and the problem corrected. One hundred percent inspection is then conducted on parts previously processed to remove the defective items. In addition, a less accurate quality inspection is carried out by the workers at the end of the line on each part processed, before stocking the part in a container. In this case the defect was discovered by one of the workers at the end of the line, before the sampling inspection. The target lot was almost completed so it was sensible to anticipate the die change rather than performing a repair intervention on the dies. However, the quality control backwards was not performed.

> start to consider whether what I told you is useless, is true, is not necessary, and if you do not do it nothing happens, and so on and so forth. These events help to demonstrate that I was right in passing on the advice to you, and then you become more convinced of what is required from you, especially if the problematic event belongs to the set of things that I had asked you to perform.

It is precisely because of their recurrence that those problems require a general procedure. However, there are types of anomalies (less frequent ones) that may require a certain act of creativity because they appear for the first time and do not fall into the repertoire of existing cases/knowledge. A different type of knowledge is mobilised in these cases, one that emphasises the peculiar competence of the middle managers:

> Let's suppose that you have to face a problem you never expected. I make good parts and I have to put them into that closed container, and I have to fill it only to a certain height otherwise when I put another container on top of that one it will smash the pieces in it. Once it happened that we received about fifty pieces back and we could not understand what the problem was. At last we realised that it was because we had filled one of the containers too high and consequently the one on top of it smashed some of the pieces. Here there is no such thing as a method, common sense is the one thing piloting you through, but it is clear that if it happened again, I would have to set up a procedure. Then you say: you see that container, you can only fill it to that certain height, above that it becomes dangerous. This is part of an informal rule of common sense; common sense tells you to be careful to fill it in only to that point, but not even we have stopped to wonder: what is that specific height? How high can we fill it? [24]

6.4.2 The Panda's dashboard (2)

Five months after my second visit to the plant, the Panda's dashboard is at the centre of a second case of disruption. Once again, the anomaly concerns a hole out of centre, namely the hole where the steering column is supposed to pass. Once again, the anomaly had been detected by the Mirafiori assembly plant. The anomaly emerges only at a late stage of the assembly process (the car body is already completed), when the moment comes to assemble the steering column. Consequently, the damage involved is quite remarkable: the faulty component is internal to the car body and therefore cannot be disassembled. The UTE technologist along with the team leader is called up by the assembly plant to make sense of the problem. The identification of the operation producing the anomaly is almost immediate: it is the

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[24] "Common sense" is literally translated in Italian as "good sense".

punching press along the line. The "dynamic" of the problem is less clear though. More importantly, the two UTE members are wondering who within the UTE may be responsible for having sent forward parts that were clearly defective. The part itself does not make it possible to identify the time or the shift in which the anomaly was produced. The anomaly concerns only two pieces and therefore cannot be detected through the routine sample quality inspection. The responsibility is certainly attributable to one of the end of the line workers, who are supposed to check each component before storing it in the container.

A repair intervention is performed, without really understanding the cause of the problem. However, the same episode repeats three weeks after and then again after one month. The anomaly seems to arise in a random way and therefore escapes the sample quality inspection which is normally performed every 500 pieces (or one hour). The UTE is confronted by a double puzzle: a) Fix the problem; b) Detect which shift has produced the anomaly and accordingly warn the end of the line workers of that shift. Through a trial and error procedure the team members attempt to reproduce the problem in a fictional way in order to reconstruct the dynamic of the incident. Apparently, the problem stems from a wrong positioning of the part on the die. Instead of lying flat, the sheet hits against one of the die guides and remains in a slanting position. That is why the hole is not centred in its right position. They decide to place two sensors on the metal sheet of that component in order to detect a wrong positioning. One of the puzzles in now solved. But who did send the defective components to the assembly plant? The UTE technologist comes up with a tricky solution. Without informing his colleagues, he decides to set up the production line so that the shift is marked on the component (as is normally the case for most of the parts produced). The solution devised allows the technologist to locate the anomaly in time and therefore discover the culprit.

6.5 Detective stories as narrative devices

The problem solving activity depicted in the above episodes seems to be linked to a peculiar problem solving ritual, whereby human and non-human "actants" (Latour, 1987) are involved in a process of investigation. The problem solving procedure entails a set of moves aimed at detecting the cause of the problem, performing a

diagnosis and agreeing upon corrective actions.

More generally, what we see in the two episodes is a process of dramatisation characterised by the typical ingredients of a detective story. Investigation is triggered by the occurrence of a breakdown which is treated as a murder case. Problem solving takes the form of an inquiry in which the detective attempts to collect clues and reconstruct the facts. It implies locating the anomaly in space and time, formulating hypotheses and conjectures, conducting interviews. Even inanimate objects are summoned up as witnesses: dies, blue prints, gauges, samples, the UTE diary. In the second episode, the case is solved though delegation to an automatic "detector". The process of investigation inherent in the detective stories defines a distinctive sensemaking activity aimed at constructing a plot out of a disruptive event and proceeding through a series of inferences.

The relevance of detective stories for a theory of organisational knowledge is at least two-fold. Detective stories say something about sensemaking and the narrative dimension of knowledge. More specifically, they illustrate a specific mode of building plots out of disruptive occurrences. In order to understand this important point, it is worth examining the above findings in the light of the phenomenological analysis of action brought forward by Paul Ricoeur (1984) in his *Time and Narrative*. As we saw earlier, breakdowns bring a discordance into the smooth flow of action. In so doing, they act as triggers of a sensemaking process whereby actors switch their cognitive gears from habits of mind to active thinking (Luis and Sutton, 1991). Detective stories refer to a process of *mise-en-intrigue* (emplotment) whereby, as Ricoeur put it, "goals, causes, and chance are brought together within the temporal unity of a whole and complete action." The emplotment of an equivocal happening in the form of detective stories provides operators with a meaningful representation of action. "Intrigues" turn action into narratives, unfolding in a chronological/sequential manner and are characterised by a logical consistency inherent in the enchainment of facts and events. Admittedly, the location in space and time and the presence of a subject matter are the typical ingredients of a story. However, what makes a story meaningful is precisely the process of sequencing inherent in the enchainment of events. This latter point is clearly addressed by Karl Weick (1995). According to him, stories imply building a plot for an outcome through a process of sequencing.

The plot follows either the sequence beginning-middle-end or the sequence disruption-transformation-solution. But sequence is the source of sense in that it allows organisational actors to impose a formal coherence on equivocal happenings. Correspondingly, sequencing is a powerful heuristic for sensemaking (p.128-129). Dramatic and temporal unit are brought together in the narrative: time becomes human in so far as it is articulated in a narrative fashion.

Consider the interaction between time and narrative (sensemaking, punctuation) in the following account by the UTE technologist reporting a blackout occurred during the night shift:

> *Technologist*: "It has been a circuit failure in the electrical booth. The UTE 4, 5 and 6 have been idle for four hours. Actually the blackout has lasted for 2.5 hours, but, since for the robotised lines, when there is a blackout you lose the software, the memory, etc. and you need to restart the programmes, we have lost some more time... Look here (reading the notes jotted down in the UTE diary). Line 21: At 1.15 a.m. a die change was being performed. The blackout occurred at 2.10. The line was restarted at 3.30, but as it was on die change... at 1.15 I performed the die change, let's say it takes one hour, therefore it means 2.15, here we are, I have a line that has just completed a die change (at the time of the blackout). Then, I have other die changes to perform, but the dies cannot be moved because of the lack of power supply. So I try to work on the set-up... Therefore, in my opinion, line 21 you see here, die change, repairing of the dies in the repairing area, all these operations have been performed.... They probably had completed the die change... 4.15: start-up of the robots... therefore they had completed the die change. Then line 22: from 10 p.m. to midnight die change and start-up completed. Restarted at 4.30 a.m., then it's a bomb... therefore that line too was recovering from a die change..."
>
> *Researcher*: "A bomb?"
>
> *Technologist*: "That is what happened. After the blackout, electric power was supplied again at 3.00 a.m., not successful because of interference with the fire alarm system. Let's say that they had some work to do, maybe later on we can have a look at the visual control system to see whether they have posted any memo. We always act this way, in the face of a stoppage, of a stomach-ache, we try to switch to other types of jobs. For example, there is a lot of maintenance interventions that can be performed when the machine is idle...."

In the above conversation, a narrative is constructed around minimal information, namely time references and a list of activities performed by the team members during the night shift. The episode depicts a story, characterised by a distinctive plot. The enchainment of events is accomplished by means of inferences and conjectures, based on the knowledge of similar past occurrences, whereby the technologist retrospectively makes sense of the disruption.

The process of dramatisation of action also highlights the emotional quality of breakdowns. As in Greek tragedy, the emotional response of the spectator is built into

the drama (Ricoeur, *ibid.*) Ultimately, the narrative process and the construction of a plot around a disruptive occurrence is a strategy to absorb discordance. Catharsis, i.e. emotional release, is what turns discordance into concordance by bringing consistency back into equivocal action. In Ricoeur's words, it joins cognition, imagination and emotion.

The second aspect of the sensemaking dynamics described above relates to the prescriptive value of narrative in the process of knowledge acquisition and utilisation. Detective stories turn disruptive occurrences into cases, characterised by a specific plot, high emotional content, and a cathartic solution. In so doing, they define a distinctive process of knowledge acquisition that can be labelled "learning by examples". Competence displayed by middle managers on the shop floor seems to point to a repertoire of concrete examples, functioning as "templates" to which present occurrences can be reconnected. On the other hand, given the peculiar nature of knowledge creation dynamics on the shop floor, learning and knowledge acquisition seem to be closely associated with memory and the activity of collective remembering (Middleton and Edwards, 1990; Walsh and Ungson, 1991). In fact, the learning by cases strategy not only implies solving puzzling problems, but also remembering key resolutions. More importantly, it involves identifying common patterns between cases in order to reconnect present occurrences to past events (as in diagnostic activities) or to make predictions about future occurrences. The above considerations can be rephrased as follows: emplotment as a distinctive sensemaking activity carried out by shop floor operators is a necessary, but not sufficient condition for remembering. An important issue in understanding the process of knowledge acquisition, then, is to determine which cases will become part of the knowledge repertoire of the middle managers, or better, which occurrences will be remembered and therefore acquire the status of templates. This problem can be referred to as the "selection" of noteworthy experiences. In order to address the above issue, a temporal dimension needs to be introduced; in other words, we need to relate activities of sensemaking "in action" to emblematic stories of the past. The juxtaposition of sensemaking in the "here and now" to "retrospective" sensemaking provides the link between ordering equivocal action by means of emplotment and dramatisation, and remembering significant stories. Secondly, we need to situate narratives within the core values of the team in order to understand the mechanisms

for selection of notable experiences.

6.6 Team values, consensus and company culture

The identity of the team is grounded in the broader cultural system of the company expressed in the tenets of the integrated factory, where working together becomes a sort of ethical principle. The above quotes are representative of a pervasive way of thinking within the team:

> *Technologist*: "The challenge of the integrated factory and teamwork is to foster a general commitment so that a problem is not only yours, but involves everybody. Individual interests must not exist. The old way of working was the celebration of the individual's inventiveness. Working in team means working together".
>
> *Operations manager*: "... to think the same way with the same objectives".
>
> *UTE leader*: "we believe that what really matters is neither a professional factor, nor experience, but harmony and mutual respect. Then comes the more or the less capable".
>
> *Technologist*: "personal interest must not exist. If I say to a colleague working on a different shift: "I am better than you are because I have produced more pieces", this is a curb to the integrated factory's philosophy, because what really matters is the amount of pieces produced by the UTE, the turnover of the UTE as a whole. It is good to have a healthy competition between UTEs, but within the same UTE competition must not exist; within the team people must work in harmony and agreement".

During the fieldwork, a number of emblematic stories were reported by the team members, supporting the above statements with some concrete evidence. Below are the most significant:

> *UTE leader B*: "once a conductor accidentally broke a robot's arm. He immediately came to report the incident, taking upon himself the responsibility for it. This spared us the trouble of analysing the causes of the incident and made us save a considerable amount of time."
>
> *Technologist*: "let me tell you an episode that made me particularly glad. During a visit to the shop floor the director of the plant notices a container upside down and the pieces inside it scattered on the floor. He calls the UTE leader and the technologist to account for the episode. Meanwhile the forklift conductor stops and explains how the incidents occurred saying that it was his fault. The director thanks us and goes away. In a subsequent meeting the director congratulates us on the atmosphere that has been established within the factory and reports the episode of the forklift conductor as an emblematic one. He was very glad

that the forklift conductor had admitted his error.[25]

UTE leader A: "let me give you a concrete example. We had just started to produce the Punto on line 24. We had to produce a component that, given its peculiar shape, was critical to press. Our assembly plant needed the components. We got into serious trouble and the line had been idle for the last three shifts. We were able to produce only three components at a time. Nevertheless there was a car at the end of the line, with its trunk open, waiting for the pieces to carry them to our assembly plant."

Any technical problem, especially when deriving from a human error, raises important ethical issues related to blame attribution. In fact, detecting the source of a technical breakdown implies finding a culprit (human or non-human). The way operators deal with blame management is particularly insightful. Specifically, the team seems to reward those behaviours that prevent painful investigations aimed at discovering a culprit. This is consistent with the team spirit and the new values brought about by the integrated factory model (e.g. working together, harmony, being part of a family) At the same time, the power element contained in the above stories highlights the impending presence of the hierarchy. Generic workers are indeed subordinates. They are supposed to work according to the procedures and report to their superiors. In other words, the margins of freedom inherent in the work of middle managers do not seem to apply to line workers. Hiding the truth is a sanctioned behaviour for at least two reasons: it drags the entire team into time consuming investigations; it eludes hierarchical control mechanisms.

