The institutionalization of knowledge in an automotive factory: templates, inscriptions, and the problem of durability

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Abstract

This paper focuses on the process of institutionalization of technical and organizational knowledge in the work setting. Drawing on actor-network theory, we extend and apply an inscription-delegation model to the analysis of knowledge dynamics in a green field automotive plant. In particular, we depict knowledge making as a recursive process that involves the progressive writing, enactment and reproduction of a structural template or code within a stable medium. We reconstruct the chains of transformations by which agency and knowledge are inscribed into a variety of technical and organizational artifacts, leading to the creation of a cognitive and institutional order. Finally, we focus on the frictions and tensions that emerge in the transformations, and discuss problems of vulnerability and durability that arise in the maintenance and reproduction of such institutional order.

1. Introduction

Knowledge is widely recognized as a strategic source of competitive advantage within a firm. Following this, a broad stream of literature in strategy and organization theory has been devoted to the study of knowledge management (e.g. Davenport and Prusak 1998, Scarbrough et al.1999, Boisot 1999), that is the collection of tools, techniques, and practices through which firms create, encode, transfer, and diffuse knowledge in order to achieve superior performance. In explaining knowledge-based phenomena in organizations current theories have privileged knowledge creation (Nonaka and Takeuchi 1995) and transfer (Kogut and Zander 1992, Szulanski 1996) processes over the subtle and less explored dynamics of institutionalization. In particular, emphasis placed by the existing literature on the instrumental exploitation of knowledge assets seem to take for granted that knowledge, once it is synthesized in its most diverse forms and variety of media, can be easily "anchored" and reproduced within a given organizational setting. However, just like in the formation of scientific facts and

technological artefacts knowledge making processes in organizations are often characterized by uncertainties, controversies, tests, and debates (Knorr-Cetina 1981, Latour 1987, Lanzara and Patriotta 2001). It often happens that knowledge thought to be undisputable at an earlier stage is discovered to lie on shaky grounds and disconfirmed at a later stage. In order to persist and yield increasing returns, knowledge must gain an institutional connotation; it must become an institution in itself, that is, the unquestioned background for acting, communicating, and further knowing.

Following Zucker, in this paper we refer to institutionalization as the 'phenomenological process by which certain social relationships and actions come to be taken for granted' (Zucker 1983: 2). Institutionalization processes are particularly relevant in relation to knowledge making processes in organizations. They help us understand the performativity, durability, and persistence of organizational knowledge systems, i.e. why knowledge works, why it is stable, why it is "sticky".

Admittedly, as the management literature has pointed out, the ability of a firm to create and transfer knowledge is a major source of superior performance. However, effective knowledge creation requires achieving closure through institutionalization, that is, through erecting and reproducing stable structures of signification in which core knowledge is embedded. These include scripts, frames, rules, stories, routines, procedures, equipment, technologies, material artefacts, and so on. When the above structures of signification are accepted as an undisputable part of the organizational reality, they become institutionalized and serve as cognitive tools that people use to make sense of their world and their own practical dealings (Garfinkel, 1967).

Perhaps more importantly, institutionalization is crucially linked to tacit knowledge, i.e. knowledge that cannot be easily articulated or expressed in words. In a sense, institutionalization refers to the degree of tacitness or "taken for grantedness" of a firm's idiosyncratic knowledge base. Knowledge can be more or less institutionalized. If it is weakly institutionalized, it means that it is intrinsically unstable and variable, needing direct social control or other intervening mechanisms in order to maintain and reproduce an existing order of things. If on the contrary knowledge is highly institutionalized, then it means that it is taken for granted, and does not need the

intervention of exogenous human action for its reproduction (Jepperson 1991, Zucker 1991). In this latter case knowledge within a given organizational setting is accepted without further dispute because it has gained some degree of authoritativeness and legitimacy in front of its agents. It becomes a sort of ontological block of what the agents come to define as *the* reality of a situation (Berger and Luckmann 1967). Also, it is likely to diffuse more easily or to facilitate diffusion to a larger extent.

Finally, the taken for granted quality of certain practices and their reproduction in existing institutional arrangements is seen as a source of persistence (Zucker 1977), which accounts for the accumulation and maintenance of knowledge in organizations. Because of persistence the effects of institutionalization for organizational performance are often ambivalent. On the one hand institutionalization is positively connected to legitimacy and durability; on the other hand it also introduces elements of rigidity, stickiness, and resistance when change is needed (Leonard Barton 1992a). As Jepperson (1991) has pointed out, the more institutionalized is a structure or a rule the higher is the threshold to be overcome in order to subvert it through collective action.

In addressing the institutional character of knowledge-based phenomena we argue two main points. First, knowledge institutionalization requires a generative principle or knowledge kernel that reproduces a behavioural pattern across a variety of media, artefacts, and organizational devices. We call this generative principle a template. A template can be defined as a practical example, often based on a shared cognitive analogy, that, because of its ontological "obviousness", soon becomes the accepted way of doing things, and a master model or pattern by which other similar things can be made.[i] As a working example the template performs a number of functions. It is a source of signification and sensemaking, providing a coordination mechanism and a guide to conduct for the members of a community. It acts as a referent for the reproduction of certain practices and behaviours (Jensen et al. 2003). Reproduction reinforces the meanings conveyed by the template and therefore ensures durability and transferability of a given stock of knowledge. It functions as a persuader (Jensen et al. 2003) enrolling a large number of recipients and generating commitment around a common task or mission.

Second, a template is created, enacted and reproduced through inscription and delegation mechanisms. Such mechanisms work as anchoring forces linking a template to particular sign-agency-meaning configurations. The concepts of inscription and delegation, rooted in semiotics and brought to the forefront of social theory by Actor Network theorists (Callon 1980; Latour 1988a, 1991; Akrich 1993; Law and Hassard, 1999; Organization 1999), link knowledge with human agency. As the term is used here, inscription is a form of *authoring*. It concerns the writing of a program of action or a pattern of use into a stable medium, which becomes both the receptacle and the carrier of human agency. The medium functions as a *tertium*, that is, as a set of independent actants regulating, channeling, and driving the interaction between two or more parties.[ii] Inscription is linked to transactional efficiency. It confers durability to social arrangements, which, because they rest on human bonds, may be shaky and unreliable: "Inscription translates a program of action from one repertoire to a more durable one… from a provisional, less reliable one to a longer-lasting, more faithful one" (Latour, 1988a:306). For example a speed bump is more reliable than an officer telling drivers to slow down because it cannot be disputed and it does not require any form of control.

