



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 a rich qualitative study, we apply an inscription–delegation model to the analysis of knowledge dynamics in a greenfield automotive plant. In particular, we depict knowledge institutionalization as a recursive process that involves the progressive writing, enactment and reproduction of a generative template or code within a stable medium. We first reconstruct the chain of transformations by which agency and knowledge are embedded into a variety of technical and organizational artifacts, leading to the creation of a cognitive and institutional order. We then focus on the frictions and tensions that can emerge in the transformations, and we discuss problems of vulnerability and durability that may arise in the maintenance and reproduction of such order.

Keywords: institutionalization, knowledge, template, inscription–delegation, durability

Introduction

In this paper we introduce the notion of a template and an inscription–delegation model to account for the institutionalization of technical and organizational knowledge in the work setting. Our central argument is that institutionalization can be regarded as a recursive process that involves the progressive writing, enactment and reproduction of a generative template or code within a stable medium. We first reconstruct the chain of transformations by which human agency and knowledge are progressively developed and embedded into a variety of material and organizational artifacts, leading to the formation of a self-reproductive pattern or order (Jepperson 1991). We then focus on the tensions that can emerge in the transformations, and discuss problems of vulnerability and durability that may arise in the maintenance of such order.

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

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factory on a greenfield site 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 had plagued Fiat throughout the 1980s, resulting in poor-quality products, low productivity and endemic industrial conflict. Fiat's management conceived the project as a design experiment supported by a pre-emptive agreement with the unions, whereby a core group of 1,000 knowledge workers — after an intensive training period at Fiat headquarters in Turin — would go to the greenfield site at Melfi and contribute to building the factory: 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, thus assuming the character of a self-contained world (Douglas 1986).

Fiat's experiment proved to be successful and the factory soon achieved high productivity levels. For over a decade the plant was considered by both Fiat and its competitors to be a leading example of productivity and corporate efficiency. Yet, what came to be labelled and widely praised as 'the Melfi model' (e.g. Camuffo and Volpato 1995; *Economist* 1998; *Fortune* 1994) suffered a sudden and unexpected breakdown in April 2004, when the workers of the Fiat plant and the supply firms located at the same site went on strike, halting the assembly line and all factory operations for several weeks. This was the first significant protest since the construction of the Melfi plant. Although largely unexpected, the strike was a major national event and received extensive coverage in the media: it not only marked a major discontinuity in Fiat's production, but also called into question Fiat's design strategy for the Melfi factory.

Based on our field observations, we argue that the building of the factory and its establishment as a cognitive and institutional order were supported by the recursive enactment of a generative template, namely the method and practice of (dis)assembling (D/A) (Ciborra et al. 1995; Patriotta 2003). We show that the D/A template helped reproduce the factory's operations and its associated knowledge system by being acted out in endless repetitions, but, in the same process, it generated tensions and strains that led to conflict and revision of the factory's institutional order.

The paper is organized as follows. In the next section we illustrate the notions of template, inscription and delegation and discuss their relevance to the study of knowledge-making and institutionalization. We then describe the setting and research method of our study. In section three we tell the Melfi story from the Turin training period, through to the start-up of the plant, to the later events that led to the strike. The discussion in section four analyses the strengths and weaknesses of the specific generative template enacted by Fiat in the building of the Melfi plant and in the creation of a cognitive and institutional order. In the final section, we highlight the distinctive institutional character of Fiat's strategy at Melfi and we suggest that our framework and findings add value to both neo-institutional perspectives and actor-network-theory, encouraging further research on the dynamics of organizational knowledge systems in a variety of empirical settings.

Templates, Inscriptions and the Institutionalization of Knowledge

In explaining knowledge-based phenomena in organizations, current theories have privileged processes of knowledge creation (Nonaka and Takeuchi 1995) and transfer (Kogut and Zander 1992; Szulanski 1996) over the subtle and less explored dynamics of institutionalization. In particular, the emphasis placed by the existing literature on the instrumental exploitation of knowledge assets that once knowledge has been synthesized in the most diverse forms and in a variety of media, it can be easily ‘anchored’ and reproduced within a given organizational setting. However, just like the construction of scientific facts or the development of innovations, so knowledge-making processes in organizations are often characterized by ambiguities, controversies, tests and debates (Knorr-Cetina 1981; Latour 1987; Lanzara and Patriotta 2001), which may eventually give rise to shared and more durable frameworks. If knowledge is to persist and yield increasing returns, it must gain an institutional valence, thus becoming the unquestioned background for acting, communicating and further knowing.