For example, oversights and human errors are tolerated (and indeed turned into emblematic stories) insofar as they reinforce existing team values. Some of these values imply the recognition of seniority and the hierarchy. Consider the stories of the line conductor who broke a robot's arm and that of the forklift driver who accidentally hit a container. The two stories contain some fundamental ingredients: a disruptive event, a power relationship (line conductor *vis-à-vis* the UTE leader, forklift driver *vis-à-vis* the director of the plant), high emotional involvement, a happy ending and a moral. These ingredients turn the story into a noteworthy experience that can be remembered and which acquires a prescriptive value (guide to conduct). It reinforces the value of taking responsibility for one's own mistakes,

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[25] This episode is well known within the factory. The HRM manager reported the same episode during a subsequent conversation.

which is crucial when working in a collaborative environment.

On the other hand, the cases of the Panda's dashboard tell a different story about the social implications of organisational disruptions, emphasising a crucial knowledge divide within the team. This episode too is clearly concerned with a human error. More specifically, the way knowledge is divided on the shop floor seems to reflect the existing division of labour characterised by a clear separation between middle managers and line workers (despite the team spirit). As a consequence, while middle managers seem to rely on experience and common sense (the detective's approach), line workers are supposed to follow the procedure and learn to develop methods for dealing with anomalies.

The ethical implications of ordinary disruptions provide an insight into the activity of remembering (i. e. the selection of noteworthy experiences). Sensemaking seems to be associated with the conceptualisation of disruptive events as emblematic situations, either real or hypothetical. In the episodes considered so far (see also previous sections), this recurrent pattern takes the form of a significant example: "suppose that..." or "let me give you a concrete example". Emblematic stories serve as narrative maps or "guides to conduct" (Weick, 1995). What is striking, the "learning by examples" pattern links the acquisition of technical knowledge to the appropriation of organisational values. In other words, learning dynamics at the group level are shaped by the definition of the team's identity and by specific patterns of social behaviour. The above correlation emphasises the conceptualisation of knowledge as "justified true belief": the local practices of the team are situated within a system of sanctions and rewards.

To sum up, the emblematic stories analysed above highlight a process of infusion with values that makes certain episodes part of the patrimony of knowledge of the team. Put another way, noteworthy experiences are institutionalised as knowledge templates that become part of organisational memory and reinforce the team's identity.

6.7 The detective's approach: theory of method

The detective stands as a metaphor of investigation in everyday life and therefore carries an existential meaning. The detective is first of all a sensemaker, engaged in the resolution of everyday disruptions. Accordingly, detective stories, far from merely referring to a literary genre, identify a particular mode of making sense of our everyday practices.

Detective stories point to a theory of method, which is at the same time a theory of knowledge. Carlo Ginzburg (1990) has conceptualised the detective's strategy of investigation as an emergent epistemological model which he labels "evidential paradigm". The essence of the paradigm lies in the formation of conjectures based on the collection of evidence in the form of clues. It stresses the importance of guesses, systematic gathering of "small insights" and attention to detail in the process of knowing and discovering reality. The conjectural method stands behind what Ginzburg calls the "humane sciences" as opposed to the "natural sciences", dominated by the "quantitative and antianthropocentric" Galilean method. The pervasiveness of the evidential paradigm is visible in the methodology for the "recognition of painting" (i.e. identifying fakes, distinguishing originals from copies) as well as in Freudian psychoanalysis or in the inductive method of investigation epitomised by Sherlock Holmes. It stands at the heart of history and Hyppocratic medicine, as well as more exotic disciplines such as physiognomics, and divination. Ginzburg demonstrates how this paradigm works effectively in understanding the tacit features of reality: "through reality may seem to be opaque, there are privileged zones - signs, clues - which allow us to penetrate it."

When related to an institutional context, the evidential paradigm points to the nature of normative structures. For example, in ancient Mesopotamia the evidential paradigm was evidenced by "an attitude oriented towards the analysis of specific cases which could be reconstructed only through traces, symptoms and clues. Mesopotamian legal texts themselves did not consists of collections of laws or ordinances, but of discussions of concrete examples."

Transposed to the context of the present study, the pervasiveness of detective stories informing operators' practices and the related paradigm possibly refer to the use of

knowledge that has become tacit. This type of knowledge does not seem to reside in standard procedures or written norms, but rather has been institutionalised as common sense. Indeed, a distinctive feature of the detective's approach is its commonsensical nature. It implies questioning the obvious, sometimes breaking the rules if necessary. Moreover, following Weick (1995), it is possible to argue that common sense is the outcome of inductive generalisations grounded on narratives (rules of thumbs, anecdotes, war stories.).

The tacit nature of common sense knowledge highlights an interesting paradox related to the question of what it means to be a professional. Common sense is the distinctive feature of middle managers' competence. It is professional knowledge that has been developed through experience by seeing the same problem many times. Because commonsensical knowledge is tacit, it cannot be articulated and therefore transferred to generic workers or to newcomers. On the other hand, if common sense was made explicit it would be transformed into procedural knowledge and probably lose its effectiveness. Once again, Ginzburg's insights into the nature of conjectural knowledge and the impossibility of formalising it are particularly illuminating:

> Knowledge of this sort in each instance was richer than written codification; it was learned not from books but from the living voice, form gestures and glances; it was based on subtleties impossible to formalise, which often could not even be translated into words... These insights were bound by a subtle relationship: they had all originated in concrete experience. The force behind this knowledge resided in its concreteness, but so did its limitation - the inability to make use of the powerful and terrible weapon of abstraction (Ginzburg, 1990:114-115).

6.8 Making sense of sensemaking activities: a model of competence development

The nature of the production process in a pressing plant is such that people are continuously confronted with interruptions, breakdowns, and perturbations in the work process. Lines stop rather frequently, both because of discretionary decisions and unexpected events. Machinery requires constant maintenance work, work force needs to be re-allocated whenever the line is idle, changeover operations take place almost every day, and fluctuations in the customer's demands are very likely. All these interruptions and unexpected events require a continuous activity of variance absorption. Production schedules are constantly adjusted. Production voids are envisaged in order to allow for different types of intervention. Teamwork is a

fundamental absorption mechanism. It helps to keep the emotional content of breakdowns under control. Moreover, the need for continuously making decisions is a reinforcement of the group culture.

Taking into account the constraints imposed by the production system, the study has attempted to draw upon the narratives reported by relevant actors on the shop floor in order to investigate those sensemaking dynamics that lead to the development of middle managers' competence. The model in Figure 16 displays a pattern of competence development based on the resolution of critical incidents.

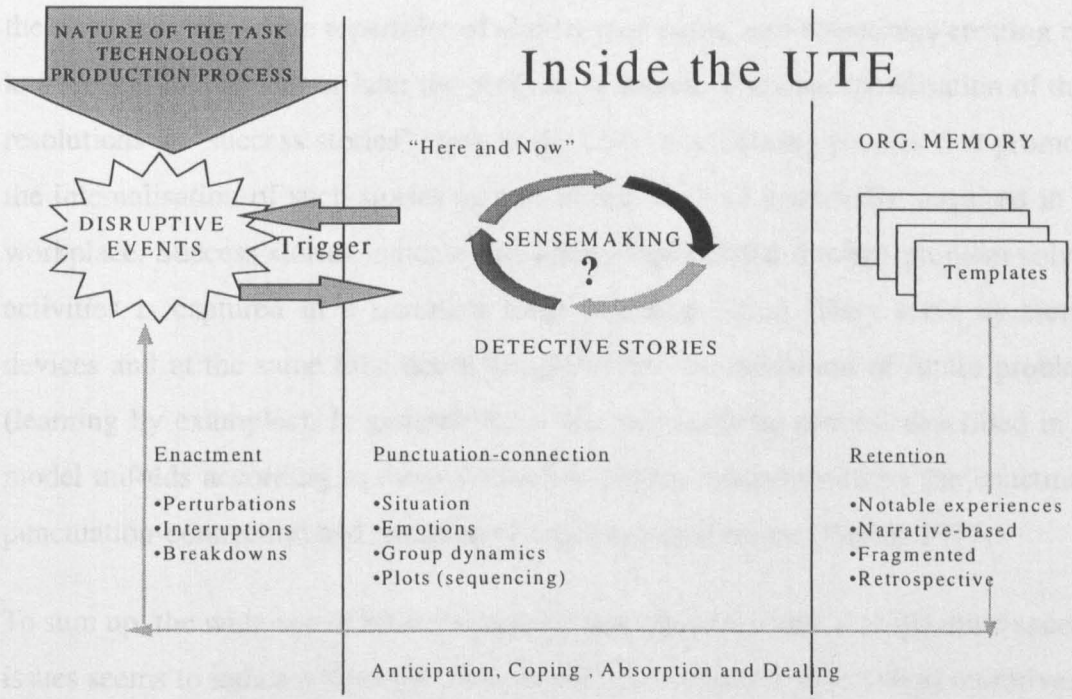

Figure 16. Sensemaking on the shop floor

As it can be seen, sensemaking is triggered by disruptive events (breakdowns, interruptions, and technological perturbations) occurring at the interface between the "business as usual" of routine situations and the conscious awareness of problem solving activities. While solutions are still "pending", operators are confronted by the equivocality of the "happening"; time becomes a matter of concern and emotions play an important role. The situation is socially constructed through a network of conversations between the members of the team, and by piecing together different sources of information:

> Most of the times, meetings arise spontaneously along the line, when faced with a concrete

> problem. For example, you are on the line, you detect a fault on a component, you know that somewhere there is a fax from a customer complaining about that defect.... you look for the quality control manager... the most important meetings arise in that way since everything happens on the shop floor and everyone is available (Technologist).

Diagnosis occurs as a narrative process, in which problems are dramatised and made visible. More specifically, it involves turning equivocal happenings into meaningful stories, characterised by a distinctive plot. The enchainment of events and the representation of action, inherent in the diagnostic process, take the form of a detective story, emphasising the conjectural, evidential nature of the process of knowledge acquisition and utilisation. Eventually, solutions are elaborated (most of the time drawing on the repertoire of similar past cases, and sometimes creating new knowledge) and sooner or later the problem is solved. The conceptualisation of these resolutions as "success stories" stays at the core of a learning process that promotes the internalisation of such stories as part of the stock of knowledge acquired in the workplace. Success stories indicate that knowledge created through problem solving activities is captured in a narrative form (learning units). They serve as storage devices and at the same time act as templates for the resolution of future problems (learning by examples). In general terms, the sensemaking process described in the model unfolds according to three distinctive phases characterised by the enactment, punctuation-connection and retention of organisational action (Weick, 1977).

To sum up, the wide use of telling examples that operators utilise to illustrate specific issues seems to indicate that competence and knowledge lie in the vivid narratives of the team members. Competence builds up through the stratification of problematic events that have occasioned a perturbation both in work and sensemaking processes. These episodes impose heavy demands on interpretation since they require performing diagnoses, elaborating solutions, and making decisions. Also, the degree of emotional content associated with these events is probably crucial in establishing their relevance and accordingly causing the most emblematic episodes to be memorised. As a consequence of the dynamics underlying the interpretation and resolution of disruptive events, existing competence can be described as tacit, situated, retrospective, oral and fragmented. The nature of such competence makes it difficult to encapsulate it in a well defined framework and consequently may hinder the process of knowledge transferral.

6.9 Concluding remarks

The case described above documents the complex interplay between the organisational context, the technology and the practices of a best performing team, showing how the interaction between these three elements leads to the creation and institutionalisation of organisational knowledge. We have argued that operations on the shop floor are governed by a stock of highly idiosyncratic knowledge which is enacted and constructed by means of narratives. In bringing the main findings of the study to a synthesis, this concluding section highlights the contribution of narratives for a study of organisational knowledge. This implies addressing the following questions: Why do we bracket stories as knowledge? How do the stories become knowledge? What is distinctive about stories?

The study has thoroughly tackled the above issues. First of all, stories act as noticing devices or attention directors affecting the dynamics of knowledge creation and collective remembering. Specifically, the construction of narratives highlights distinctive sensemaking processes of enactment, punctuation and retention, through which operators frame the complexity of the shop floor. An exemplification of the above is the strategy of investigation, based on the detective's method, adopted in the face of disruptive occurrences. Secondly, stories stay at the core of a selective process whereby daily experiences are filtered out and capitalised in the form of templates, thus becoming part of the team's patrimony of knowledge. We have labelled this distinctive process of knowledge acquisition "learning by examples". In this regard, stories possess a strong metaphorical character resulting in a double edge: they are prompts and reminders, collectors and transmitters of knowledge. Finally, stories in the form of notable experiences are part of a cultural system reflected in the conventional wisdom of the team members. Here, the value-driven character of knowledge as "justified true belief" is emphasised.

The latter point highlights the contribution of these findings when compared with Orr's (1996) classic study on photocopy repair technicians. Admittedly, stories analysed in the above case engage with the technology in that they tell about workers confronting troubled machines. However, the punch line of the stories collected on the Mirafiori shop floor seem to point to social relations (e.g. transgressing hierarchical boundaries), teamworking and collective labour. Narratives support the

flow of information between people rather than machines. For instance, the detective metaphor underlying the daily talks about machines is actually about the unknowability of people, it is about human behaviour and moral conduct (i.e. who is the culprit?) Likewise, common sense as a cultural system is about behaviours, boundaries and censorship. It points to cultural rather than technical knowledge.