Programs of action are inscribed into different sorts of media through processes of delegation, which endow non-human actants with the ability to accomplish ad hoc performances. Delegation is the act of ascribing action to an actor/author, that is, *authorizing*. It concerns the transfer of agency, knowledge, and meaning between human and non-human actants along a chain of activities. In this respect "to delegate" means to "stand for", to represent, to act on behalf of, to assign, endow, entrust, empower. According to Latour (1988a) delegation can be understood as the transformation of a major effort into a minor one; it has to do with task simplification (for example a speed bump or a traffic light taking charge of a policeman's task; or an assembly line replacing the human effort of building cars bit by bit). By delegating human agency and knowledge to non-human actants individuals are relieved from the burden of thinking (Gehlen 1940). In this sense institutionalized artifacts are machines that think and act on behalf of individuals (Douglas 1986). They are established as cognitive devices based on delegation mechanisms. Through delegation organizations reduce the cognitive complexity of the task and achieve cognitive efficiency.

Our argument is based on a case study dealing with the construction of an avant-garde automotive factory. This is a unique setting. In the early 1990s Fiat, one of Europe's leading car manufacturing companies, decided to build a new factory from the green field at Melfi, in Southern Italy. The plant was the outcome of a major re-engineering effort undertaken by the company in response to a persistent crisis that plagued Fiat all along the 1980s, resulting in low quality products, low productivity and endemic industrial conflict with workers' unions. Fiat's management conceived the project as a design experiment whereby a core group of 1000 knowledge workers – having spent an intensive training period at Fiat headquarters in Turin - would go off to the green field site at Melfi and contribute to building the factory, that is, the place and the setting in which they would later be assembling cars (Patriotta 2003). As a result of this design experiment, the plant erected by the workers became the taken-for-granted background of the car manufacturing activities. For the builders now become automotive workers, the factory gained an institutional quality that came to obscure its purely human origins.

Fiat's design experiment proved to be successful and the factory soon achieved high productivity records. For over a decade the outstanding performance of the plant contributed to the rise and diffusion of an enduring myth, generating countless positive accounts (e.g. Fortune 1994, Camuffo and Volpato 1995, The Economist 1998). But the myth of the Melfi factory came to a sudden and unexpected break on April 19th, 2004, when the workers of the Fiat plant and the supply firms located at the same site went on strike, stopping the assembly line and all factory operations for several weeks. The events of April and May 2004 marked a sudden discontinuity in Fiat's production and called into question Fiat's design strategy for the Melfi factory.

In this paper we recount the Melfi story as a case of knowledge creation and institutionalization. Based on our field observations, we spell out what to us is the structural template that guided the making of the factory and its establishment as a cognitive and institutional order, namely the method and practice of (Dis)Assembling (D/A) (Ciborra et al. 1995; Patriotta 2003). The D/A template is a program for action which lies at the core of the chain of inscriptions and delegations leading to a full-fledged manufacturing system: first it is instilled by Fiat management to the core

knowledge workers, thus turning them into Fiat agents; then it is appropriated and applied by the workers themselves to the making of the factory and the manufacturing of the car. We argue that the D/A template supports and helps reproduce the workers' and the factory's cosmology by being acted out in endless repetitions, but in the same process it generates tensions and strains that lead to conflict and revision of the institutional order cast by Fiat's management onto the factory.

In the following section we describe the setting and research method of our study. In section 3 the outline of the story is told with the main data, from the Turin training to the start up of the plant and to the later event of the workers' strike. The discussion in section 4 analyses the strengths and weaknesses of the (Dis)Assembling Method as a structural template for the institutionalization of knowledge. We conclude the paper by suggesting how our case and findings can provide insights on problems of vulnerability, reproducibility and durability of knowledge systems in organizational and institutional settings.

2. Setting and data collection

The Melfi plant was the first example of Fiat's transition to a new work organization based on the principles of lean production and known as the *integrated factory* model. As it stands nowadays, the factory is divided into four operating units (OU) responsible for the different stages of the production process: Stamping, Body Welding, Painting and Assembly. Each OU is divided into a number of UTEs (Elementary Technical Units). The UTE, which comprises between 80 to 100 workers and supervisors spread over three shifts, is the basic production structure of the integrated factory. It can be seen as a semi-autonomous work team managing a defined segment of the production process. The various units composing the organizational structure are linked according to an *internal customer model*, by which is meant that each UTE must think of the next process as its "customer". More generally, the entire production system is organized as a customer-driven market in which activities are structured as a network of flows and transactions among semi-autonomous units. The production lines are organized so that every workstation (and

therefore every UTE) receives and passes on a "finished product" that can be assessed in terms of its quality (Ciborra et al. 1995).

Interview, documentary and observational data were collected first on the early beginnings of the factory, covering a time span of about ten years, from 1989 to 1998. Fieldwork on the Melfi site was conducted during the period 1994-1998. Data collection combined naturalistic observation with open interviews. Interviews were mostly conducted along the production lines, rather than in locations separated form the workplace. Most of the respondents had been involved in the construction of the factory from the green field. Overall, we interviewed about 40 people at the field site, and spent about five weeks on the shop floor distributed over seven visits to the plant. Interviews (from 30 to 60 minutes long) encompassed a variety of profiles, including managers of different functions, middle managers and technicians, and to a lesser extent, line conductors. Key informants were interviewed more than once and at greater length. All the interviews and conversations along the production lines were tape recorded and transcribed. Additional informal conversations were not recorded. Direct observation required the taking of detailed and descriptive field notes. Field notes of all that could be remembered were made soon after leaving the setting.

Further interviews with the former Personnel Director and the former Plant Director at Melfi (currently occupying top management position at corporate level) were conducted at Fiat's headquarters in Turin. Throughout the duration of the project we regularly visited Fiat's training company (ISVOR) to collect additional information from the company library. During those visits we held several informal conversations and a few interviews with managers and consultants at the company. Interviews and observation were supplemented with analysis of internal documents and archival records, which were collected throughout the field project, both at the field site and in the company library. Further, the design concept of the factory (1991-1993) was reconstructed retrospectively using the archival data and interviews with key organizational actors involved in the construction of the factory. Finally, additional data were extracted in more recent times on the April 2004 strike, mainly from the media coverage and from the Fiat and labour unions websites on the Internet. Not being able to collect first hand data on the strike itself and on the phases leading to it possibly constituted a limitation of the study. However, this option was in line with

the main focus of the study. In fact, we were not interested in uncovering the latent processes that gradually led to the explosion of conflict. Instead, we treated the strike as a major breakdown or "cosmology episode" (Weick 1993) calling into question the established cognitive and institutional order of the factory and forcing us to reconsider the myth of the Melfi plant under a new light. Therefore the strike served as a methodological lens allowing us to assess the degree and effectiveness of institutionalization achieved by the factory over the years.

3. Inscribing organizational knowledge in an automotive factory

This section examines the sequence of operations involved in the construction of the factory. It takes into account the making of three main entities: the workforce, the factory, and the car. As each phase of the sequence is illustrated, we articulate the acts of inscription and delegation and their significance for the institutionalization of knowledge in the factory.