Taking our lead from neo-institutional theorists, such as Zucker (1983) and Jepperson (1991), we conceive institutionalization as the phenomenological process by which a social order, a pattern, or a practice, comes to be taken for granted and is reproduced in structures that are to some extent self-sustaining. The analysis of institutionalization processes is of particular importance in relation to knowledge-making dynamics in organizations, for it yields understanding of the performativity, durability and persistence of organizational knowledge systems — that is, why knowledge works, why it is stable, and why it is ‘sticky’.

The effective deployment and exploitation of organizational knowledge requires a degree of closure to be achieved through institutionalization. This occurs when ideas, intentions and haphazard modes of action gradually become embedded in durable artifacts and stable structures of signification, which may include scripts, frames, rules, stories, routines, procedures, equipment, technologies, material objects and so on. When these structures of signification are accepted as indisputable parts of the organizational reality, they become institutionalized and are used as cognitive tools by people to make sense of their world and their practical dealings (Douglas 1986; Garfinkel 1967; Hasselbladh and Kallinikos 2000).

Perhaps more importantly, institutionalization refers to the degree of ‘taken for grantedness’ of an organization’s idiosyncratic knowledge base (Tsoukas and Vladimirou 2001). Knowledge may be institutionalized to a greater or lesser extent in a given organizational setting. If knowledge is weakly institutionalized, it is intrinsically unstable and variable, and direct social control or other intervening mechanisms are required to maintain and reproduce an existing order of things. If, on the contrary, knowledge is highly institutionalized, then it is accepted without further dispute because it has gained some degree of authoritativeness and legitimacy among its agents, and it does not require the intervention of exogenous human action for its reproduction (Jepperson 1991; Zucker

1977). It becomes a sort of ontological basis for what the agents come to define as *the* reality of a situation (Berger and Luckmann 1967). Moreover, it is likely to diffuse more easily or to facilitate diffusion to a greater extent: 'once institutionalized, knowledge exists as a fact, as a part of objective reality, and can be transmitted directly on that basis' (Zucker 1977: 726).

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. Owing to persistence, the effects of institutionalization for organizational performance are often ambivalent. On the one hand, institutionalized knowledge is connected to an organization's core values and thereby constitutes a source of legitimacy and durability; on the other, the same connection with taken-for-granted values also introduces rigidity, stickiness and resistance when change is necessary (Leonard Barton 1992a, Szulanski 1996). As Jepperson (1991) has pointed out, the more institutionalized a structure or a rule is, the higher the threshold to be overcome in order to subvert it through collective action.

Although neo-institutional theories provide many useful insights into the institutional character of knowledge-based phenomena in organizations, they have been recently criticized for portraying institutionalization from a predominantly adaptivist and diffusionist perspective (Hasselbladh and Kallinikos 2000). By emphasizing isomorphic convergence on rationalized beliefs and practices, such theories tend to overlook the dynamic and situated character of institutionalization, and specifically the inner processes by which knowledge — in the form of myths, ideas, archetypes, recipes and templates available in institutional environments — is adopted, developed and enacted within organizations. In order to remedy this shortcoming, we claim that neo-institutional theories can be enriched by integrating their insights with concepts derived from actor-network-theory (ANT) and the sociology of translation (Callon 1986; Latour 1991, 1999; Akrich 1993; Law and Hassard 1999; Organization 1999).