To conclude, the findings of the study highlight the presence of distinctive modes of knowledge creation, utilisation and institutionalisation within a highly institutionalised setting. Indeed, "all that is planned is organisation", as a team member put it; and it is also true that the presence of machines is quite conspicuous. However, the dynamics observed over the Mirafiori shop floor emphasise the role of humans in their everyday endeavour to articulate tacit knowledge in a narrative form. Under these circumstances, organisational routines seem to have been replaced by narratives as the main carriers of organisational (tacit) knowledge. Common sense, encompassing both the team's values and the distinctive capabilities underlying the execution of factory operations, stand out as a cultural system (Geertz, 1983). Within such a type of cosmology, organisation as a machine governed by a set of plans seems to recede into the background, its presence confined to the daily talk of the team members.

CHAPTER 7: LESSONS FROM THE CASES: THEORETICAL INTERPRETATIONS

7.1 Introduction

Having reviewed the main literature on organisational knowledge in chapter 1 and presented the case studies that constitute the backbone of the research, it is now time to address the main research questions of the study in order to fill the gaps identified in the literature. Accordingly, the purpose of this chapter is to build generalisations from the main empirical findings of the case studies presented earlier. To accomplish this task, the chapter looks retrospectively at the research process in order to a) make theoretical interpretations from the case studies; b) identify empirical patterns within and across the cases.

In order to achieve the above purposes, a classificatory system is needed, providing a vocabulary for knowledge-related phenomena as well as explaining how those phenomena develop in organisations. This serves as an interpretative framework that can eventually be applied to the case studies considered in this research. At the same time, the classificatory system ought to be anchored to a conceptual definition of organisation and the phenomenon of organising, here referred to as the ontological argument. In fact, the knowledge-related dynamics described in this study originate from distinctive organisational activity systems that point to the nature (way of being) of organisation.

At the overarching metalevel the study has attempted to follow the transformations of organisational knowledge over time in order to describe both the content and the nature of the dynamics of knowledge creation, utilisation and institutionalisation in the work setting. Accordingly, the analytical cornerstones of the classificatory system should include a definition of the content, process and context of knowledge in organisations, conceived as related dimensions of the same phenomenon rather than separate knowledge categories.

The classificatory system presented in the following sections sets out to fill the main

gaps in the knowledge literature identified in chapter 1. As we have seen, most of that literature relies on the distinction between tacit and explicit knowledge as alternative forms of knowledge, without really addressing the content of the knowledge creation and acquisition processes. Furthermore, although it is recognised that knowledge creation occurs through a transformation process occasioned by the interaction between the tacit and the explicit, there are some important gaps in the description of this process. As a consequence, knowledge creation appears to be an abstract process, detached from practice and from empirical evidence.

In the pursuit of knowledge, the inquiry conducted in this study has stressed its processual nature by focusing on the following key questions: how does a system of knowledge come into existence? What are the conditions that make organisational knowledge durable and therefore usable? How does knowledge come to be taken for granted by organisational communities? In what way does knowledge make organisations unique and how is it turned into a source of competitive advantage? In order to address the above questions, our interpretative framework portrays organisational day-to-day activities as recursive processes of knowledge creation, utilisation, and institutionalisation. The above processes identify the typical knowledge cycle by which organisations produce generic knowledge outcomes. Finally, the framework refers to knowledge contents as organisational black boxes in order to stress both the tangible and the intangible aspects of knowledge in organisations.

The second part of the chapter applies the notion of knowledge cycle to the main empirical findings of the study in order to emphasise the linkages between process and content of knowledge development in each case study. Accordingly, we move from abstract knowledge contents, generically defined as organisational black boxes, to specific ones. We label the principal knowledge contents identified in the study *blueprints*, *routines* and *common sense*. In addition, the combination of knowledge processes and contents highlights specific knowledge types. Three main knowledge types are identified in relation to the transformations that knowledge undergoes over time: *foundational knowledge* is connected to the design of organisation; *procedural knowledge* refers to the routinised character of organisational action in consolidated work settings; *experiential knowledge* points to more mature stages in the

evolutionary trajectory of knowledge and organisation. Finally, by juxtaposing the three case studies in a sort of "photo-montage", we try to identify knowledge trajectories within organisations and speculate on some possible evolutionary trends in knowledge creation.

The chapter is organised as follows. The next section defines a main ontological argument underlying the way of being of organisation. Based on a phenomenological description of the dynamics of organising, the ontological argument relies on the categories of being and becoming as main determinants of organisational behaviour. Section 3 develops a classificatory model of knowledge linking the three dimensions of process, content, and context in a coherent whole. The model, to which we refer as the "knowledge cycle", constitutes the essence of the epistemological argument of the study. Section 4 applies the above interpretative framework to the case studies developed in this research. The concluding section stresses the heuristic nature of the above model insofar as it is built on ideal types of knowledge. This is exemplified by showing elements of continuity across the cases and identifying possible overlapping regions between different knowledge types within the same setting.

7.2 Being and becoming: the ontology of organisation

A leading thread of this study is that a dynamic theory of knowledge in organisations should be grounded on a conceptual definition of organisation and the phenomenon of organising. In contrast to functionalists' views of organisations (e.g. Parsons 1951; Selznick, 1957; Blau, 1964), which privilege unity and instrumental order, our main ontological argument is that organisations are characterised by an intrinsic condition of ambiguity and disorder (Cooper, 1990). Accordingly, we focus on the processes whereby organisations appropriate order out of disorder: "the work of organization is precisely focused upon transforming an intrinsically ambiguous condition into one that is ordered, so that organization as a process is constantly bound up with its contrary state of disorder. Seen in this way, the mutuality of the organization-disorganization opposition becomes a central issue in the analysis of social organization and social action" (Cooper, 1990: 172). Cooper's analysis suggests that we should look at organisation-disorganisation not as a dichotomy, but rather as different facets of the same phenomenon. In a more recent elaboration of the

organisation-disorganisation opposition, Cooper and Law (1995) have attempted to move from a vision of organisation as a *fait accompli* to the process of organising, in order to capture the *in fieri*, emergent character of organisational phenomena. Accordingly, organising rests upon the dynamic interactions between order and disorder, routines and breakdowns, steady states and controversies. These interactions can be described by referring to the ontological categories of *being* and *becoming*, to which Cooper and Law allude as distal and proximal modes of thinking in organisational analysis. The two modes are somewhat complementary. Distal thinking emphasises outcomes and ready-made aspects of organisations. Proximal thinking refers to processes and looks at organisations as ongoing accomplishments (organisations in the making). The shift from the proximal to the distal occurs through a process of translation whereby processes and actions are transformed into stable structures and effects.

This process becomes apparent when we consider the authors' phenomenological description of action: "in its most callow sense action is a *happening*; before anything else—before meaning, significance, before it's fitted into any schema—*it simply happens*... The happening is "nothing"—or rather no thing, no object, no form—because it doesn't possess any meaning, it is equivocal and symmetrical; it's not yet properly articulated, ordered, organised, not yet been converted into a product or effect. In other words, the happening is a heterogeneous process that has no before or after, no start or finish, no cause or effect: it always remains "unfinished". Only when it takes its place in the network of what has *already* happened does it become ordered and organised, translated into an effect" (pp. 241-242).

In the pursuit of knowledge, the distinction between the proximal and the distal underlines the way organisations seek to make sense of the flows and processes which characterise their activity. It highlights the importance of the kind of sense-making processes which have been most carefully dissected in the work of Karl Weick (see chapter 1). According to Weick (1995), action is a continual flow which shapes and is shaped by the unfolding of time. Following the philosophical ideas of phenomenologists like Schutz, Weick observes that time exists in two different forms, as pure duration (happening) and as discrete segments. Pure duration is a "coming-to-be and passing-away that has no contours, no boundaries, and no differentiation"

(Schutz, 1967: 47). Pure duration makes sensemaking somewhat transparent, as it renders actors unaware of the activity in which they are engaged. In pure duration, action is experienced as a *continuum*, characterised by symmetry and equivocality. In other words, action is "raw material" that needs to be put into some frame of reference in order to become meaningful. So how do people make sense of situations they encounter? How is meaning created? Weick observes that flows are often punctuated by discontinuities in action and time, interruptions, discrepancies, situations of novelty, and so on. When such discontinuities occur, purposeful action is disentangled from the flux within which it was immersed, and thus from the flow of pure duration. Discontinuities allow agents to look at things in a retrospective way and therefore transform action into events, processes into outcomes, experiencing into experiences. Retrospection is crucial to sensemaking. As Weick puts it, "people are always in the middle of things (projects), which become things only when those same people focus on the past from some point beyond it."

The phenomenological description of action suggests that making sense of equivocal and symmetrical occurrences is closely connected to the experience of time. Anticipation and retrospection act as temporal devices whereby "happenings" are harnessed into structures of signification and action is rendered meaningful. Anticipation and retrospection can be related to the design of organisations. As Akrich (1993) has pointed out with respect to the design of objects: "designers define actors with specific tastes, competencies, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science and economy will evolve in particular ways. A large part of the work of innovators is that of *"inscribing"* this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or "scenario"." Likewise, organisations are designed to anticipate action in space and time, and to direct and prescribe the behaviour of organisational actors according to a particular vision of the social reality. The script refers to a pre-understanding of reality, a pre-interpreted world that provides the background knowledge underlying organisational performance.

However, this pre-understanding is grounded on retrospection, that is, on the possibility to focus on the past from some point beyond it and consequently to

foresee certain outcomes: "the problem of what will come next is perhaps the fundamental problem of ordering and organizing" (Cooper and Law, 1995: 242). Hence, organisation can be seen as the ex-post rationalisation of action, a mechanism that continuously swings between anticipation and retrospection. The latter is considered by the Cooper and Law as a real *engineering* of time: "without retrospection there is no anticipation, no ordering, no organisation... it is a matter of constructing the future so that it looks like it's always been there" (*ibid.*: 242).

As stated above, anticipation and retrospection highlight the importance of the factors of time and tense and their influence on the way organisations seek to make sense of their activities. More specifically, they point to the difficulty, within organisations, of dealing with the unknown, whether that means living the present as "here and now", or perceiving action as a happening, as an equivocal and symmetrical experiencing. In order to overcome this difficulty, a third mechanism, which provides a perspective on the present *from* the present, needs to be introduced. Here is where repetition comes into play. Repetition transforms novel experiences into ordinary events. Once again the work of Cooper and Law provides a useful insight: "an obvious (but neglected) feature of organisation is that it has to repeat itself in time, to renew actions every working day." Repetition, in the form of routinised activities, allows organisation to cope with everydayness by turning the "happening" of action into a familiar sequence of events. Routines represent the liturgy of organisation, the effort to frame the equivocality of action through rituality. Action is thus encapsulated into stable patterns, entangled into standard plots. Anticipation, retrospection and repetition make the circularity of time a permanent feature of organisation. Anticipation casts a glance on the future from some point behind it; retrospection focuses on the past from some point beyond it; repetition attempts to harness the present into some stable, recognisable pattern. In this way, organisation is turned into a sort of clockwork, again a blackbox, whose functioning depends on the possibility of rendering time transparent. The above activities - and the related processes of planning, ordering and sequencing - incarnate the strategies whereby organisations manipulate action in an attempt to appropriate order out of disorder.

To sum up, the division of labour, the production system, the design of standard operating procedures and interlocking routines can be viewed as an attempt to

anticipate action in space and time. These devices do so by providing sense-making mechanisms and predetermining resolutions to problematic situations. As with any object, organisations are designed on the basis of a pre-understanding of reality (Winograd and Flores, 1986). At the same time, the above devices point to what organisations take for granted, thus making them more transparent. As we shall see in the following sections, sensemaking in organisations relies on the presence of black boxes, which can be seen as embodiments of organisational knowledge and constitute a pre-condition for the utilisation of that knowledge.

7.3 Building a classificatory system of knowledge: the epistemological argument

As stated in the introduction, a theory of knowledge cannot be divorced from the conditions underlying the way of being of organisation. Accordingly, the epistemological argument underpinning this study contends that organisational knowledge springs from the tension inherent in the dichotomies organisation/disorganisation, being/becoming, order/disorder, routines/breakdowns, and so on. Drawing on the above dichotomies, a classificatory system of knowledge in organisations should be able to capture the changing forms that knowledge assumes over time by dynamically deriving knowledge outcomes from knowledge processes. This section sets out to construct such a system.

7.3.1 Organisational black boxes

In analysing the content of knowledge in organisations, two arguments seem to collide. On the one hand, knowledge can be regarded as a "presence", as a "ready-made" product, which can be manipulated and used instrumentally with respect to the goals of a firm. As a consequence, knowledge is considered as a strategic factor of production and causally linked to organisational performance. This functionalist argument is consistent with the definition of organisation as a steady state and resonates with the strategy literature on knowledge analysed in chapter 1. On the other hand, there is the constructionist argument, privileging the notion of becoming, for which knowledge creation is about resolving controversies. Accordingly, the constructionist approach focuses on the translation of controversial knowledge into

hard facts and products. This process of social construction and utilisation of knowledge is supposed to explain how organisational actors make sense of the everyday practice in which they engage.

Despite the sharp contrast in the assumptions informing them, the two arguments seem to have at least one point in common: the presence at some point along the path of knowledge creation of a durable outcome. In order to capture the nature of knowledge outcomes in organisations we introduce the notion of the black box. The term black box contains a fundamental semantic duality. On the one hand, it evokes the idea of a durability (a physical object) and therefore points to a commodified vision of knowledge. The black box has clear boundaries and shape, it can be seen, touched and manipulated. At the same time, the box is black and therefore opaque to the user. But what is invisible in the black box? To answer that question, let us consider a concrete example. What is invisible in a personal computer, a TV or a VCR? For the end user, it is certainly not the physical piece of equipment, but its inner workings. However, the mechanism that makes the black box work is not simply the array of electronic and mechanical sub-components that we could see if we only had the patience to unscrew the box that contains them. Rather, that particular configuration of sub-components is the result of a controversial process of knowledge creation that has now been settled and concealed in the box. The box is black also in another sense. It is an obvious, unproblematic entity that can be taken for granted by the user. A computer, a TV or a VCR only needs to be switched on in order to function, without requiring any knowledge of its technicalities. Therefore, blackboxing is a condition for use. The user does not care about what is inside the black box, only its instrumental character, or better, what the black box *does*. The black box allows the user to make sense of the functioning of a computer, a TV or a VCR without questioning the artefact.