3.1 The making of the workforce: the work method

The first act of inscription of Fiat's knowledge and agency into the factory took place during a massive, year long training period at Fiat Turin headquarters and, subsequently, at the Melfi Learning Center. The original core group of hired workers consisted of about 1000 novices. The basic stock of knowledge they possessed came from high school education and had little to do with the needs of the factory (70% of them were either surveyors or accountants). Also, their culture was thought to need to be developed and re-oriented according to industrial values and the new organizational model of the integrated factory. Fiat aimed at building a learning factory (Leonard Barton 1992b) characterized by high levels of skill and commitment of the workforce. To this purpose the training program was designed to achieve two main objectives: a) shape a socially homogeneous group of workers, that would develop a strong sense of commitment to the project and the company and would act as Fiat agents and "pioneers" in building the Melfi plant on the green field; b) form highly skilled knowledge workers that would thoroughly understand the logic of assembling and the overall system of industrial manufacturing.

The definition of cultural values promoting coherent behavior and common goals, and the development of a work method as a regulator for both intellectual and practical activities, provided the key pillars of the *modus operandi* of the Melfi community. In this initial phase a main debate concerned the rules that the core group would adopt as a guide for work practices and organizational behaviour. As a result of a number of interviews conducted with Fiat's top managers, consultants, and professional trainers, the company defined a set of core organizational values to be transferred to the young workforce. Among the values was, for instance, identification with the company, a sense of challenge, personal and collective responsibility, taking pride in doing a good job, developing team spirit, etc. Specific courses of action were designed with the aim of transferring the above values. The "value matrix" became a jointly written text which was continuously and repetitively evoked and talked about in training sessions and in other occasions, and was displayed everywhere on the shop floor during the start up phase of the factory. For the workers it was a sort of constitution.

Furthermore, to compensate for the lack of experience of the workforce the management codified and implemented a work method based on disassembling systems and problems, on re-assembling, and on the formalization of solutions. The method functioned as a general rule for production and for problem solving, but also served as a mode of governance of factory activities. Its critical role in training the workers surfaces in the words of the Former Plant Director:

"Melfi represents a bit of a paradox. Since the start up phase the Melfi plant has been very successful and today it is one of the most competitive automotive plants in the world. Yet, since the very beginning the factory has been governed by a group of young novices who where on training. Where did such a complex system find the power to sustain itself and become more and more productive? In my opinion the secret of the success of this plant lies in the capability to sustain its growth through method. Because the novice workers lacked experience, what turned out to be crucial was the transfer of a method for handling problematic situations to them. This has made possible the accumulation of further knowledge about the factory both during the start up phase and at full production. Method implies very practical questions such as: how to solve a problem? How to organize a job? How to plan? How to take action? How to control? How to question? The methodological capacity of this organization has been a major success factor."

"Learning to do things with method" meant a number of things for the workers. First, being able to diagnose, solve and eventually anticipate problems by breaking them down into component parts and detecting sources of errors and anomalies. Second, as a result of problem solving, being able to re-design and re-engineer structures and

processes online as they operated them. Third, being able to communicate and share solutions and inventions by means of formalization and codification. This range of interconnected capabilities made up for a knowledge platform that was shared by the workers: it constituted the premise of their ability at structuring the logic of processes and planning activities, forecasting critical problems, designing and testing solutions. More importantly, the "working with method" became a code of conduct at Melfi, the correct way of doing the job, and a critical value in itself. It stressed the importance of hierarchical order, analysis, and transparency.

The core of the method was transferred to the workers in classroom lectures and laboratory exercises through endless simulations and repetitions. The formal training in Turin was critical in turning a crowd of inexperienced workers into a collective of competent professionals. The act of inscribing the method of (dis)assembling into the workers' mental frames and skills amounted to the delegation of agency and knowledge to the workers. The method constituted the core competence of the workers. More importantly, this phase produced the seeds of both material and cognitive inscriptions, providing the antecedents for further acts of inscription. By learning the values and the work method the newly hired workers were smoothly turned from being novices to being "agents" of Fiat. As soon as they completed the training period in Turin, they would be sent to the green field site at Melfi, where they engaged in the construction of the plant, in which they would finally end up working.

3.2 The making of the factory: Work Breakdown Structures

As soon as they arrived at the green field, the 1000 workers enacted a further inscription by assembling the plant. They acted as operators supporting the building contractors that were on site. Turned into "troopers" by their Turin training, the core group of workers acted like an army setting up a military camp. Buildings, equipment, machinery, various implements and all sorts of industrial paraphernalia were assembled and lined up according to a pre-designed plan. The complete factory materialized as if it was simply "unfolded".

The strategic choice of the company to involve the future workforce in the physical construction of the factory played a crucial role in the creation of what Fiat regarded as a manufacturing community. It helped to anchor the workers' knowledge and skills

to the concrete practice of making the factory in a specific place. The building site experience promoted a sense of belonging to a community of "pioneers and constructors" (Ceruti 1994). Working on the green field assumed for the novices the significance of a founding experience. In their recollections the green field site incarnated the myth of genesis; it was a 'non-place' where little or nothing existed before their arrival and where they started to assemble the factory:

"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 involve our work force in issues related to setting up the assembly unit. They assembled this unit, together with the other companies that were here. They started from the basic element, the "pit", where the electrical system that controls the production lines would be lodged" (Production Engineering Manager, Assembly Unit).

"I've been here since May 1993. Now it is 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 couldn't 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).

As the above quotations suggest, the workers experienced the green field as a point of departure, a beginning in space and time, and perceived the construction of the building as an act of collective appropriation. Equally important, the green field also played a critical role in anchoring knowledge and skills learned in the Turin training to concrete building operations. On the green field the workers appropriated the method of assembling/disassembling further by inscribing it in the material fabric of the plant. The method then did not simply remain a mental procedure or a classroom exercise, it became an everyday practice linked first to the foundation of the plant on a virgin territory and subsequently to the concrete building experience of the workers.

Step by step the components of a whole new activity system were to be inscribed in the material and functional structures of the plant that, in turn, would become the premises for future action and knowledge. In order to turn the green field enclosure into a dedicated work setting for manufacturing cars a sequence of transformations was needed. The "unfolding" of such transformations was organized and steered through the creation of Work Breakdown Structures (WBS), responsible for the development of the multi-faceted aspects of the factory: drawing the functional layout, erecting pillars, walls and roofs, monitoring the construction of the buildings, wiring the shop-floor, installing and testing the machinery, and adapting the

management tools to the specific context. Each WBS would act as a start-up team, directed by a team leader, and was encouraged to submit written proposals for online design variations and inventions to the newly formed steering committee of the plant.

The WBS provided the main project management tool adopted for the start up and subsequent development of the factory. It was deployed to codify and articulate all the activities required for the construction and the operation of the plant. The methodology informing the functioning of a WBS involved listing activities, grouping them according to thematic content, ordering them in a hierarchical way, allocating resources, defining responsibilities, and setting deadlines in relation to the implementation of the project. The WBS reflected the basic work method learned by the workers in their Turin training. It was based on a mechanism of hierarchical decomposition of the whole into parts, whereby each thematic area (work package) would be unpacked into elementary activities, analyzed in its smallest details, and executed. Thus the WBS were an instance of the same (Dis)Assembling method transposed to the domains of construction engineering and organizational design. Through the WBS the basic method was iteratively enacted to produce inscriptions at the level of the whole manufacturing system.