Our conceptual framework is based on two main assumptions. First, the institutionalization of knowledge requires a generative principle, or code, that reproduces a behavioural pattern across a variety of media, artifacts 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, which, because of its ontological 'obviousness', soon becomes the accepted way of doing things — a master model or pattern by which other similar things can be made.¹ As a working example, the template performs a number of functions. It is a basic design element serving as a building block for the construction of a variety of entities. It is a source of signification and sense-making, providing a referent for the reproduction of certain practices and behaviours (Jensen et al. 2003) and thus ensuring the durability and transferability of a given stock of knowledge. A template also functions as a persuader (Jensen et al. 2003) by enrolling a large number of recipients and generating commitment to a common task or mission.

Second, a template is enacted and reproduced through inscription and delegation mechanisms. These mechanisms act as anchoring forces linking a template

to particular sign–agency–meaning configurations: that is, coherent orderings of a domain of activity that acquire their meanings from the selective interaction of heterogeneous materials (signs) with action programmes (agency). The concepts of inscription and delegation, rooted in semiotics and brought to the forefront of social theory by actor network theorists, link knowledge with human agency. As the term is used here, inscription is a form of *authoring*. It concerns the writing of a programme of action, or pattern of use, into a stable medium, which becomes both the receptacle and the carrier of human agency. The medium functions as a *tertium* or, in other words, as a set of independent actants regulating, channelling and driving the interaction between two or more parties.² Inscription is linked to transactional efficiency. It confers durability on social arrangements, which, because they rest on human bonds, may be shaky and unreliable: ‘Inscription translates a programme 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 a traffic police officer telling drivers to slow down, because it cannot be disputed and it does not require any form of control.

Programmes of action are transferred and reproduced across different media through processes of delegation that endow non-human actants with the ability to accomplish ad hoc performances. Delegation is the act of ascribing action to an actor, that is, *authorizing*. It concerns the transfer and reproduction of agency and knowledge between human and non-human actants along a chain of transformations. 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 and cognitive efficiency (for example, a traffic light taking over a traffic police officer’s task; or an assembly line replacing the human effort of building cars piece by piece). By delegating human agency and knowledge to non-human actants, individuals are somehow relieved from the burden of thinking (Gehlen 1940).

Yet, as a mechanism for the reproduction of agency, delegation exerts ambivalent effects. By means of delegation, agency is simplified, reproduced and extended. On the other hand, not all features of human agency can be smoothly translated into the affordances and functionalities of non-human actants. Simplification may entail the loss of important features such as autonomy, self-directedness, situatedness, flexibility, and even the sense of personal causation and responsibility. Consequently, as we shall note in our study, tensions and strains may emerge in the processes of inscription and delegation.³

The inscription–delegation framework conveys a particular model of agency mediated and channelled by material artifacts. Specifically, agency results from the formation of human–non-human associations that gradually connect together heterogeneous materials within a network of social actions and relations (Latour 2005). The process of translating agency into a network of human and non-human actants does not efface agency vis-à-vis structure. Rather, agency is embedded in the network of relations so that it cannot be attributed solely and separately to human agents. The framework recognizes non-human agency and the performative character of entities and relations. It addresses the

need to understand not only how social actors construct and manipulate objects, but also how objects, despite being passive and obedient, shape the way in which actors understand themselves and their roles (Hasselbladh and Kallinikos 2000: 712).⁴

The interplay of templates, inscription and delegation underlies the creation and institutionalization of knowledge in the work setting. In particular, the strength and effectiveness of institutionalization processes (and hence the performativity and durability of knowledge) depend on the effective reproduction, repetition and maintenance of a given pattern. However, the reproducibility of a pattern is contingent upon the presence of features that can be efficiently replicated (low cognitive and social costs), because they are simple, self-explanatory, easy to grasp and to communicate, and can be inscribed in a variety of media acting as channels for reproduction and transfer.

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 and 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 making up the organizational structure are linked on the basis of 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 designed 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).

Our research methodology was based on multiple data sources. Fieldwork on the Melfi site was conducted during the period 1994–1998 by the second author. Data collection combined documentary data, naturalistic observation and open interviews. Interviews were mostly conducted along the production lines, rather than in locations separate from the workplace. Overall, 40 people were interviewed at the field site, and five weeks were spent on the shop floor distributed over seven visits to the plant. Interviews (lasting 30–60 minutes) were conducted with managers of different functions, middle managers and technicians, and, to a lesser extent, line conductors. Most of the respondents had been involved in the construction of the factory from the greenfield site. 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. Field notes on all that could be remembered from the visits and observations on-site were made soon after leaving the setting.