The above example demonstrates that the notion of the black box acts as a watershed between the two arguments considered above. For this reason, we believe that the two approaches are to a certain extent complementary, although the different purposes underlying them produce different methods of inquiry about knowledge. For the functionalists, the black box is a point of departure. They need to solve a fundamental problem related to the fact that, unlike the other strategic factors of

production, knowledge is "intangible". For this reason, they take for granted the facticity of knowledge and treat it as a "ready-made" product. The commodification of knowledge makes it visible, transferable, and even measurable. This operation is instrumental in defining knowledge as a source of competitive advantage. In different versions within the same paradigm, knowledge is conceptualised as intellectual capital, competence, capabilities, core capabilities - all terms that clearly contain a prescriptive value and point to a causal/functional link to organisational performance. For the constructionists, the black box is a point of arrival. They are interested in the process of materialisation (commodification) of knowledge which culminates in the epistemological closure of the black box. Their method is to follow the agents of knowledge creation while they are busy at work, to present the different factions involved in the process and make explicit the controversies characterising the contest. But this controversial process can be reconstructed only after the fact, only in the presence of a black box that can be reopened. One approach stops exactly where the other begins. In the next section we present a theoretical model that builds on the complementarity of the two approaches outlined above in order to bridge the gap between them and hopefully provide a more holistic picture of knowledge-related phenomena in organisations. Specifically, the model describes the fundamental processes leading to the production of organisational black boxes (or knowledge contents). In metaphorical terms, the model is concerned with explaining *why* the box becomes black.

7.3.2 The knowledge cycle

Transforming knowledge into black boxes is a fundamental requirement for the use of that knowledge. However, in order to be turned into a black box, knowledge has to be recognised as valid: the closure of the black box implies an act of social acceptance and legitimisation. Therefore, in order to understand the transformations occurring along the value chain we need to explain the process whereby knowledge comes into existence, becomes socially accepted, and is eventually embodied in durable outcomes. This section sets out to provide a description of the dynamic cycle that leads to the production of generic knowledge contents, herein referred to as organisational black boxes. This cycle can be articulated in three main processes:

creation, utilisation, and institutionalisation. Figure 17 provides a diagrammatic representation of organisational knowledge processes.

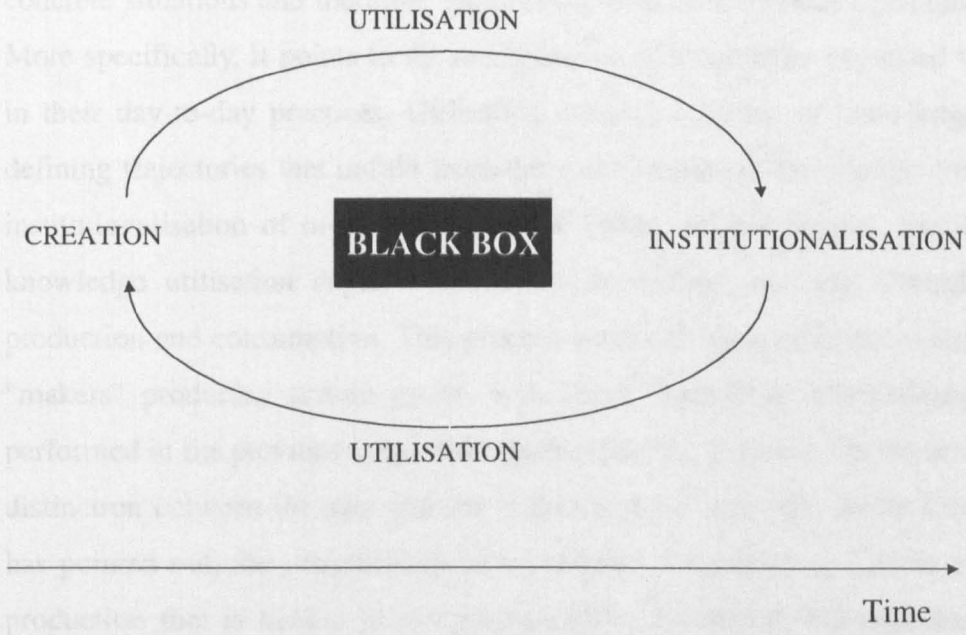

Figure 17. The knowledge cycle

Knowledge creation: Creation belongs to the domain of arts. It is the act of making, inventing or producing knowledge. In the classic work of Nonaka and Takeuchi (1995), knowledge creation is defined as "the capability of a company as a whole to create new knowledge, disseminate it throughout the organisation, and embody it in products, services and systems" (p. 3). This definition portrays knowledge creation as a self-contained process, with a beginning, a middle and an end. In this study, however, we place knowledge creation within a broader knowledge cycle. In this regard, creation is an incipient, generative process, identifying the sources and agents involved in the production of knowledge-related phenomena. In organisations, knowledge is created day by day at different levels and through a variety of planned and emergent activities going from meetings, conversations, and problem-solving to design and innovation. Furthermore, creation is about knowledge that is contested, controversial, provisional and therefore cannot be used in a systematic fashion. In

particular, the contested nature of the knowledge creation process can be reconnected to the uncertainty of the outcomes and the ambiguity of the intermediary pathways that lead to those outcomes. In its hypothetical connotation, knowledge creation represents a potential for the production of durable contents.

Utilisation: Utilisation refers to the application of a particular stock of knowledge in concrete situations and therefore identifies a distinctive "modus operandi" of a firm. More specifically, it points to the manipulation of knowledge exercised by the users in their day-to-day practices. Utilisation conveys a vision of knowledge "in flux", defining trajectories that unfold from the controversies of knowledge creation to the institutionalisation of organisational black boxes. In this respect, the dynamics of knowledge utilisation depict a model of knowledge evolving through cycles of production and consumption. This process occurs along a value chain that comprises "makers" producing certain goods, and "users" taking up (blackboxing) the work performed in the previous stage and transforming those goods. On the other hand, the distinction between the user and the maker is not a neat one. As de Certeau (1984) has pointed out, the consumption of a product can be seen as a form of secondary production that is hidden in the process of its utilisation. Through the process of consumption, the users enrich the materials at hand with new meanings and continuously reinvent them. Likewise, Latour (1987) has argued that the fate of a fact or machine is in the hands of its latest users. Accordingly, the notions of final product or end user are relative to the stage of knowledge creation that is being considered. The above considerations characterise knowledge creation as a circular process. In other words, through the dynamics of utilisation institutionalised knowledge is constantly manipulated and transformed, leading to further processes of knowledge creation. As a consequence, knowledge utilisation accounts for the dynamic character of knowledge in organisations, stressing processes of change and transformation. In mediating the interaction between knowledge creation and institutionalisation, the process of utilisation maintains the tension between being/becoming, order/disorder, opening/closure, from which knowledge springs.

Institutionalisation: Institutionalisation adds two important aspects to the process of knowledge creation. Firstly, it implies an act of social acceptance whereby knowledge is legitimised and recognised as valid within a community of practice.

The legitimisation of organisational knowledge points to the importance of reaching a consensus around what is "valid" knowledge, whilst highlighting a problem of conformity with existing organisational standards. Secondly, once it has been created and recognised as valid, knowledge needs to be represented and formalised in order to be transferred and diffused at a corporate level. For instance, organisational charts display a formal definition of the division of labour within a certain company, which has been socially accepted and legitimised by its members. However, the controversial process that has led to that particular division of labour has now become tacit. The organisational chart has been turned into a black box, into an unquestioned artefact. In order to trace back the process of social construction, we would need to reopen the black box following the strategies outlined in the methodology chapter.

Through articulation, knowledge is represented and made visible (articulation can be defined as the act of making knowledge manifest). At the same time, controversies recede into the background and legitimate knowledge is "sealed" into organisational black boxes: organisations create knowledge that can be fitted into purposeful devices. The organisation is formally represented and reduced to an abstraction. Only now can we see knowledge as a product or a commodity. The commodification of knowledge lies precisely in this apparent paradox of making manifest while hiding (e.g. duality of black boxes). As a result of institutionalisation, knowledge is inscribed into a system of norms, practices and conventions, and incorporated into stable structures. Knowledge becomes canonical, factual, definite and certain. Institutionalisation implies a process of epistemological closure similar to the creation of a black box. This process responds to the need of organisations to secure and protect the patrimony of knowledge they create. Finally, institutionalisation entails a process of infusion with values (Selznick, 1957) pointing to the philosophical definition of knowledge as "justified true belief". In that sense, institutionalised knowledge can be seen as a source of "difference", i.e. it stands as the factor that makes a firm what it is. Institutionalised knowledge is not related to organisational performance, but rather to the distinctive identity of a firm expressed in such concepts as reputation, accountability, prestige, fame, distinction, etc.

The above argument suggests four important considerations:

1. Knowledge cycles are seen as part of the broader phenomenon of organising. As for the ontology of organisations, the epistemological argument deals with the processes by which organisations harness the equivocality of action and accordingly appropriate order out of disorder;

2. The three processes depicted in the model address the what, how and why of knowledge-related phenomena. They provide general categories linking the process, content, and context of knowledge in organisations;

3. The notion of cycle contains a time element. A knowledge cycle is a process of transformation generating knowledge outcomes in a recursive fashion. In this respect, it is meant to capture the transformations that knowledge undergoes in organisations at different evolutionary stages;

4. A final issue concerns the role of the context within the above knowledge cycles. As specified in the research design, context is a function of the degree of knowledge institutionalisation (e.g. low, medium, and high), and, ultimately, tacit knowledge. Under these circumstances, context itself is time dependent. Furthermore, context is subsumed within action and evolves in parallel with knowledge cycles. In this respect, context is not defined as a sheer container of activity or a meta-level structure that can be treated as an independent variable. Rather, it is enacted (Weick, 1977, Smircich and Stubbart, 1985) in what people do and how they do it. The above conceptualisation of context points to the agency problem as elaborated by structuration and institutionalisation theories (e.g. Giddens, 1984; Pettigrew, 1987; Barley and Tolbert, 1997).[26]

7.4 Making theoretical interpretations of the case studies

Having defined a classificatory system of knowledge processes, this section applies the model described above to the three case studies. The three cases represent variations in context, and accordingly provide alternative backgrounds against which the knowledge cycle unfolds. The analysis of the case studies highlights three main

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[26] These issues will be discussed in more detail in the concluding chapter.

generic outcomes - here categorised as blueprints, routines, and common sense - resulting from the transformations that knowledge undergoes over time.

7.4.1 Blueprints: the mark of organisation

Case 1 depicts a situated learning process related to the coming into existence of a new factory. The essence of the case lies in the description of the successive transformations whereby a blueprint - expressed in the design concept of a new avant-garde factory - is turned into a complex hard product (the physical factory). The translation from the blueprint to the factory is not straightforward. Rather, it occurs through intermediary pathways that need to be carefully described. In this case study, we attempted to identify a number of phases by following the chain of transformations that knowledge undergoes over time. In its connotation of "in between", the "construction work" stands at the core of this process of knowledge transformation. It incarnates precisely the gap (in this case a radical discontinuity) that separates the blueprint from the coming into existence of a real organisation, and in this respect, stands as a metaphor of knowledge construction.[27]

The longitudinal analysis of the phases going from the design of the factory to its official opening has made it possible to follow a process of knowledge construction in a very detailed way. The analysis has highlighted the role of the actors involved, the structural constraints and opportunities offered by the green field site, and the learning processes and knowledge outcomes resulting from the construction of the factory.

The case portrays two interconnected processes of knowledge creation-institutionalisation. The first, related to the decision-making process upstream of the design concept, involves the top management of the company and revolves around a controversial process of change and innovation. The second concerns the implementation of the design concept. It involves a larger number of organisational

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[27] The involvement of the future work force in the construction work makes matters more complicated. Not only is the distinction between physical and social construction blurred, but so too is the one between producers and users.

actors and is centred around the construction work that leads to the opening of the new factory.

Knowledge creation is initially triggered by some kind of discordance: environmental perturbations in the automotive sector call the current performance of the company into question and emphasise an urgent need for innovation. The latter will eventually take a form of a radical paradigm shift. In fact, the decision-making process following the awareness of the crisis situation revolves around the question of how to handle the transition towards a new organisational model, one that is alternative to the Fordist production system. The initial controversy faced by the management of the company relates to the content and the scope of the innovation process and involves a strong debate between innovators and defenders of the old organisational model. The debate leads to the definition of a project for the construction of an avant-garde factory, which will incorporate in its design principles the main assumptions of the new production paradigm, known as the "integrated factory". The project is grafted upon substantial benchmarking activities (a knowledge creation process in itself) and the contributions coming from the task force endorsing the project. Interestingly, the company's board acts as a sort of tribunal, set up to redeem controversies, assess and select proposals. Furthermore, the board is a legislatory body, legitimating propositions and translating them into normative criteria for the definition of the project. At the end of this controversial process of legitimisation and articulation of the main guidelines of the Melfi project, we find a charter stating a mission and the main objectives of the project, and providing a blueprint for the design and implementation of the new factory. The blueprint is the result of a collective decision making process, highlighting the gap existing between knowledge creation and institutionalisation. It contains strategic choices selected from a variety of options available and recognised as valid through a process of legitimisation. Secondly, the blueprint articulates organisational knowledge around a specific vocabulary (the integrated factory, lean production, JIT and TQM), outlines the rationale for the above choices, and defines in detail the guidelines and operational steps for the implementation of the project. Finally, the blueprint incorporates new company values related to the process of innovation. In this respect, the epistemological closure incarnated by the written project is achieved through a process of infusion with values. Knowledge is sealed into normative principles which

make it possible to put it to use, and acquires a prescriptive value for the organisational actors.