The following example illustrates our point. It shows the functioning of a typical start up team engaged in setting up the presses within the stamping shop, while stressing a crucial learning pattern based on a comparative experience surrounding the installation 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 Komatsu and Schuler 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 rationalize 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 containers; 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 utilized 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)

The example points out that the core group of knowledge workers gradually developed the factory's activity system through an ongoing practice of *unpacking* and *re-packing* leading to the progressive appropriation of organizational knowledge. Following the LEGO-like logic inherent in the functioning of the WBS, the knowledge workers accomplished the complex task of assembling the plant in a piecemeal fashion. In so doing they engaged in an organizing exercise where they materially "wrote" the organization and developed a symbolic map of the factory. They first performed and practiced such critical organizational concepts as hierarchical decomposition, ordering and planning, the division of labour, differentiation and integration, flexibility and variation, and coordination and communication. Then they subtly inscribed those concepts into stable structures of signification: organizational artefacts, procedures, rules, routines, transactions, equipment, machinery, infrastructures, and conventions. As a result they gradually assembled the work organization as an architecture of complexity (Simon 1969) that can be composed and decomposed, broken down into elementary parts and activities. The physical and symbolic space of the factory was "organized" as a table of contents with headings and sub-headings, arranged according to categories for sorting things out. The WBS provided a structure for governing the plant's operations, a classification system for ordering work practices and human interaction. By repeatedly practicing the WBS the workers progressively inscribed their own knowledge into a system – the factory – where new rules for acting and knowing could be enforced. Within the new system events and actions of a different sort could be "authorized" and undertaken, and all the conditions were set for starting the production process.

3.3 The making of the car: Learning to (dis)assemble

The induction phase that followed the construction work was aimed at familiarizing shop-floor workers with the details of the product and the intricacies of the production process. This marked a further step in the enactment of the method of Dis(Assembling) and in the process of inscription-delegation of knowledge to the machinery of the manufacturing system. In the body-welding unit, car bodies were dissected and inspected again and again so that the workers could understand the interfaces among the different car parts. In the assembly unit, a number of simulations

were conducted off the line in order to teach a practical mode of thinking and knowing:

"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, now they had the opportunity to get some 'hands on' experience" (Production Engineering Manager, Assembly Unit).

Elsewhere, the practical act of disassembling the car was intended to yield understanding of the relations between parts and whole:

"In order to familiarize themselves with the list of components, the young engineers were asked to develop it *physically*. Basically, they took all the parts that are needed to make a car assembly, as listed on the bill of materials, and spread those parts over a surface of about 800 square meters. Subsequently, they developed all the Punto's product range by separating the common parts from the specific ones" (Former Plant Director).

Through the endless repetitions of the assembling/disassembling task the workers simulated the functioning of the assembly line, and when they had completely assimilated the practice, they delegated it to the line, which thus inscribed the agency and the task (time and motion, functions and operations). Interestingly, in the process of appropriating the work method a major anchoring role was played by the car and its physical components. Through the repeated hands-on procedure of breaking down the car into separate pieces and then remaking it by putting the pieces back together, the structure of the task was revealed and the logic of manufacturing was appropriated. Thus the car, in addition to being the thing to be manufactured (the product), also became a cognitive tool – a medium – both for the understanding of the manufacturing method and for the institutionalization of knowledge.

What makes the process of inscription/delegation particularly interesting is the somewhat insidious way in which it took place. Meaning and values that were inscribed into the factory and the car were interpreted by the workers, and their lessons were learned directly, not passed from manager-to-worker or from worker-to-worker. As the workers learned the right way to build the car from the assembling/disassembling exercises, at the same time the car "taught" the workers the right way for it to be built: which made the process more real and probably more

compelling than authority rule or peer agreement would have done. The machine turned into a machination (Latour 1988b), and it is difficult to find evidence that the managers and the workers were fully aware of it.

3.4 Closing the box: delegating knowledge to the machine

At the end of the induction phase the plant was formally opened and the first car rolled out of the assembly line. This moment represented the completion of the sequence of inscriptions and delegations and the *closure* of the black box. The factory then gradually moved into full production capacity. A new phase began in which the original stock of knowledge transferred to the workers had been deeply transformed. A technology-based institutional order was created in which large components of human agency and knowledge were handed over to impersonal mechanisms.

When the factory turned into a black box and became fully operational, it acquired the status of an "inscribed world" (Akrich 1993, Joerges and Czarniawska 1998) for the workers, characterized by institutionalized rules, shared values and knowledge structures that sustained a set of self-reproductive processes. Together with practical knowledge, an entire coordination system was inscribed into the machinery. Embodied in the technology were organizational rules for performance and monitoring of the collective task of manufacturing, so that explicit human effort at coordination and control was greatly reduced. Under these circumstances, the factory became a sort of computation tool (Hutchins 1993), a structure for orientation that enabled the workers to make cognitive economies in production, communication and coordination. It apparently was operated and controlled by self-activating reproductive routines, as if it had gained a life of its own. As a result of *closure* a whole knowledge system was sealed and handed over to the factory.

The impersonal, objectified character of the factory and the idea of an intelligence “hidden” in the rationality of the production process are powerfully evoked in the words of Melfi’s former director:

“Machines are smart, robots are smart. They timely signal different types of anomalies and criticalities. Smart machines allow for a diagnosis of what is going on, so that it is relatively easy to receive and process information and use that information for continuous improvement… At the same time there is a different type of intelligence, which unfolds alongside the construction of the object, and which is

made available to those who work further down the line and who have to prepare for the transit of the object. The car body starts in the Body Welding unit and, while it moves along the lines, it sends information on an ongoing basis: a carrier of intelligence, a vehicle of knowledge exchange that asks the system to prepare for its transit… Certainly (human) knowledge and abilities are required to govern all this. There is a continuous demand for generating knowledge so that those variables can be managed."

Clearly, while the above quote was intended to support the claim that governance of complex systems requires human intelligence, the language deployed reflects a conceptualization of the factory as a cognitive tool that functions as a clockwork.

Yet, together with technical knowledge and agency, patterns of social relations were also inscribed in the production system. The production task and the organization of the factory were shaped into component units so as to match the internal customer-supplier model, where each UTE would be both a customer and a supplier of the adjacent UTEs. Power and control over the production system were delegated to formal lean production devices such as Just In Time, quality control procedures, and kanban. The internal customer-supplier model generated a system of "impersonal" transactions between upstream and downstream processes along the production system. Within such a system a virtual customer enacts a production mix (a sequence of orders) and dictates the pace and speed of production. The integrated factory was based on the principle that "the next process is your customer". During the start up phase each UTE would display a large banner stating "the customer is in the UTE" with charts of the UTE's obligations toward its internal customers and the customers satisfaction criteria. Rather than a mere slogan, such statement represented the way the organization was internally structured. It was designed to make people recall the framework by which the whole system was broken down into customers and suppliers and to help them internalize the fact that everyone is working for a customer. As a result of such arrangements, a system of customer/supplier transactions was inscribed in the production system, and both systems were ruled by the same principle of Dis(Assembling).