The design concept of the factory (1991–1993) was reconstructed retrospectively, using archival data and interviews with key organizational actors involved in the construction of the factory. Several interviews with the former personnel director and the former plant director at Melfi were conducted at Fiat's headquarters in Turin. Throughout the duration of the project regular visits were made to Fiat's training company (ISVOR) to collect additional information from the company library. During those visits were held several informal conversations with managers and consultants at the company.

Finally, additional evidence from secondary data sources was collected more recently following the April 2004 strike. Given the impossibility of gaining access to the plant while the protest was in progress, data were extracted mainly from the wide media coverage of the strike and the events leading up to it, including press releases, press archives and websites on the internet. Secondary data were informally checked with our personal contacts at Fiat. The focus of our analysis was not so much on the contingent claims of the Melfi workers as on the implications of the strike for the industrial model established by Fiat at Melfi. Accordingly, we treated the strike as a critical episode in the Melfi story, which could provide, in retrospect, additional insights into the features and the effectiveness of the process of institutionalization that had unfolded in the factory over the years.

Inscribing Organizational Knowledge in an Automotive Factory

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

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 an intensive formal training programme based on classroom lectures and practical exercises at Fiat's headquarters in Turin. The basic stock of knowledge possessed by the original core group of hired workers consisted of high school education and had little to do with the needs of the factory (70% of the workers were either surveyors or accountants). Efforts were consequently made to develop a mindset and culture compatible with industrial values and the new organizational model of the integrated factory. Fiat's aim was to build a 'learning factory' (Leonard Barton 1992b; Barton and Delbridge 2001). The training programme was accordingly designed to achieve two main purposes: a) shape a socially homogeneous group of workers with a strong sense of commitment to the project and the company; b) develop highly skilled knowledge workers who thoroughly understood production assembly in the overall system of industrial manufacturing.

Promoting common goals and a shared culture was considered important for the *modus operandi* of the Melfi community. In this initial phase, the main issue of debate concerned the rules that the core group would adopt as a guide for their work practices and organizational behaviour. Fiat's top managers, consultants and professional trainers defined a set of core organizational values to be transferred to the young workforce. Among these values were, for instance, identification with the company, a sense of challenge, personal and collective responsibility, taking pride in doing a good job, and developing team spirit. The 'value matrix' became a jointly written text that was continuously and repetitively evoked and discussed in training sessions and on other occasions, and it was displayed everywhere on the shop floor during the factory start-up phase. For the workers it was a sort of constitution.

To compensate for the workforce's lack of experience, the management codified and implemented a work method based on disassembling systems and problems and reassembling them, and on the formalization of solutions. 'Learning to do things with method' meant a number of things to the workers: first, being able to diagnose, solve and eventually anticipate problems, by breaking them down into their component parts and detecting sources of errors and anomalies; second, as a result of problem-solving, being able to redesign 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 a knowledge platform that was shared by the workers: it constituted the premise for their ability to structure the logic of processes and planning activities, to predict critical problems and to design and test solutions.

'Working with method' was promoted by Fiat's management as a code of conduct for production and problem-solving, as the correct way to do the job, and as a critical value in itself. It stressed the importance of functional decomposition, analysis, and transparency. Its critical role in training the workers is evidenced by the following extract from the interview with the former plant director

'Since the very beginning the factory has been run by a group of young novices who were on training. Where did such a complex system find the capacity to sustain itself over time and become more and more productive? In my opinion the secret of this plant's success lies in the ability to support its growth through method. Since the novice workers lacked experience, what turned out to be crucial was the transfer of a method for handling problematic situations to them. 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 above observations highlight the multi-purpose nature of the work method: that is, the work method served, among other things, as (i) a procedural mechanism for accomplishing the work itself, (ii) a medium for creating and mobilizing knowledge and (iii) a governance device superintending the cultural conduct of work.