The blueprint contained in the written project can be seen as a black box, a temporary stable outcome of knowledge creation which marks the coming into existence of a core nucleus of organisational knowledge embodied in the design of a new factory. At the same time, the design concept of a new avant-garde factory like Melfi is the expression of controversial knowledge in so far as it contains hypotheses about the future functioning of organisation, which need to be tested and put to work. In other words, the translation of a blueprint into a real work setting does not necessarily occur as a smooth, unproblematic process. Another way to express the contested nature of knowledge embodied in the blueprint is to view it as the espoused theory of innovation formulated by the company (Argyris and Schön, 1978). In this respect, the blueprint is the carrier of a gap between hypotheses and reality. It bears a number of open questions exhibiting the uncertainty of the outcomes of the project (e.g. Will the project deliver the company's expectations? Will the green work force be suitable for the job?). On the other hand, the green field site stands as the empirical counterpart of the project written on paper, and in this respect sets the stage for a subsequent knowledge creation process.

As explained earlier, the green field site and the contingencies surrounding the design of Melfi's factory, represent a very peculiar situation characterised by low levels of knowledge institutionalisation. Clearly, organisations are never constructed *ex nihilo*. As laboratories, they rely on the indefinite sedimentation of languages, equipment, institutions, practices and conventions (see Latour, 1995). The latter define the accumulation of successive layers of knowledge. In this respect, Melfi's green field rests upon the highly institutionalised stock of knowledge stemming from the history of the company and, more generally, the historical evolution of car manufacturing. Yet, as the literature has pointed out (see chapter 4), the green field situation seems to impose less constraints for the construction of knowledge. The character of *tabula rasa*, of *terra incognita* - not to mention the "virgin" work force" - make the Melfi green field almost an exotic place. To a certain extent, here it is possible to see the phenomenon of organising making its debut.

On the green field, we witness a process of organisational becoming, one that moves

from an embryonic form of knowledge, embodied in the design concept, to a more sophisticated one (the operational factory). The construction work that leads to the opening of the factory exemplifies a process of knowledge creation based on the appropriation of order out of disorder, and stemming from increasingly complex interactions within a heterogeneous network of human and non-human actants. The latter includes the design concept, the top management of the company, the green field, the newly recruited work force, the variety of actors involved in the construction work, the Trade Unions, and the local authorities. The construction work entails the progressive transformation of "raw material", in the form of heterogeneous knowledge sources, into stable outcomes.

The main knowledge outcome is epitomised by the factory itself. The factory represents a steady state, a state of order born out of disorder (the building site), a clockwork mechanism whose functioning is based the presence of stable organising principles. Routines are the emblem of the knowledge institutionalisation process related to the "formal" opening of the factory and defining the (epistemological) closure of a black box. The blueprint is now instanced by and articulated in the concrete functioning of the factory, embedded in organisational routines. Routines have now gained the front stage, but this does not mean that the stock of knowledge embodied in the blueprint has disappeared. Rather, by receding in the background it has become invisible, undisputed and taken for granted. However, as we will see in the next section, the analysis of breakdowns on the shop floor has brought to the surface some elements of continuity between the original blueprint and organisational routines, stressing the pervasive analogy between the design concept and the current factory operations.

7.4.2 Routines: organisations as clockworks

The black boxing of technical knowledge described above identifies a process of institutionalisation. In fact, once knowledge has been created and accepted as valid, organisations need to devise mechanisms to secure knowledge and make it durable. Case two addresses this issue. In other words, the case asks: How is knowledge put to work and made durable? What are the distinctive learning and knowledge acquisition processes related to the dynamics of institutionalisation? In order to tackle these

questions, we need to look at the further transformations and translations that knowledge undergoes over time.

The description of Melfi's plant, once it has become operational, points to the ways in which knowledge is proceduralised and articulated in a variety of organisational devices, and highlights the presence of the defining elements of organisation. The dynamics observed on the shop floor bring to the fore a network of human and non-human actors, carrying out concrete activities. However, in order to become meaningful, organisational actors and activities need to be inscribed into organisational devices and translated into specific plots. Actors are turned into roles and stylised into organisational charts portraying the division of labour; tasks are delegated to the technology (assembly line and IT) and organised around a production system; machines are ordered following a layout, activities enchained according to a workflow; time becomes measurable and punctuates the duration of the working day through the creation of shifts; the rhythm of machines is ruled by working cycles. The future is harnessed into production plans and deadlines. What characterises organisations is precisely this formal translation of a material network of actors and activities into a more abstract entity, of the proximal into the distal.

By putting boundaries around organisational actors and activities, knowledge is harnessed into stable structures of signification or organisational black boxes. The latter provide sensemaking devices and set the contours of action. As explained earlier, the "commodification" of knowledge through organisational black boxing entails a deliberate manipulation of time. Anticipation, retrospection and repetition - and the related processes of planning, ordering and sequencing - are the mechanisms which make it possible to relate present occurrences, or equivocal happenings, to the network of what has already happened. Furthermore, the notion of a black box conveys a dual emphasis: on the one hand it refers to the presence of boundary objects; on the other hand, it points to the fact that those "objects" can be taken for granted and are transparent to the user. As we stated earlier, the transparency of black boxes is a pre-condition for the effective execution of work practices and routines.

The above description seems to depict organisation as a clockwork mechanism, where, to use Mary Douglas' felicitous expression, "individual thought has been turned over to an automatic pilot" (Douglas, 1986: 63). On the other hand, the

perspective taken in the study points to a definition of knowledge as situated performance (Pentland, 1992), stressing the conceptualisation of work as practice. In fact, practices can be seen as the empirical counterpart of the clockwork. Case two portrays a further process of knowledge creation and institutionalisation centred around work practices, and related to the utilisation (consumption) of the existing stock of knowledge.

The transformation of the factory into a clockwork mechanism, where knowledge has been proceduralised and embedded in organisational routines, renders knowledge somewhat transparent. In order to enter this new level of complexity we need a different lens, a technique which allows for the displacement of tacit knowledge. In this situation of relatively advanced institutionalisation, breakdowns have provided a valuable entry point. As explained in chapter 2, the rationale behind the methodological tool is counter-intuitive: if organisational knowledge has become transparent (institutionalised) as a result of a routinisation process, the solution is to look at what happens when routines are disrupted or called into question. Accordingly, breakdowns offer an alternative method to open organisational black boxes. They provide a cleavage between organisation-disorganisation and thereby point to the dynamics whereby organisation appropriates order out of disorder. In the process of knowledge creation, disruptive events can be seen as a source of controversy since the lapse of time separating the occurrence of a disruption to its solution is intrinsically characterised by ambiguity and uncertainty. In other words, breakdowns stand as a challenge to the "business as usual" of routine situations as they trigger the application of existing knowledge in a deliberate way or the creation of new one. In this respect, breakdowns can be seen as "moments of truth", providing access to the stock of tacit knowledge which governs the execution of routines and revealing their *raison d'être*.

The observation of the dynamics of knowledge utilisation in day-to-day activities on the Melfi shop floor highlights processes of knowledge production and re-production, occurring in the here and now. The D/A routine, applied by shop floor operators in response to disruptive events along the assembly line, provides a basis of certainty, a structural framework for problem solving. Our analysis has shown that the D/A routine is grounded on a deep-seated stock of background knowledge presiding over

the execution of factory operations and characterised by situatedness, concreteness and pervasiveness. A main finding of the case is that this stock of knowledge seems to be grounded on a "founding analogy" (Douglas, 1986), born on the green field and institutionalised in a subtle way once the factory had reached the full production stage. What we called the D/A analogy is in fact mirrored and articulated in a variety of organisational devices underlying the functioning of the plant and relating work practices to organisational routines, core capabilities and the formative context of the factory. The presence of a founding analogy also reconnects the process of knowledge institutionalisation to theories of imprinting (Stinchombe, 1965). The above finding is quite important. The linkage between blueprint and organisational routines - incarnated by the D/A analogy - highlights elements of continuity between the green field and the operational factory, and thus provides a valuable insight into the genesis of organisational routines. As it is known, the importance of routines in organisations has been widely recognised in the literature. Nelson and Winter (1982) offer the most powerful conceptualisation of routines within the field of organisation studies. As we have seen earlier, they view routines as the genetic code of organisations, hinting at the primacy of structural elements over human ones and ultimately pointing to a definition of organisation as a clockwork mechanism which evolves in a random fashion. A major omission of the above theory, however, is the issue of the origin of routines.

The present study has attempted to relate routines, as we observe them in the everyday life of organisations, to organisational design as articulated in a blueprint. The "D/A analogy" clearly relates the current routines and practices observed on the shop floor to the design of the factory and, more generally, to the archetype of the assembly line. More importantly, the (founding) analogy highlights the isomorphism between organisational design and organisational practices. In this respect, it stands at the core of a knowledge institutionalisation process, pointing to some kind of organisational "cosmology" (Weick, 1993) and emphasising the cognitive imageries and institutional arrangements that operators take for granted in their everyday coping with both routine and breakdown situations (Ciborra and Lanzara, 1994).

The isomorphism between the task, the technology, the organisational artefacts, and the cognitive structures governing the execution of routines bears important

implications for the institutionalisation of organisational knowledge. Institutionalisation is evidenced in the pervasiveness of certain organisational patterns, images, and so on, that is, in the equivalence of certain organisational forms. Knowledge is formalised and articulated, mirrored, represented and reproduced in a variety of organisational devices, hence the importance of isomorphism. In analysing the dynamics of institutionalisation, Di Maggio and Powell (1983) have defined institutional isomorphism as the engine of rationalisation and bureaucratisation. Put another way, isomorphism is the essence of institutionalisation in that it allows knowledge to be formalised, secured and articulated in organisational artefacts. Isomorphism defines the consistency between a set of institutional arrangements and the cognitive imageries characterising a specific work setting. In this respect, organisational isomorphism is a pre-condition for rendering knowledge durable and usable.

The relevance of institutional isomorphism is apparent in the learning dynamics underlying problem solving activities on the shop floor. The D/A analogy possesses a normative value in that it sets a path for learning and pre-determines a repertoire of moves to be enacted in the face of disruptive events. But what makes the analogy work? In order to address this question we need to look at cognitive systems as inferential structures governed by dominant analogies. An analogy is an efficient cognitive tool in that it helps people to make sense of complex situations by providing short cuts in the execution of everyday practices. In every cognitive system it is possible to distinguish between an analogic system (as-if) and an inferential one (if-then). The as-if of the analogic structure rules the system of inferences. In other words, the analogy of "disassembling", based on an as-if syntax, enacts a specific problem-solving procedure. In this regard, the efficiency of the cognitive structure is based precisely on the isomorphism of the analogic and the inferential structures.

7.4.3 Common sense: organisations as human artefacts

Although there is no historical continuity between this case study and the previous ones, the institutional characteristic of the Mirafiori Pressing plant seems to offer a fertile ground for speculating about a further transformation of knowledge occurring

over time.

Case three is the emblem of a mature stage of knowledge creation and institutionalisation. With Mirafiori we move to a brown field, that is a setting characterised by an experienced work force and stickiness of organisational knowledge (Szulanski, 1996). Experience adds a heavy layer to the sedimentation of organisational knowledge, making it difficult to articulate. After so many years of operation, automatisms have become so deep-seated that it is hard for the observer to grasp the purposefulness of organisational actions. Indeed, the contention that "all that is planned is organisation", expressed by one team member in Mirafiori, seems to capture a further transformation of knowledge. More specifically, the maxim reveals the presence of a distinctive stock of knowledge which is enacted against the background of the organisational mechanisms analysed above. In other words, planning may well constitute the essence of organising (see case 2). However, in order to cope with the everyday micro-disruptions occurring on the shop floor, a different type of knowledge needs to be mobilised, one that is experience-related and characterised by a human component. Improvisation and common sense are the outcome of a deep-seated learning process whereby knowledge is progressively stocked in a repertoire of noteworthy experiences and becomes part of the organisational memory.

Common sense provides a further perspective on knowledge creation and institutionalisation. What is common sense and how can we open this third organisational black box? Common sense is difficult to capture in a straight definition. Clifford Geertz (1983) has attempted to conceptualise it in a well known essay on local knowledge. According to the prominent American anthropologist, common sense can be defined as a cultural system, equivalent to religion, art and the like. Accordingly, its prescriptive value is very strong as common sense points to "what everybody knows". Common sense draws its authority on an unspoken premise and therefore points to a stock of tacit knowledge which the members of a collective enact in their everyday coping with the world. This knowledge possesses a practical connotation, i.e. "its tenets are the immediate deliverances of experience" and "it can be defined as a sound working knowledge" (*ibid.*). Unfortunately, the English term does not convey the important distinction between "common sense" and

"good sense". While the former emphasises the notion of conventional wisdom (what everybody knows), the latter refers to the performative character of common sense (effectiveness of commonsensical solutions). As Geertz points out, common sense is prompted by the occurrence of disruptive events, which provide a typical domain of application: "common sense is enacted in coping with everyday problems in an everyday way with some effectiveness" (p. 76).