The governing function of the virtual customer is even more apparent in the way in which the production sequence is currently organized. Since the body welding phase a code number identifies the specs of each car to be produced and links the car to the name of the final client before the distribution phase. An impersonal device such as

the kanban (a tag containing instructions regarding the specs of each car to be produced) pulls the system by delivering instructions to the operators on the assembly line and regulating the transactions between internal customers and suppliers. Apparently, in such technology-regulated transaction system very little discretion is allowed and minimal authority is enforced to rule the system. Technology and the internal market associated to it seem to have replaced authority in ruling Fiat Melfi's institutional order.

3.5 The strike: questioning the factory's institutional order

After several years of smooth factory operations the technology-based institutional order established by Fiat clashed with workers' expectations. Together with innovative aspects Fiat's strategy also re-enacted some of the traditional features of the company's industrial culture and logic. Particularly, at the outset, it was essential for Fiat to win the workers' commitment to the project of the new integrated factory. To this purpose Fiat made a pre-emptive agreement with the unions and established a participative model where the unions would accept becoming the guardians and 'guarantors' of the company's productivity. In simple terms, the agreement established a trade off between jobs and rights: on its part Fiat would create new jobs in Southern Italy by locating the plant at Melfi instead of choosing alternative and eventually more favourable locations; on their part the unions and the workers would concede some of their rights concerning wages, working conditions, and autonomous initiative in industrial relations.

To be sure, Fiat's institutional experiment was a gamble with uncertain odds. At the outset none could tell whether the move of making the workers become Fiat agents and delegating the implementation of the project to them would produce the intended outcomes. For a number of years the gamble seemed to be successful. In the early times of the factory operations the agreement produced smooth workers/managers relations with industrial conflict practically nonexistent and little unions' interference in the daily dealings of the organization. The new green field plant successfully combined advanced production technology and management of human resources. The product had a high quality standard and productivity levels were comparable to benchmark Japanese automotive factories such as Nissan and Toyota. All this contributed to feed and spread the myth of Melfi's integrated factory. But the myth

came to an unexpected crash with the workers' upheaval and strike of April 2004. The workers' claims concerned three main issues: the salary, that in spite of a 20% higher individual productivity at Melfi, was 20% lower than in other Fiat factories; the unfavorable working conditions, especially the six-night double shift, that resulted in 12 nights of work in a row; the strict hierarchical enforcement of discipline, with thousands of disciplinary measures taken by management against the line workers.

For many years the workers had complied with the 1993 agreement between the company and the unions. The memories of the beginning, the pioneers' times and the green field stories were still vivid and repeatedly evoked. The early 1000 knowledge workers were still the leading hands of the factory. But things at Melfi had gradually changed throughout the years. The bilateral union-management committees stopped being called for periodic meeting. Workers' participation declined. Old hands quit the factory and were replaced by new hands, often hired on a temporary basis. Fiat's old hierarchical-authoritarian management model slowly crept into the integrated factory and the "participative" work organization faded. The UTE heads turned from being team leaders to line bosses, more connected to top management than to their UTE fellows. A new line position with controlling and supervising functions was introduced in the UTE - the team speaker, who reported to the UTE head. The speed of the assembly line was increased to accommodate productivity, and work shifts became more and more stressful. Discipline and control were increasingly enforced by hierarchy and authority rule, to the point that 2500 disciplinary measures were taken against the workers in the year 2003 only. As a consequence, in spite of the high productivity records and the spreading myth of Fiat Melfi, uneasiness and discontent were growing under the surface. All this put mounting pressures on the workers, leading them to the stoppage of the assembly line and to calling into question the work organization. Below are the voices of the workers extracted from the media coverage of the strike:

> "On April 19th we had just started our shift when suddenly the bosses told us that we had to go back home without pay because bolts and car doors to be assembled had not come from the suppliers and they could not keep us there inactive. Not even dogs are thrown out of the house in this manner. It was the spark that made us understand" (Walter, UTE operator on strike, La Repubblica, daily newspaper, may 5th, 2004)

> "I am sick of being nothing. I am not a member of the union. I thought it wouldn't be necessary in such an advanced plant. But on April 19th we all realized we were nothing…we are worth less than a bolt" (Giuseppina, worker on strike, La Repubblica, daily newspaper, may 5th,2004)
>
> "Fiat thought they had built a governable factory, but they did not realize that the factory wasn't governable anymore… From now on Melfi will never be the same as before". (Bruno, worker on strike, La Repubblica, daily newspaper, may 13th, 2004)

Particularly, the workers experienced Fiat's behavior as a "betrayal" of the obligations taken in the original 1993 agreement:

> "The Melfi model is a trick. We have been cheated, because years ago we knew nothing of industrial production and work in a factory, we didn't know Fiat. At that time it looked like a dream to us, the best of all possible worlds. Then little by little we came to realize what was going on…we woke up" (Sara, worker on strike, press review at http://rassegna.it/2004/vertenze/articoli/melfi3.htm)
>
> "You ask why we spent ten years without making any claim? We had to understand how things work here. This factory of ours is based on mobbing" (Alessandro, worker on strike, La Repubblica, daily newspaper, may 5th, 2004).

The words of an early pioneer, Emanuele, reveal mixed feelings of pride and anger:

> "Of course I am proud of working in one of the most advanced factories in the world, but I have to say that at Melfi we produce more cars than anybody else and we get less than anybody else. I really resent that Fiat has not understood us for so long." (press review at http://rassegna.it/2004/vertenze/articoli/melfi3.htm)

By stopping the production lines and going on strike the workers called Fiat's strategy for building the factory into question and re-opened the box. The strike was an interesting event for our study, because it revealed some critical features of the process of institutionalization of knowledge at Melfi that were difficult to observe, being hidden in the chain of previous inscriptions and delegations. Particularly, it offered new data about the institutional significance of the (Dis)Assembling method and unveiled some asymmetries and dis-alignments between the workers' agency and the factory's technical system. The strike brought to the surface the limitations of Fiat's experiment in institutional design and led us to question the nature and the effects of the institutionalization process enacted by Fiat.

4. Discussion

What strikes in the Fiat Melfi story is its ambivalence. Depending on how we look at it, this story of institutional construction can be told either as a success or a failure. A

full appraisal of it requires answering to two basic questions: on the one hand, why was Fiat's design experiment so successful in the early phases, creating an automotive factory with outstanding productivity performances in a very short time? And, on the other hand, what did not work out as expected in the institutional establishment of the factory? In the following sections, based on the data of the story, we assess the strengths and weaknesses of the institutional order created by Fiat and show why Fiat's design for the factory was ambivalently both a machine and a machination.