The formal training period in Turin was of crucial importance in turning inexperienced recruits into a collective of competent workers. By learning the values and the work method, the newly hired workers were smoothly transformed from

novices into 'agents' of Fiat. As soon as they had completed the training period in Turin, they were sent to the greenfield site at Melfi, where they engaged in the construction of the plant in which they were subsequently to work.

The Making of the Factory: Work Breakdown Structures

When they arrived at the greenfield site, the 1,000 workers enacted a further inscription by assembling the plant. The company's decision to involve the future workforce in construction of the factory played a crucial role in the constitution of what Fiat regarded as a manufacturing community. First, the building-site experience promoted a sense of belonging to a community of 'pioneers and constructors' (Cerruti 1994). For the novices, working on the greenfield site assumed the significance of a founding experience. In their recollections, the greenfield site incarnated the myth of genesis; it was a 'non-place' where little or nothing existed before they arrived and started to assemble the factory. This pioneering ethos was well described by a UTE head:

'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 booths: 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)

The greenfield experience heightened the workers' perception that their construction of the factory was an act of collective appropriation with a distinct beginning in time and space. Secondly, and more pertinently to the argument here, the greenfield experience helped anchor the knowledge and skills learned in Turin to the concrete practice of building the factory in a specific place. On the greenfield site, the workers further appropriated the assembling/disassembling method by inscribing it in the material fabric of the plant. They directly experienced what it means, in practice, to build an artifact. The method did not simply remain a mental procedure or a classroom exercise; it became an everyday practice linked to the founding of the plant on virgin territory and to the workers' concrete building experience.

Operations on the greenfield site were organized and steered by work breakdown structures (WBS) responsible for development of the multifaceted nature of the factory: designing the functional layout, erecting pillars, walls and roofs, monitoring construction of the buildings, wiring the shop-floor, installing and testing the machinery and adapting the management tools to the specific context. Each WBS acted as a start-up team headed by a team leader, and it was encouraged to submit written proposals for online design variations and inventions to the newly formed plant steering committee.

The WBS was the main project management tool used for the factory's start-up and subsequent development. It articulated and planned all the activities required for the construction and operation of the plant. Each WBS listed its activities, grouped them according to thematic content, ordered them hierarchically, allocated resources, defined responsibilities and set deadlines for implementation.

In order to engineer and design work, the WBS applied the same (dis)assembling method as learned by the workers during their Turin training course. The whole was hierarchically decomposed into its parts, so that each thematic area (work package) was unpacked into elementary activities, analysed in its smallest details and executed. The basic method was iteratively enacted through the WBS to produce inscriptions at the level of the entire manufacturing system.

The following example illustrates the functioning of a typical start-up team engaged in assembling the presses in the stamping shop. In this particular instance, the team was led by the Japanese suppliers of large presses, whose application of the D/A method provided a critical learning experience for the young engineers involved in the installation of the machinery:

'The Japanese team had managed to rationalize their activities to the point where, in the event 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. They 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 ... Our engineers were involved and clearly 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 Personnel Director)

The example highlights that the core group of knowledge workers gradually developed the factory's activity system through an ongoing practice of *unpacking* and *repacking* involving the progressive appropriation of organizational knowledge. By following the Lego-like logic inherent in the functioning of the WBS, the knowledge workers accomplished the complex task of assembling the plant in piecemeal fashion. In so doing, they engaged in an organizing exercise where they materially 'wrote' the organization and developed a map of the factory. By repeatedly practising the WBS, the workers progressively inscribed their own knowledge in a system — the factory — where new rules for acting and knowing could be enforced. Events and actions of a different kind could be 'authorized' and undertaken within the new system, and all the conditions were put in place for the production process to start.

The Making of the Car: Learning to (Dis)assemble

The ensuing induction phase marked the shift of activity from assembling the plant to assembling the car. This entailed a further step in the enactment of the method of dis(assembling) and in the process of inscription—delegation of knowledge in/to the manufacturing system machinery. Workers were introduced to the product by working on a stock of cars provided by the Mirafiori plant in Turin. They did further training on those cars by manually disassembling and reassembling them again and again. The workers were then asked to draw on this exercise and provide suggestions for improving the production cycle.