Although Geertz does not explicitly distinguish between "common sense" and "good sense", he actually refers to common sense as a network of practical and moral conceptions (p. 81). The dual emphasis on the practical (the immediate deliverances of experience) and the moral (the stable configuration of values or cultural system) is probably one of the key features of the concept. This duality is apparent in the findings of the case, namely in the distinctive character of detective stories. On the one hand, detective stories stress the empirical character of knowledge applied in problematic situations, i.e. they refer to a repertoire of past solutions which have been proven to work in practice. On the other hand, the sedimentation of narratives relies on the presence of recognisable patterns in their plot which turn ordinary stories into noteworthy experiences. Detective stories are grounded in the distinctive values and identity of the team members. In this regard, they refer to a particular organisational cosmology (Weick, 1993) or "common sense view of the world". Put another way, common sense points to "the obviousness of the obvious". In commenting on the introduction of a TPM (total productive maintenance) activity following the Japanese principles of lean production, one team member remarked: "there is nothing new in it, we've always done it like that; it's just common sense; this is something we were taught twenty years ago at the company's training school".

When compared to procedural, methodical ways of operating, the contrast is quite striking. In its practical connotation, common sense focuses on performance. It implies searching for quick solutions (immediate deliverances), choosing short cuts in order to get straight to the heart of the problem, rather than following a decision tree. Most of the time, the distance between thought and action is reduced to the point where certain solutions seem almost obvious. Of course, in striving to get around procedures, common sense knowledge is more exposed to fallacies and human error as our detective stories illustrate.

Common sense provides a general background against which notions of natural causations are developed (Geertz, *ibid.*: 77). In this respect it acts as an interpretative system focusing on the immediacies of experiences and directing human behaviour in accordance with a shared set of values and visions. However, unlike scientific theories, common sense is unarticulated and deeply tacit. For this reason, commonsensical knowledge is difficult to grasp. Unlike routines and standard operating procedures, common sense is not inscribed (and therefore visible) in organisational artefacts or any other type of sensible structures. Here is where narratives come into play. If common sense is based on unspoken premises and is deeply tacit, it is also true that common sense wisdom is displayed in organisational discourse: narratives, anecdotes, jokes, and war stories. Narratives (articulated as plots) are the carriers of such a deep-seated, sticky, commonsensical stock of knowledge. The deconstruction of organisational narratives should then allow the analyst to penetrate a knowledge system that has become deeply tacit and institutionalised.

Through narratives, collective knowledge is to a certain extent articulated and translated into a text, on which both the actors and the observer can reflect. The task of the researcher, then, consists in making sense of this text, indeed a second order interpretation in itself. The problem of interpretation lies precisely in dealing with "interpretations of interpretations", that is, how certain organisational actors make sense of sensemaking.

In Mirafiori we looked at how organisational actors weave webs of signification (Geertz, 1973) by means of narratives. The knowledge creation process in Mirafiori is triggered by the occurrence of disruptive events resulting either from technological perturbations (e.g. die change) or technical breakdowns. As noted earlier, breakdowns provide a source of controversy since they temporarily question the effectiveness of the existing stock of knowledge governing the execution of factory operations. The case highlights a distinctive process of investigation and interpretation of disruptive occurrences which we have characterised using the metaphor of the detective story. The latter point to a distinctive mode of knowledge utilisation, grounded on conjectural, evidential strategies and stressing the narrative dimension of knowledge. Interestingly, detective stories seem to draw on a repertoire

of existing solutions which have sedimented over time. Success stories of the past provide operators with effective templates for the solution of present occurrences. To be sure, narratives stress the importance of the time dimension in relation to knowledge and sensemaking. For example, the construction of plots and narratives implies locating organisational occurrences in space and time and accordingly translating equivocal happenings into meaningful events. In fact, the strength of narratives as interpretative devices (guides to conduct) stems precisely from their ability to link the present to the past and the future, anticipation to retrospection and repetition. Finally, narratives emphasise the role of collective remembering and organisational memory. (Indeed, the dynamics described in this case seem to be in sharp contrast with Melfi, which appears to be a factory without a past).

On the other hand, the normative value of success stories points to the dynamics of knowledge institutionalisation within the factory. The case has attempted to describe the process whereby success stories become infused with value and thereby direct and prescribe human behaviour. More specifically, we have identified a set of crucial ingredients which turn ordinary disruptive occurrences into noteworthy experiences. Those ingredients point to the specific cosmology - what everyone takes to be part of the way in which the world is arranged - of work teams on the shop floor. They include, for example, the appearance of a technical disruption (disorder), the presence of a power relationship, a happy ending. From an epistemological perspective, the solution of the riddle contained in the story can be seen as a way of appropriating order out of disorder and therefore can be reconnected to the dynamics of knowledge creation and institutionalisation. Organisational memory, in the form of story templates, points to the factory's patrimony of knowledge which has become institutionalised over time and ingrained in collective common sense.

7.5 Linking knowledge to organisational becoming

The empirical findings of the case studies highlight distinctive knowledge outcomes that unfold according to the processual model described in section 2. We categorised the above outcomes, respectively, *blueprint*, *routines* and *common sense*. In this regard, the green field, the D/A analogy and the knowledge templates underlying detective stories can be seen as descriptive as well prescriptive analogies epitomising

the main knowledge patterns which emerged in the three case studies (see Figure 18).

At the same time, the above knowledge outcomes incorporate a meta-level temporal dimension, as they refer to processes of knowledge institutionalisation occurring over time. As specified in the research design, the selection of the three cases reproduces "artificially" different phases of the knowledge creation and institutionalisation process. In this regard, the three cases represent variations in context. By juxtaposing the three cases, we describe the transformations that knowledge undergoes over time. More specifically, we move from visible forms of knowledge to more "sticky" ones. The presence of a temporal dimension in the research design allows the researcher to speculate about tentative evolutionary paths of organisational knowledge. Specifically, by following the transformations of knowledge over time, one could link those transformations to the dynamics of organisational becoming. Figure 19 exemplifies the above considerations.

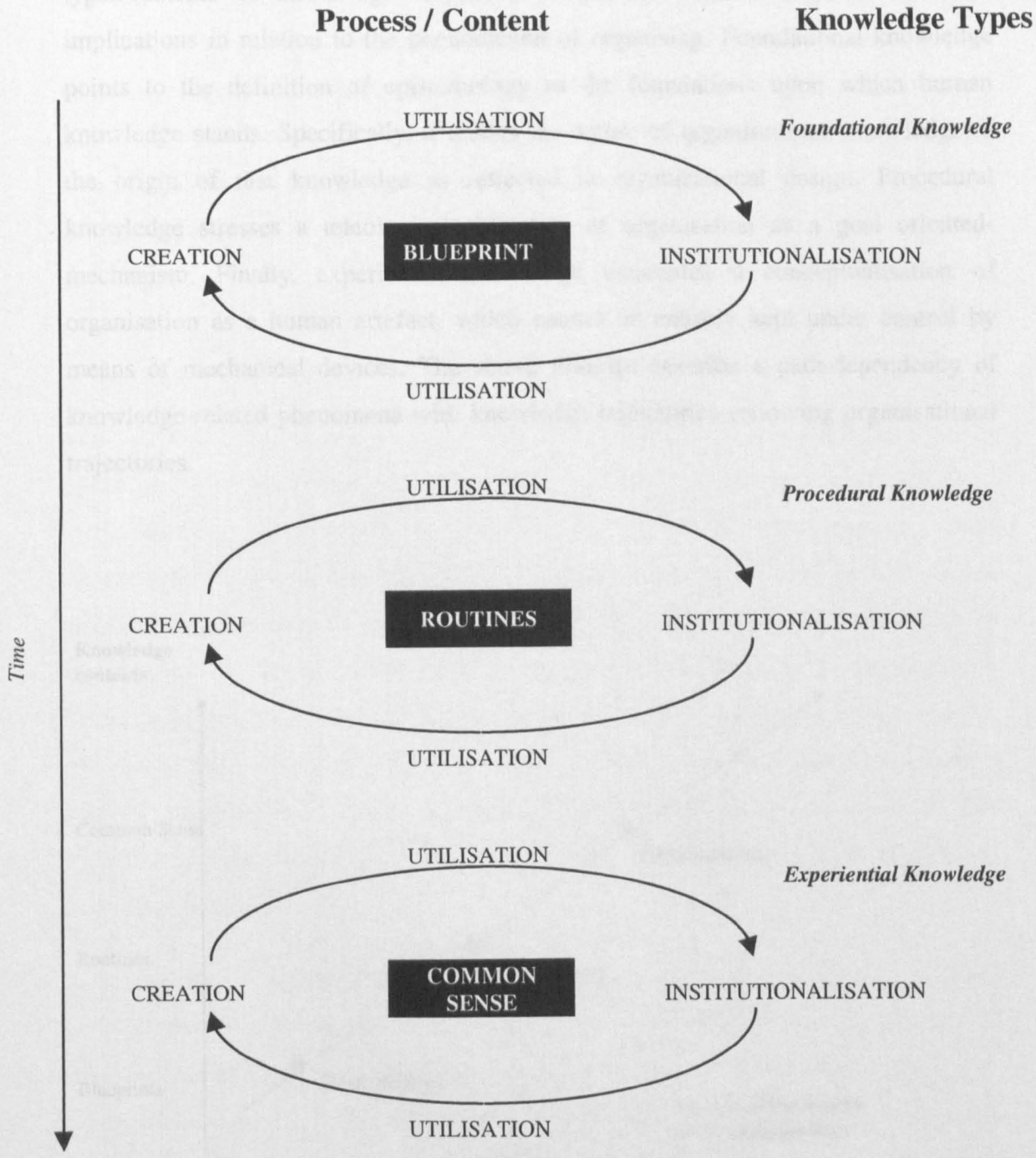

Figure 18: The D/A analogy is reflected in the definition of the product as an assemblage of parts.

At the diachronic level, the combination of knowledge processes and contents at different stages of organisational evolution identify three main knowledge types, which we label *foundational*, *procedural* and *experiential* knowledge. The three types/contents of knowledge identified in the case studies highlight different implications in relation to the phenomenon of organising. Foundational knowledge points to the definition of epistemology as the foundations upon which human knowledge stands. Specifically, it relates the nature of organisational knowledge to the origin of that knowledge as reflected in organisational design. Procedural knowledge stresses a teleological definition of organisation as a goal oriented-mechanism. Finally, experiential knowledge incarnates a conceptualisation of organisation as a human artefact, which cannot be entirely kept under control by means of mechanical devices. The above findings describe a path-dependency of knowledge-related phenomena with knowledge trajectories following organisational trajectories.

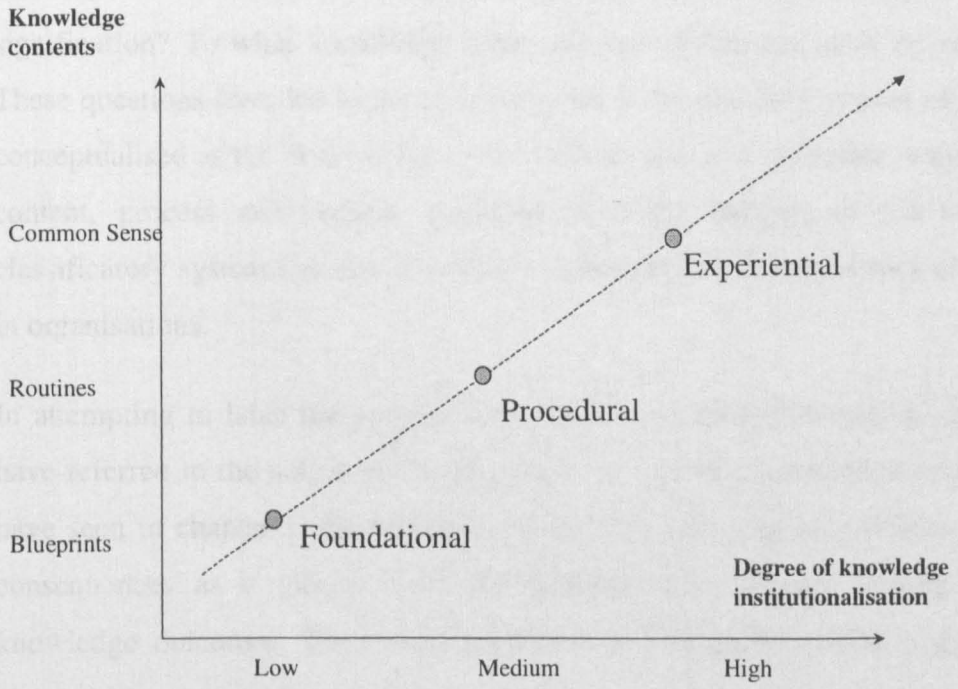

Figure 19. Knowledge Types

Admittedly, what appears to be a coherent account of an evolutionary process is the result of a "photo-montage" (Latour, 1995), once again a narrative construction devised by the author. In this respect, what is captured by the three case studies is a series of transformation states (i.e. knowledge outcomes) rather than an evolutionary transformation process. Furthermore, rather than distinct types/outcomes of knowledge creation, the three stages identified above have to be seen as ideal types, existing at the same time in any organisation. In this respect, the evolutionary path identified above has a heuristic value and needs further research to be validated (see concluding chapter).

7.6 Conclusion

In this chapter we have revisited the empirical findings of the case studies in order to make theoretical interpretations as well as identifying empirical patterns within and across the cases. This chapter has addressed a number of important questions: what are the specific knowledge outcomes emerging in each case? How do knowledge outcomes come into existence and are eventually crystallised into stable structures of signification? To what knowledge types can knowledge outcomes be reconnected? These questions have led to the elaboration of a classificatory system of knowledge, conceptualised as the "knowledge cycle", able to link in a systematic way knowledge content, process and context emerging from the findings of the study.[28] The classificatory system has also provided a vocabulary for the dynamics of knowledge in organisations.