4.1 The inscription-delegation chain and the D/A template

In table 1 we have summarized the chains of transformations that occurred in the process of making the factory, as we have tracked them in our fieldwork and articulated them in our account.

INSERT TABLE 1 ABOUT HERE

The creation of the factory's production system required the institutionalization of a core stock of knowledge. This was achieved through the progressive inscription of human agency into artifacts to which component programs of action were transferred via delegation mechanisms. At the outset of knowledge making processes was the emergence of a particular sign-agency-meaning configuration. Something that stood for something else produced certain actions that conveyed particular meanings to the agents. The progressive enactment, enchainment, and sedimentation of sign-agency-meaning configurations eventually led to the institutionalization of a cognitive and institutional order embodied in the factory's production system.

As we see it, the inscription-delegation chain is both an activity map and a knowledge map. It shows at the same time the actual building operations and the associated cognitive and sensemaking activities for each round of inscription and delegation. Each act of inscription-delegation is both the consequence of the previous one and the pre-condition for the next one. At each round technical operations and knowledge processes cannot start and run unless the previous round is completed.

At the core of the knowledge making process surrounding the design experiment was an underlying pattern based on the Disassembling/Assembling concept and

functioning as a structural template. The D/A template supported the recursive act of inscription-delegation underlying the training of the workforce, the construction of the factory, and the manufacturing of the car. D/A is both a technical and an intellectual operation. It is not just a method of production by piecemeal assembling; it is also a powerful cognitive device for ordering the world and bestowing meaning onto it. Assembling is both a way of making things and a way of seeing things. Each way entails different kinds of knowledge, which at Fiat Melfi in the early phases seemed to be strangely aligned.

The workers internalized the D/A template through reiterated cycles of inscriptions and delegations that started in the Turin classrooms when Fiat smoothly inscribed the template in their minds and skills. Then, acting as Fiat agents, they delegated that knowledge to the factory, and developed it further by assembling the guts of the plant and the car piece by piece in each successive building phase. In their roles as Fiat agents the workers were not just passive carriers of received knowledge and agency; on the contrary they actively generated new knowledge and new forms of action in their daily dealings with the operations of the system.

The delegation mechanism retained a retrospective character in the chain of transformations developed through the repeated applications of the D/A template. At each step of the building process, each single act of delegation transferred and enacted only a potential capability for producing cars. Each single act of delegation became visible, made sense and had an effect when the box was closed and the factory started off its operations, not before. In other words the whole factory system would (could) not start unless the last minimal piece of the system was in place. Indeed, it was the final act of closing the box that switched on the production machine and retrospectively gave sense to the entire chain of previous delegations. The meaning of each building step was revealed only by going backwards, from the fully operating production system back to its foundation: the next-next-next sequence of the construction process that points to the future was then reversed in time, reverting upstream to the early phases of the process.

Our analysis suggests that knowledge making that unfolds in a work setting is similar to the writing of a text based on simple rules. The more frequently and fluently the

text is used, the more it makes sense, and the more transparent or invisible it tends to become. What caught our attention at Melfi, and what in our view makes the case unique, was the fact that first the workers learned the logic of assembling, then assembled the factory, which in the end became the context and the tool for assembling the car. Once the factory had been completed and started its operations, it embodied encoded and institutionalized knowledge that turned into a collective good for all the workers, something that was shared and collectively known because they had made it together. While the practical skills developed in the classroom D/A exercises and in assembling the plant were swiftly transposed to the shop floor activity of assembling the car, the plant was projected onto the background of the activity system. Thus the factory became in the workers' minds *the necessary infrastructure* and the taken for granted setting for assembling the car. The "thing" that the workers had built became the *world* in which they now worked and lived. It was both a technical and a cognitive infrastructure for doing work, thus gaining an institutional value.

4.2 The D/A template as a source of institutionalization

We wish to stress here two major factors that explained the initial success of the design experiment and progressive transformation into a self-reproductive cognitive and institutional order. These are the role of assembling as a code and regime and the historical anchoring of the D/A template.

When the box was closed and the assembly line was finally set in motion, all the elements that made the factory a self-sustaining, purposeful system were at last in place, and the entire sequence of building steps gained purpose and meaning in retrospect. The switch was turned on and production began. The final act of closure completed the chain of inscriptions and delegations and imbued each of them with a meaning. By this act, a complex system was generated which *stood for* something else, being a sort of vicarious structure of human action. The inert components layered on the green field and variously connected now worked within a large network of human and non-human actants (Latour 1988a, Latour 1991). Much human agency was delegated to action programs and to self-reproductive processes embodied in the technology. These programs and processes all shared a common

code and were operated within the same technological regime. The code ruling the factory was the Disassembling/Assembling template.

The code-like character of D/A illustrates the workings of the template as both a referent and a persuader. On the one hand the D/A template is a code because it acts as a symbolic reference system that generates signification and confers meaning to the workers' everyday activity. The D/A template has remarkable generative and ordering powers: it is easy to understand, easy to accept because of its ontological self-evidence, easy to reproduce due to its simplicity, and easy to communicate. As a pervasive cognitive analogy and basic design concept, the D/A template embodies the concepts of decomposability and organization, conveying the idea of a system of interrelated parts (Simon 1969). In Fiat's design the D/A template was a source of systemic understanding, intended to link, in an isomorphic way, the nature of the task to the techno-structure of the factory and the organization of work. For the workers it soon became both the elementary pattern for building structures and the basic method to understand their functioning. It provided a heuristics that supported individual and group initiative in solving problems and developing new knowledge. In this regard, the D/A template played a constitutive role in the making of the factory.

On the other hand, the D/A template is a code because it fulfils the regulative and prescriptive functions that in a society are usually accomplished by a system of laws or by any other set of principles or standards. That which in society is accomplished by law in the factory is accomplished by technology. In Melfi, the ordering function of the D/A template gave rise to a self-enforcing technological regime. The manufacturing system was a regime in that it comprised a set of implicit and explicit principles, rationales, norms, rules, technical standards, conventions, and decision making procedures around which the actors' practices and expectations converged in a given field of technology use and application, namely the field of automotive production. Within the regime, areas of competence and responsibility were marked out, and the boundaries between them established, which facilitated positioning and the mutual recognition of roles and identities, rights and duties. Machinery and technical equipment, roles and tasks, skills and identities, meanings and cognitive frameworks all revolved around the basic D/A analogy and the assembly method. In this respect the D/A template constituted not only a method of production but also a

method of ruling, a mode of governance. Perhaps the institutional dynamics underlying the construction of Fiat's Melfi plant display, in its most perfected and transparent form, the institutional character of the division of labor and the cognitive structures associated with it.