In attempting to label the specific knowledge outcomes emerging in each case we have referred to the notion of the black box as a generic knowledge content. As we have seen in chapter 1, the metaphor of the black box can bear insidious empirical consequences as it glosses over the transformation process leading to specific knowledge outcomes. The model presented in this study initially black-boxes the

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[28] The knowledge cycle also resonates with Kolb's (1979) idea of a "learning cycle", insofar as it links knowledge dynamics to agency theories and problem solving. Unlike Kolb, however, here emphasis is placed on the institutional dimension of knowledge rather than on the experience-based processes leading to cognitive growth.

outcomes of knowledge creation. However, this operation is done on purpose, and only temporarily. By black-boxing the outcomes, we problematise the content of knowledge creation while searching for a solution. The contents/types of knowledge creation are only eventually labelled - following the empirical findings emerging from the study – and categorised as a classificatory system. Furthermore, the transformation process that led to the creation and institutionalisation of those outcomes is analytically defined.

The analysis has highlighted three main knowledge contents – blueprints, routines, and common sense – corresponding to three main knowledge types identified in relation to the transformations that knowledge undergoes over time: *foundational knowledge* is related to the design of organisation; *procedural knowledge* refers to the routinised character of organisational action in consolidated work settings; *experiential knowledge* points to more mature stages in the evolutionary trajectory of knowledge and organisation.

As explained in the introduction the model has a heuristic value. Accordingly, the linearity of the model does not mean that one should take symmetry for granted. Blueprints, routines, and common sense, and the related knowledge types exist at the same time. These categories do not evolve separately. Rather, they have to be seen as ideal types, existing at the same time in different evolutionary phases. In any firm we find overlapping regions between different knowledge types. Although, for analytic purposes we have not explored in depth those regions in the above case studies, it is nonetheless possible to exemplify the idea.

Foundational knowledge in Mirafiori is related to the design of the plant back in the 50s. The latter takes place under specific historical and socio-economic contingencies that have been described in some detail in chapter three (e.g. immigration, booming of the economy, car as an emergent product, and the pervasive presence of conflict). Additional contextual elements include state-of-the-art knowledge in the car industry (e.g. Fordism and mass production) and the specific know-how of the company. These contingent factors are all encoded in the imprinting of the factory and still affect its functioning. In the case study on Mirafiori we have stressed, for example, the traditional values of hierarchy and seniority as an integral part of the team's cosmology. Likewise, procedural knowledge is present in a variety of organisational

aspects and chiefly in production plans.

In the first case study on Melfi, the overlap is apparent in the dual connotation of the green field site. The green field can be seen as a "spring board" enabling the company to build a factory from scratch; at the same time the design of the avant-garde plant is constrained by the existing company know-how and the industry recipes available in a mature business sector like car manufacturing. As for Mirafiori, the design concept necessarily takes for granted the knowledge available on "how to make cars" as well as the company's distinctive know-how. The latter clearly emphasises the role of experiential knowledge in organisational design.

In the second case study on Melfi, we have stressed elements of continuity between the green field and the fully operational factory, thus relating procedural knowledge embedded in routines to foundational knowledge. The so-called D/A analogy epitomises this continuity. Interestingly enough, the presence of experiential knowledge in Melfi is just emerging and will become more conspicuous with the passing of time. However, common sense is apparent in a number of organisational dilemmas and trade-offs which the factory is currently facing. Those dilemmas are related to the strong emphasis on the human element which the company has stressed from the beginning and which is increasingly shaping the functioning of the plant. They are visible, for example, in the trade-off between trouble-shooting (reaching solutions quickly by deliberately violating the existing procedures) and problem-solving (fixing a problem by relying on method, analysis and deductive reasoning), between the imperatives of production (keeping up with the output targets) and maintenance (preserving machinery from the wear and tear), and, ultimately, between immediate deliverances and long terms commitments. The above organisational dilemmas emphasise the need for improvised practices, albeit grafted upon procedural knowledge. In addition, craftsmanship in Melfi provides a fertile ground for the use of experiential knowledge.

CHAPTER 8: CONCLUSIONS

8.1 Introduction

This work is a knowledge creation endeavour: it entails an empirical inquiry into knowledge which involves the production of new knowledge, albeit in a different form. The identity of the subject under study and the outcome to which the study leads, characterise this work as self-referential. Accordingly, the present conclusions are part of a reflexive inquiry, performed "after the fact", on the tacit assumptions of the researcher. The trajectory that unfolds from the introduction of this dissertation to the present conclusion reflects the change in my perception of the subject under study and possibly describes a learning process. The above considerations can be synthesised in one fundamental question: how has this research modified my perceptions and understanding of knowledge-related phenomena in organisations?

In our journey around the concept of organisational knowledge, we have progressively moved away from an explicit (static) definition of knowledge and focused on those phenomena that constitute the essence of knowledge in the making, namely action, context and time. The analysis of the interactions between these elements has led us to conceptualise organisations as entities "in becoming". In this journey we have been comforted by a good deal of organisational literature that has attempted to explore the dynamics surrounding the construction of knowledge in organisations and to look for ways to make knowledge empirically observable.

Admittedly, the complexity of the phenomena under study makes it difficulty to draw clear-cut conclusions about the nature of knowledge-related phenomena in organisations. In this last chapter I shall assess the main contributions of the study in relation to the existing literature. These contributions can be organised around three themes: theoretical, methodological, and empirical. Going back to the main research questions, this chapter will assess what the study has achieved and what are its main limitations. As observed above, the judgement about contributions and limitations of the study necessarily engages the researcher in a reflexive inquiry on the tacit assumptions informing the research process.

From a theoretical perspective the contributions of this study have been achieved following a two-fold strategy. On the one hand, the strategy deployed in this research entailed applying particular streams of the literature, which are usually not associated with organisational knowledge, to the subject under study. The reference to institutionalism constituted such an example. In this respect, an innovative aspect of this study derives from a deliberate displacement of established concepts in the literature. Importantly, this shift was legitimised by the fact that certain theories and established frameworks seem to possess a general validity. For example, Pettigrew's model for explaining change processes is also valid to illustrate the creation and institutionalisation of knowledge in organisations. In fact, the strength of this framework derives from its ability to link process, content and context as generic categories in a coherent whole, rather than from the specific domain of application (i.e. change). Furthermore, the presence of kin domains of application (e.g. organisational change and learning theories) facilitated the deployment of certain concepts in an original way. The above type of strategy was principally dictated by the nature of the research questions of the study and the scarcity of empirical studies on knowledge. On the other hand, the theoretical contributions of the study are related to the introduction of new concepts and a new vocabulary. The knowledge cycle and the conceptualisation of knowledge systems as "assemblages" point in this direction. At the methodological level the research has developed a coherent framework for studying knowledge as an empirical phenomenon. The nature of the phenomenon under study required the crafting of novel methodological tools for dealing with the observation of phenomena that are often elusive and transparent. Finally, the three case studies provided the evidence supporting the present conclusions. Taken individually, they engaged the researcher in an exacting sensemaking exercise. The interpretation of the case involved assembling different bits of literature according to new configurations and testing the methodological tools constructed by the researcher in an *ad hoc* fashion. The next sections develop in some detail the conceptual themes outlined above.

8.2 Theoretical contributions

This section organises the main theoretical contributions of this research around a

number of thematic issues derived from the discussion of the findings presented in chapter 7.

1. *Knowledge in action.* As it was shown in chapter one, most of the existing theories of knowledge have focused on the content (e.g. knowledge as a commodity) rather than the process of knowledge creation. The lack explanation of the transformation process leading to the production of knowledge assets was a major omission of those theories. This study has looked at organisational knowledge "in action" in order to emphasise the fact that knowledge, or better the activity of knowing, can only be understood through its practice and not as an abstract phenomenon. Accordingly, both the ontological and epistemological arguments of this study are grounded on a phenomenology of action, emphasising the processes of sensemaking and social becoming. From a theoretical perspective the study has developed a classificatory system of knowledge linking in a systematic fashion organisational knowledge content, process and context. In so doing, this study has offered a processual theory of knowledge, able to explain the transformations that knowledge undergoes over time. The knowledge cycle presented in chapter 7 captures a fundamental transformation process, unfolding in a recursive fashion and progressively leading to the creation and institutionalisation of durable knowledge outcomes. This theoretical outcome resonates with Pettigrew's (1985, 1987) processual model on change in so far as it relates content, process and context of knowledge-related phenomena in a coherent whole. On the other hand, the above conceptualisation of organisational knowledge processes raises the issue of the relationship between agency and structure. As it is known this problem has been dealt with by structuration theories (Giddens, 1984), the chief claim being that agency and structure are not independent from each other but rather mutually interact and shape each other (see duality of structure). Like Giddens, the present conceptualisation of knowledge-related phenomena in organisations subsumes structure and context within action. Accordingly, context and structure are not treated as independent variables. Rather, emphasis is placed on the modes of production and reproduction of knowledge structures in organisational practices. More specifically, the dynamic interplay between action and structure can be seen as the enactment of institutionalised stocks of tacit knowledge. In this regard, context and structure are viewed as enacted (Weick, 1977; Smirchich and Stubbart, 1985) in the content of what people do and how they do it (situated knowledge).

2. *Knowledge is about difference and diversity.* Different knowledge systems are unique and internally consistent, and knowledge is not transmutable. Blueprints, routines and common sense - the main knowledge outcomes of this study - can be seen as local knowledge systems instanced by the construction site, the D/A analogy and the detective stories informing the narrative of shop floor operators. This finding stands in sharp contrast to the conventional assumptions underlying mainstream knowledge theories. These theories are informed by a reductionist view of knowledge whereby knowledge itself is conflated in the dichotomy of tacit and explicit. For example, Nonaka and Takeuchi's popular framework defines knowledge creation as a conversion process. In its turn, the centrality of the conversion process between tacit and explicit stresses the transmutable nature of knowledge. The assumption of transmutability makes it possible to treat knowledge as a disembodied object or commodity which can be isolated from the context of production and utilisation. The findings of this study suggest that knowledge creation is not a form of conversion, but rather it is about construction and evolution. The latter emphasise the importance of sensemaking and institutionalised meaning (see below).

3. *Knowledge systems are characterised by holistic nature* in so far as they relate different aspects of work organisation in a coherent whole. Once again, the findings of the study support a view of knowledge which is substantially distant from the reductionist argument propounded by the mainstream literature. Knowledge is not seen as a discrete commodity; rather it is conceptualised as an "assemblage" subject to continuous transformations and reconfigurations. As Cooper (1998) has pointed out, assemblage comes from the Greek word *sumbolon*, the act of bringing together separate parts. Assemblage is defined by the dialectic of separation and joining, dispersions and collection, disorder and order. In other words, the concept of assemblage goes back to ontological categories of being and becoming and to the definition of knowledge creation as the appropriation of order out of disorder. In this regard assemblage stresses the dynamic character of knowledge systems: "(Assemblage) is the continuous movement of parts in a restless flux in which the separate identities of the parts give way to a mutual coming *and* going, uniting *and* separating" (Cooper, *ibid.*: 110). An assemblage is neither a unity nor a totality, but a multiplicity, a collection of heterogeneous materials which are mutually interrelated. In other words, assemblage stresses the importance of relations over the elementary

parts, i.e. what goes on "between" the parts (Cooper, *ibid.*: 112). In this regard, what makes knowledge distinctive is not the discrete collection of commodities, but the nature of the assemblage. In sum, the notion of assemblage emphasises the pasted-up nature of knowledge systems and reinforces the definition of knowledge as a phenomenon in the making.

4. *Knowledge systems as "assemblages"*. Given their holistic nature, assemblages can be seen as self-contained systems pointing to a shared worldview. In this regard, blueprints, routines and common sense are instances of particular organisational "cosmologies" (Weick, 1993). They constitute more or less organised worlds, characterised by internal consistency, in which organisational communities can dwell in their everyday dealings with practice. For example, the construction site at Melfi sets the stage for the situated practices of a particular organisational community. Likewise, the D/A analogy identified in the second case study possesses the same holistic nature in that it brings together in a coherent system different aspects of the work setting, namely the technology, the task, the division of labour and human skills. Finally, the commonsensical use of knowledge in Mirafiori points to the presence of a cultural system rooted in the team's values. A cosmology conveys the idea of knowledge as a totality, of a universe that is taken for granted within a particular community. In this regard, a cosmology possesses the character of necessity. However, the attribute of necessity is only apparent. According to Unger (1987), when the social order with which people are familiar becomes deeply entrenched in their minds, it is perceived as "natural" and taken for granted. Accordingly, the order of things is endowed with a "false necessity", i.e. a necessity that it does not possess. The notion of false necessity reinforces the local, situated, and relative character of knowledge systems. Because of false necessity, knowledge systems are not recognised as such by the individuals who dwell in them. Their effectiveness draws precisely on the tacit, unspoken assumptions underlying their functioning.

5. *Knowledge is institutionalised.* Knowledge creation cannot be divorced by the corresponding process of institutionalisation through which organisations consolidate durable outcomes and achieve epistemological closure. Firstly, at the systemic level, institutionalisation confers internal consistency to a knowledge assemblage and accordingly provides the basis for the co-ordination of individual behaviours within a

community of practice. Specifically, co-ordination is achieved through the institutionalisation of meaning. In this respect, knowledge systems act as formative contexts (Unger, 1987; Blackler, 1992; Ciborra and Lanzara, 1994). They provide a set of institutional and cognitive assumptions presiding over the behaviours of the participants in a social system. Secondly, institutionalisation is a function of time; through institutionalisation knowledge becomes habitualised, it can be repeated, represented, and reproduced in day-to-day activities. Put another way, the institutionalised nature of knowledge systems points to a set of dispositions and habits of thinking that have been acquired by the members of a community through past socialisations, and that are enacted in particular situations of action. Like Bourdieu's (1990) concept of *habitus*, knowledge systems mediate between structures and practices in the conduct of everyday life. Furthermore, the habitual, taken for granted character of knowledge explains why knowledge systems are highly idiosyncratic and characterised by stickiness. Finally, the concept of habitus as instanced by a particular *modus operandi* resonates with the notion of structural repertoire, which we encountered on a number of occasions within this study. Like the *habitus*, structural repertoires refer to a historically formed habit of thinking through which individuals in organisations deal with a particular set of problems (see below).