Yet the functioning and the meaning of the D/A template cannot be fully appreciated without considering the temporal dimension of the process of inscription. The factory was a cross-temporal structure, linked by a thread of repeated applications of the D/A template. It was a sedimentation and stratification of an ordered sequence of operations and connecting events, one being the antecedent and the reason for the next (and, in turn, the latter being traceable to the former). For its builders the factory inscribed not only technical and functional requirements but also a historical dimension, thus becoming a historical object that had a clear point of origin in the green field and whose every component or building phase made sense inasmuch as it was placed in a stream of ongoing developments (David, 1992).

Time provided a genealogy of the plant as well as a crucial sensemaking mechanism. Rather than explaining the current workings of the factory *teleologically* according to the objectives it was supposed to achieve (e.g. manufacturing, production volumes, quality standards) the present activity was understood *retrospectively*; that is, by referring to some originating experience and to the unfolding of events in the past (Weick 1995, David, 1992). The orientation to the future, which naturally characterizes all purposeful, task-oriented activity, was powerfully supported by a retrospective orientation, that is, by an understanding of the historical antecedents leading to the present state of affairs. By progressing in their building activity and by looking at the expanding equipment installed on the green field, day after day the workers could measure the distance from their past and the progress of their march into the industrial world and their new working life. This gave them directionality in time: an accumulation of installed base (Ciborra and Hanseth 1998) until the technical "blackboxing" took place and the factory began to operate.

Thus, making the factory was not only "assembling", that is, putting things together in stable configurations; It was also being able to trace its history from the early beginnings in Turin to the present day and back again. As a consequence the workers'

understanding of the practice of assembling was greatly reinforced by their ready access to a historical account of why the practice existed and how it had come about. Assembling was crucial for the creation of such access: the workers were able to travel in time, following the workflow upstream and downstream, precisely because they had assembled the structure.

4.3 Sources of vulnerability: knowledge, technology and power

In spite of its many strengths the institutional regime enacted by Fiat around the Melfi plant turned out to be vulnerable. The workers' strike was a "cosmological episode" (Weick 1993) that revealed the limits of the D/A template as a mechanism of institutionalization. Such limits regarded essentially the incomplete reach of D/A template in mediating the alignment of the factory's social and technical systems and encompassed the interactions among knowledge, technology and power.

From the very beginning Fiat codified the D/A method as a shared knowledge platform which would serve both as a code for communication and problem solving and as a mechanism for handling the complexity of the production system. As the former director of the plant pointed out the method worked as a vicarious device, intended to sustain the work organization and to accommodate for the novices' lack of idiosyncratic knowledge and work experience. In addition, the D/A method pointed to the correct way of doing things and therefore became the carrier of critical institutional values (e.g. authority and transparency). However, while the internal logic of the D/A method showed remarkable structuring and cognitive power it did not work as a mechanism capable of supporting the reproduction and the governance of an industrial knowledge system. In other words, the D/A template was perhaps effective enough as a cognitive device, enabling the workers to learn the method of work, the structure of the car and the logic of industrial manufacturing; it produced cognitive alignment between the workers' skills, the task, and the technology; but it did not achieve the same result in aligning the factory's social system with the technical one.

A similar line of reasoning applies to the role of technology. The strike brought to the fore what had been an underlying trend within the factory throughout the decade 1994-2004, namely the introduction of an array of more direct means of control of the

workforce. Among other things, this indicates that the technology needed to be complemented by hierarchy and formal authority as ordering principles, and that the code provided by the D/A template could hardly deal with the social complexity that characterized the assembly line and the governance of the production system.

This becomes apparent in the ultimate act of closing the box. As showed in our previous analysis this regarded the inscription of self-regulating and self-diagnosing mechanisms into the technology. With it, crucial components of agency and knowledge that concerned the governance of the social system of the factory were delegated to the machine. But such delegation did not work as expected. In a sense the capacity of machines to exercise control on behalf of humans was confined to the technical domain and required the support of collective sensemaking and heedful interrelating (Weick and Roberts 1993) along the production lines.

The strike challenged the idea of the factory as an inscribed world populated by intelligent machines and requiring minimal human intervention. In such world technology is assumed to embody neutrality, transparency and authority. However, as Munro (1999) has pointed out, there are limits to the capacity of technology to act as authority, that is, to function as a technology of managing. Technology is equivocal (Weick 1990) and it continually opens up new spaces for the exercise of discretion. For instance, detecting and tracking anomalies in the assembly line and in the associated knowledge system involves the search and understanding of their causes, the attribution of individual or group responsibility for problem solving, and finally the discretionary enforcement of sanctions and rewards. This is inevitably characterized by discretion. The system signals the error, but does not attribute specific responsibilities.

The institutional machine built by Fiat was also a machination, a subtle way of enrolling the workers and their agency not only to the task of industrial production, but also to perpetuate Fiat's pre-existing institutions.[iii] Whatever Fiat's deliberate aims were, the experiment turned out intrinsically ambivalent, being at the same time an effort at innovation and a design for establishing an industrial order. The design was constitutive rather than regulative: it aimed at the constitution of identities and competencies rather than relying on sanctions and rewards to behaviors. Through the

machination the workers became the active carriers of Fiat's industrial models and institutions into the new plant. Fiat provided the frames, the essential templates, and the logic of action by which the workers chose interpretations and enacted possible responses. The factory came to the workers as a self-contained world, a necessary cosmology, apparently with no alternative models they could possibly think of.

It is important to notice how this constitutive design turned into a kind of cunning. On the one hand the inscription-delegation process involved the delegation of power and authority first from management to workers and then from workers to technology to act on behalf of the agents; on the other hand the very same process also worked as a way of concealing the hierarchical asymmetry between managers and workers under the covering rule of the technology and the task system. A crucial structural feature of the industrial world, namely the conflict of interests between labour and capital was supposedly hidden, and presumably resolved, in the technical system. Multiple wills, and their interactions, were cast into the machinery, producing effects that went beyond human intentions. This is what made it a machination. But in the end the D/A template could not effectively deal with power intrinsic in human agency and in all forms of social exchange.

In this connection Fiocco (1997, 2000) has argued that the lean production model (and the kanban system in particular) produces a sort of *panopticon* were all power is somehow concealed and "neutralized" through delegation to impersonal devices. She speaks of a kanban effect: rather than an innocent tag delivering instructions and carrying information the kanban also conveys, in a concealed form, a hierarchical mode of command (from the management to the line workers). Disguised as a communication system the kanban creates the illusion that the pace and speed of production are pulled by an "objective" mix of orders generated by the final client. The final customer brings objectivity to the production system and generates a sequence that is perceived as undisputable. In a similar vein, Bonazzi (1993) has described Melfi's integrated factory model by using the metaphor of a "crystal pipeline". The image of the pipeline that portrays lean production indicates a rigid synchronization 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 first

eliminating waste and defects. Second, avoiding informal stocks and slack, and thus, curbing shirking and other forms of opportunistic behavior. Third, making all available knowledge explicit: work is made transparent and "textualized", (Zuboff 1988) by representing all relevant aspects of the workflow through a visual control system. The fragility of the pipeline is related to the rigid synchronization of the workflows 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 synchronized with the purpose of avoiding bottlenecks, work-in-process inventories and buffers. More importantly, the technical efficiency of the assembly line and the product quality are highly dependent on the quality of social relationships along the production line. In order to keep the line moving workers have to collaborate, avoid conflict, and self activate whenever a technical breakdown occurs.