6. *Knowledge as problem solving*. The findings of the study offer a view of knowledge creation as a form of situated problem solving activity. Knowing appears to be a form of problem solving related to the everyday life of organisations. It implies recovering from (harnessing) situations of ambiguity and disorder. In this respect knowledge-related phenomena can be seen as modes of organising. The construction work on the Melfi's green field implies transforming a set of guidelines specified in the blueprint into a work place. The same applies to the resolution of ordinary breakdowns on the shop floor of Melfi and Mirafiori. In all these situations, the presence of a problem triggers the mobilisation of existing knowledge according to consolidated patterns or the creation of new knowledge. This finding is consistent with Whipp and Clark's (1986) notion of structural repertoires. As we saw in chapter 1, structural repertoires can be seen as situated, highly idiosyncratic knowledge structures, which organisations develop and consolidate over time, and enact in the face of a specific set of problems. Once again, the relevance of structural repertoires is linked to the presence of an institutional dimension which accounts for the

stickiness of organisational responses in the face of problematic situations. The above finding also resonates with Scribner's (1987) view of knowledge as a form of practical thinking and *bricolage*.

7. *Knowledge is grounded in analogies.* Knowledge systems subsume the characteristics of the work setting and the *modus operandi* of a particular community of knowing within pervasive analogies. Echoing Mary Douglas (1986) it is possible to contend that institutionalised knowledge is grounded on analogy. Analogies possess a normative value in so far as they prescribe and direct the behaviours of organisational actors according to a shared image of the world. Analogies provide a powerful co-ordination mechanism. According to Douglas, they provide socially constructed categories which allow the members of a community to define reality through classifications. Under these circumstances, the capacity to think individually rests on a stock of pre-existing institutionalised knowledge, whose creation is similar to that of a public good. Analogies are not disembodied cognitive maps reproducing the world in the mind of the members of the community; they do not exist outside the nexus of behaviours, practices, and conventions over which they preside; rather they are immanent to them. Analogies are crystallised in established artefacts and structural repertoires (Whipp and Clark, 1986), they work as cognitive institutions in their own right (Ciborra and Lanzara, 1994). The notion of isomorphism, which we encountered in chapter 5, exemplifies the way in which knowledge is reproduced in a subtle and pervasive fashion within the work setting: the product, the production process, the division of labour, the task, the problem solving procedures, are inscriptions of knowledge, "encodings of institutions" (Barley and Tolbert, 1997). The construction site, the D/A analogy and the detective stories are the leading analogies identified in the case studies. Admittedly, they have to be seen as attributions of the researcher rather than explicit conceptualisation of the actors who refer to them. The purpose of labelling them is to reconnect a certain set of behaviours to a distinctive cosmology. Furthermore, as we stated above, analogies are taken for granted and therefore they may not be recognised as such by the members of a community.

8. *Knowledge systems as guides for action.* Knowledge systems function as institutions. They are established combinations of premises or programs for action

that help people think and act. At the micro level, knowledge systems provide theoretical structures mediating between action and interpretation. In this respect, knowledge systems act as scripts, relating a set of practices to shared structures of signification. They connect organisational actors with the nexus of equipment, practices, and conventions characterising a particular organisational setting. The analysis of the literature suggests at least three meanings for the notion of script. Schank and Abelson (1977) define the script as a cognitive map representing potential situations which individuals may encounter in everyday life (e.g. eating in a restaurant). In this sense, scripts account for the sensemaking and interpretative processes of organisational members and thereby govern collective action in organisations. A more sophisticated view is suggested by Barley (1986, 1990) and Barley and Tolbert (1997), who relate scripts to the process of institutionalisation. According to them, scripts can be defined as behavioural patterns of interaction explaining the processes by which institutions and actions are reciprocally related. More specifically, scripts encode institutional principles or tacit rules; they are embodiments of practical knowledge which individuals enact and apply in the work setting. Because scripts are encodings of underlying institutions, a main proposition of this perspective is that institutional change may be observed in the modification of the scripts produced over a period of time. This second definition is closer to the purpose of this study, since scripts can be referred to the process of institutionalisation of knowledge over time. Finally, a third definition of script is proposed by Akrich (1993). Within this perspective, scripts are conceptualised as a set of programs for action based on a pre-understanding of reality, and related to organisational design. As a set of programs for action, a script is designed to anticipate action in space and time, and to direct and prescribe the behaviour of organisational actors according to a particular vision of the social reality. In this respect, it refers to a pre-interpreted world that provides the background knowledge underlying organisational performance. Our study has stressed the analogic structure of scripts. The green field, the D/A analogy and the knowledge templates underlying detective stories incarnate different scripts prescribing specific courses of action.

9. *Knowledge cycles are an integral part of the phenomenon of organising*. Through them organisations deal with the equivocality of the happening and accordingly appropriate order out of disorder. In this respect, knowledge systems provide

fundamental organising principles. They are embodiments of organisation. They point to the tacit features of organisations, which have sedimented over time as a result of institutionalisation processes. The study has identified three main systemic forms which we labelled blueprints, routines and common sense. While these forms can be traced back in any organisation, their nature and content varies according to the context. In our case studies, for example, the green field, the D/A analogy and the detective stories underlying the resolution of problematic situations, qualify existing knowledge systems according to specific contingencies and historical evolution. In this respect, knowledge systems are subject to local adaptation within specific organisational contexts. Furthermore, by being context-dependent, knowledge systems are also time-related. Knowledge cycles and the corresponding knowledge systems contain a temporal dimension which points to the transformation of knowledge in organisations as a result of increasing levels of institutionalisation. The findings of the study portray a parallel transformation process of knowledge and organisations, which occurs over time. Although, this result is obtained through an artificial manipulation of time, its potential implications are particularly relevant in so far as it opens up the possibility of relating the evolution of organisations to the knowledge systems underlying their functioning.

8.3 Methodological contributions

The methodological contributions of this research are particularly relevant given the nature of the subject under study. In fact, this is not only an empirical study of organisational knowledge dynamics, but also an investigation into knowledge as an empirical phenomenon. In other words, knowledge itself is scrutinised. The core research question of the study addresses precisely this issue in that it asks: how is it possible to get empirical access into organisational knowledge systems, since a great deal of that knowledge exists at the tacit level? From a methodological perspective the study has attempted to build effective tools for deconstructing knowledge. More specifically we have developed three "lenses" for studying knowledge as an empirical phenomenon: history, breakdowns and narratives. Taken individually, the three lenses provide alternative entry points into tacit knowledge. As stated in chapter 2, history has informed a number of important works in the field of organisations studies (e.g.

longitudinal studies on change and innovation) and has become an established method within the literature. Narratives represent an emergent topic in the literature. So far, breakdowns have not been deployed within the literature, or at least not explicitly. In this respect, the systematic use of breakdowns as a methodological tool represents the main methodological innovation of this study. However, beyond the specific vantage points provided by the lenses, the methodological contribution of this research lies in the presence of a quest for method from the outset of the study.

This is perceived as an important step in closing a major gap in the literature. Admittedly, the authors encountered in this study have stressed the importance of defining some entry points for accessing knowledge systems. In different versions, they have identified breakpoints, discontinuities, interruptions, disruptive phenomena, controversies, and so on, as the elements that allow the analyst to put together a flow of events in a sensible way. However, the issue of access to knowledge systems has never been problematised in an explicit way by the previous literature. Rather, it has been treated as a marginal, taken-for-granted question. Put another way, the purely instrumental stance towards the problem of "looking for a way in" has impeded the development of coherent framework for the study of knowledge as an empirical phenomenon.

When taken as a whole, the three lenses provide a coherent framework for deconstructing knowledge systems in a systematic fashion. In chapter two we referred to the process of unpacking tacit knowledge as opening organisational black boxes. The added value of each methodological lens has already been discussed in chapter 2. Here it is important to reiterate that the three lenses are informed by a unifying principle: the presence of discontinuities. Discontinuities in time, action, and discourse provide not only access to tacit knowledge, but also the narrative devices informing "thick" description. In fact, description itself is a form of discontinuity; it unfolds by following the chains of transformations occurring within a given work setting. The technique adopted in this study was precisely that of following organisational actors at work and describing the discontinuities informing their practices. Accordingly, the use of thick description as a narrative device relied on the assumptions that knowledge systems are immanent to organisational practices. In this respect, de-scription represents a mode of disentangling tacit knowledge from the

variety of organisational devices in which it has been crystallised.

Finally, the three lenses adopted in the present study are only some of the possible techniques for describing organisational knowledge processes. As stated above, the three perspectives share a common methodological assumption: they document the process of transformation of knowledge by following different types of discontinuities. Alternative methods may include comparative analyses drawing on discontinuities in context. The latter may consider the firm, sector and industry level (see Pettigrew and Whipp, 1991).

8.4 Empirical contributions

The three case studies represent a contribution in their own right. In putting together the empirical material collected on the field sites, my main purpose was to convey an image of organisation in action by systematically relating abstract knowledge categories to concrete organisational activities. The choice of the shop floor as a main observational setting is emblematic of a conceptualisation of knowledge as an empirical phenomenon. As discussed in chapter 1, existing theory of knowledge creation displays a tendency towards deduction and abstraction, which is instanced by the use of ready-made analytic concepts (e.g. tacit/explicit). The choice of a managerial focus is also indicative of the above tendency. However, in order to understand the inner workings of knowledge and the intricacies of knowing one needs to descend to a micro-level of analysis in order to observe how knowledge is empirically produced "in action". Our "descent to the shop floor" can be compared, *mutatis mutandis*, with Dante's descent into Inferno: it was an attempt to gain hands-on experience of empirical knowledge-related phenomena associated with real actors, concrete problems, and everyday organisational practices. As a result, rather than being treated as a presence, organisation was hopefully brought to life through ethnographic descriptions of the work setting. The latter was characterised as an assemblage of heterogeneous materials and situated activities: routines and standard operating procedures, tasks, technologies, products, production processes, and so on. In this respect, the shop floor stands as a metaphor of everyday life; it provides the setting for the observation of dramas in the field.

Finally, the case studies offer a distinctive perspective on a variety of themes that, although sharing a knowledge focus, could well be studied as phenomena in their own right: the evolution of the automotive industry and production systems; the role of green fields in organisational design; the dynamics of change and innovation; the interaction between organisational routines and breakdowns; the interplay between technology and organisation; the importance of time and narrative in the everyday life of organisations. A lesson to be learned from the case studies is that some classical organisational topics, such as those listed above, can possibly be revisited from a knowledge-based perspective. This should be done by systematically asking what are the knowledge implications of distinctive organisational dynamics.

8.5 Main limitations of the study

The main limitations of the study have already been illustrated in chapter 2, at least as far as methodological issues are concerned. Given time constraints, institutional specifications (e.g. maximum length of a doctoral thesis, and the practical concerns of a PhD endeavour), and above all the scope and complexity of the phenomenon under investigation, the study inevitably presents some deficiencies. First, the design of the research was somewhat spurious: three case studies about two plants belonging to the same company. Through the photo-montage technique, the researcher achieved a compression of time. In turn, the artificial manipulation of time made it possible to align the selected case studies along a continuum characterised by increasing levels of knowledge institutionalisation. The three case studies portrayed snapshots of distinctive knowledge systems in specific organisational contexts. However, given the nature of the research design, the findings of the study invited speculation about a possible evolutionary trend in the transformation of organisational knowledge over time. The evolutionary path was traced by "stretching" the findings of the case studies and thus inferring a transformation process from a series of transformation states. This finding needs further validation and may hopefully stimulate further research in this direction. Second, the vast amount of data collected was not fully exploited. Accordingly the level of detail of the case studies could be further improved. Finally, some potentially relevant themes (e.g. the evolution of the automotive industry, the debate around production systems, and so on) have been deliberately left in the

background. Throughout the study, I have attempted to justify specific choices and judgments by referring to the research questions underlying this work. On the other hand, most of these omissions have to be reconnected to the idiosyncrasies of the researcher: issues of style, structural repertoires and, ultimately, the limited rationality of the researcher account for the impossibility of dealing with the complexity of the data in a different way. In this regard, the study represents a temporary, but hopefully solid outcome. As the title of this work indicates, knowledge (including scientific knowledge) is continually subject to transformations as a consequence of its intrinsically controversial nature.

8.6 Suggestions for future research

The present study will hopefully offer a template for further research on the dynamics of knowledge creation and institutionalisation within organisations and institutions. The experimental nature of this study and the above mentioned limitations suggest a number of interesting themes and techniques to be pursued by future research on knowledge in organisations. Firstly, the three-lens framework needs further testing in order to be validated and possibly refined. The three lenses should be used at the same time in order to a) provide a holistic picture of knowledge-related phenomena and b) achieve triangulation by combining different methodological perspectives. The evolutionary path of knowledge systems within organisations also needs further validation. Future research should take into account the interplay between identity and discontinuity in the selection of the field settings. Some of the possible variations in the design of future research may be the following: (1) Comparative studies considering companies operating in the same sector but belonging to different evolutionary phases; (2) Comparative studies considering companies operating in different sectors but belonging to the same evolutionary phase; (3) Single case studies following one company along an evolutionary trajectory.

Finally, the methodology deployed in the research could be extended to other domains of application such as the public sector and the study of IT infrastructures. Given the scope and complexity of the phenomenon under investigation, the above types of studies are probably more suitable for research teams rather than individual researchers.

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