Admittedly, the frictions and asymmetries between management and workers, and between workers and machinery that build up throughout the process were not easily observable, being hidden in the transformations. During the regime-like operation of the plant they were embedded within the technological system, and were brought to the surface only by the strike. Thus, quite ambiguously, the entire process of building the factory was a way of empowering the workers to act as Fiat's agents while at the same time implicitly asking the workers to give up large components of their autonomous agency and knowledge to the technology that runs the operations. Basically, one of the effects of Fiat's ambivalent strategy was that workers' agency was constituted as strictly dependent on the technology and the requirements of industrial production. Being enrolled by Fiat at Melfi meant for the novice workers developing a specific technology-induced agency and at the same time having to comply with a strict technology rule – the logic and regime that runs the factory. These contrasting pressures are clearly visible in the data: at one point the workers' representations of their own roles as autonomous agents diverged from the meanings consistent with the D/A template or the hierarchy: the sense of pride for being "authors" of the Melfi factory was countered by the growing feeling of being treated like "cogs". Caught in the traps of the machination, the workers felt "cheated" and responded with anger and by stopping the line. Stopping the assembly line was a way

of withdrawing from the delegation, questioning and unsettling a stable sign-agency-meaning configuration, that is, the factory's institutional order.

5. Concluding remarks

Although so peculiar that it might be regarded as a sort of contrived, unique social experiment, the Fiat Melfi case has helped us to develop an interpretation of the creation, consolidation and reproduction of a cognitive and institutional order. Specifically, our study has stressed the workings of a structural template as a mechanism guiding both the material construction of the factory and the inscription of a complex knowledge system into the production machinery. Also, we have spelled out and discussed some sources of vulnerability that characterized the cognitive and institutional order enacted by Fiat at Melfi. In a nutshell, our final diagnosis can be resumed like the following: the D/A template displayed remarkable power in structuring and reproducing the technology-based knowledge system, but because of its features failed to work as an effective tool for the social governance of the factory. In the end, growing tensions and asymmetries between the technical and the social system led to incomplete or thin institutionalization. This caused problems of durability and reproducibility of the cognitive and institutional order.

Our findings point to some broader considerations, which can be only synthetically sketched here. First, we suggest that research on templates as structuring mechanisms can be promising both in the organizational and in other domains (social, political, cultural), explaining processes of institutionalization as the progressive inscription, delegation and anchoring of human agency and knowledge into complex functional networks. Second, we have shown how simple templates can generate and reproduce complex knowledge structures embodied in material and organizational artefacts. Third, the study shows that specific templates (the D/A for instance) have limits as codes for handling the subtle relationship between knowledge and power intrinsic in human agency. As a result, templates might generate institutional structures and configurations with in-built asymmetries and instabilities eventually leading to breakdowns and revisions. Finally, we suggest that the study of processes of institutionalization can greatly benefit from merging research on organizational knowledge and neo-institutional theory. The critical link between knowledge creation

and knowledge institutionalization for organizational performance will thus be better appreciated.

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Delegation

PHASES	SIGN	AGENCY	MEANING
THE MAKING OF THE WORKFORCE	The classroom and the laboratory; the textbooks and the simulations The D/A method	Training at Turin headquarters; learning the D/A method; The act of transferring Fiat's industrial models, values and practices to the workers created a group of skilled and socialized agents	Forming a community of agents that would be Fiat's pioneers, builders and workers at the green field site
THE MAKING OF THE PLANT	The greenfield; the enclosure for the plant; the walls and physical building; the functional containers. Work Breakdown Structures Pits, cables and wires, power lines, production infrastructure, plants and machinery	The act of drawing the boundaries of the construction site. The act of assembling the factory through WBS enacted an activity system for manufacturing cars on a large scale. Construction work and installation of machinery and equipment was based on a mechanism of hierarchical decomposition of the whole into parts.	The foundation and the construction New activities and identities are originated and assembled in a dedicated place. "Writing" the organization and developing a symbolic map of the factory. Sorting things out. Building a classification system for ordering work practices and human interaction.
THE MAKING OF THE CAR	Car, components, assembly line	Learning to (Dis)Assemble The repetitive act of Disassembling/Assembling incorporated and enacted the set of programs for manufacturing the car Assembling the car bit by bit	Division of labour Sequential structure of the task Interdependence, coordination and cooperation Diagnostics and problem solving
CLOSING THE BOX	The factory The fully operating production system The internal customer model	The act of closing the box started the production system on and activated the chains of delegations Network of customers/suppliers transactions Self-activating, self-reproductive processes	The factory as an institution, a self-contained world, a background for daily practices and routines A knowledge system that is shared and taken for granted Cosmology.

Inscription

Table 1. Creating and institutionalizing knowledge at Melfi: a map of the inscription-delegation chain

[i] Our conceptualization of templates differs from the definition commonly adopted by institutional theorists (e.g. Powell and Di Maggio 1991, Greenwood and Hinings 1996). As Kimberly (1979) has pointed out, institutional theory draws attention to institutionally derived and created templates of organizing to which organizations converge, rather than to the uniqueness of organizational arrangements (in the form of culture or knowledge configurations). Emphasis is placed on the exogenous factors shaping the emergence of templates of organizing rather than the internal dynamics leading to the formation of them. While templates may well derive from

exogenous forces we are interested in the role of the template as a knowledge structure underlying the *modus operandi* of a social community and presiding over the reproduction of a given behavioral pattern across a work setting. In this respect, our definition is consistent with knowledge transfer theories (Nelson and Winter 1982, Kogut and Zander 1995, Jensen et al. (2003) and with Douglas' notion of cognitive analogy (Douglas 1987).

[ii] In semiotics the term 'actant' denotes any entity (both human and non human) endowed with the ability to act, to produce effects. More specifically, an actant can be thought of as whatever accomplishes or undergoes an act independently of all other determinations (Greimas and Courtès 1982). Unlike actors, actants are not described in terms of what they are but in terms of what they do, and by their participation in a network of social actions and relations without having projects and interests of their own.

[iii] Machination does not necessarily imply deliberate intention or strategy. The idea of machination invites to pay attention to effects and interacting forces rather than to intentions or plans. Because of incomplete data we cannot tell whether Fiat was fully aware of all the effects and implications of its strategy of institutional design, nor of all the forces mobilized by its intervention. For sure our data show that originally Fiat management framed its experiment essentially within a HRM framework with a focus on participation and productivity. But the conspicuous number of psychologists and sociologists that were hired as consultants to the Melfi project reveals that Fiat's concerns went well beyond the pure technical and instrumental domains. As we intend it here, the machination was in the unfolding chain of inscriptions and delegations, of which Fiat management was only partially aware when it unfolded.