The workers simulated the functioning of the assembly line through their endless repetitions of the assembling/disassembling task, 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, a major anchoring role was played in the process of appropriating the work method by the car and its physical components. The repeated hands-on procedure of breaking the car down into separate pieces, and then remaking it by putting the pieces back together, revealed the structure of the task, and the logic of manufacturing was thus appropriated. Hence, the car, besides being the thing to be manufactured (the product), also became a cognitive tool — a medium — for both understanding the manufacturing method and institutionalizing knowledge.

The process of learning to make the car is particularly interesting because of the somewhat insidious way in which it took place. Meaning and values inscribed in the factory and the car were learned and interpreted by the workers as lessons directly provided by the material inscriptions themselves, rather than being 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.

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 off the assembly line. This moment represented completion of the sequence of inscriptions and delegations and *closure* of the black box. The factory then gradually moved into full production capacity. As a result of closure, a whole body of idiosyncratic knowledge was sealed and handed over to the factory’s production system. When the factory became fully operational, it acquired the status of an ‘inscribed world’ (Akrich 1993; Joerges and Czarniawska 1998) for the workers, a world characterized by institutionalized rules, shared values and knowledge structures sustaining a set of self-reproductive processes. A technology-based institutional order was created, in which large components of human agency and knowledge were handed over to impersonal mechanisms. Embodied in the production system were organizational rules for the 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 ‘computational tool’ (Hutchins 1993), a structure for orientation that enabled the workers to make cognitive economies in production, communication and coordination. It was apparently operated and controlled by self-activating reproductive routines, as if it had gained a life of its own.

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

‘Machines are smart, robots are smart. They promptly signal different types of anomalies and criticalities. Smart machines allow 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 construction of the object, and which is made available to those working

further down the line and who have to prepare for the transit of the object. While the car body 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 knowledge so that those variables can be managed.'

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

Further knowledge and agency were embedded in organizational routines and procedures. For example, the manual ability to disassemble and reassemble cars, acquired during the induction phase, provided a practical knowledge background and a cognitive strategy for dealing with breakdowns and bottlenecks along the production lines:

'Our basic problem-solving routine on the assembly line is based on a mental process whereby operators go back through the production cycle in order to search for and identify the potential source of a fault.' (Production Engineer, Assembly Unit)

However, besides technical knowledge and agency, patterns of social relations were also inscribed in the production system. 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 this system, a virtual customer enacted a production mix (a sequence of orders) and dictated the pace of production. An impersonal device such as the kanban (a tag containing instructions regarding the specs of each car to be produced) drove the system, by delivering instructions to the operators on the assembly line and regulating the transactions between internal customers and suppliers. Apparently, in a technology-regulated transaction system of this kind, very little discretion is allowed and minimal authority is enforced to rule the system. Yet, later events called delegation into question and disclosed emerging gaps in the process of knowledge institutionalization.

Tensions in the System: the Workers' Strike

Factory operations at Melfi ran smoothly for a number of years within the technology-based institutional order described above. As early as 2000, however, tensions began to surface in the system. Although these tensions were initially inconspicuous, they gradually increased, generating unease and discontent amongst the workers, until they finally reached a critical threshold in April 2004 and exploded in a major strike. The workers halted the production lines for an entire month, causing huge losses for the company.⁵ Even though the timing of the strike and its massive turnout were largely unexpected, it was preceded by a series of episodes that signalled problems in Fiat's design for Melfi.

The Melfi venture was based on a pre-emptive agreement between Fiat and the unions whereby the latter would become the 'guardians' and 'guarantors' of the

company's productivity. Basically, a trade-off was established between jobs and rights: Fiat would create new jobs in southern Italy, forgoing more favourable locations for the plant; the unions and the workers, for their part, would concede some of their rights concerning wages, working conditions and autonomous initiative in industrial relations. In the early phase of the factory's operations, the agreement produced smooth worker–manager relations, with very low levels of industrial conflict and little union interference in the everyday workings of the organization. But things at Melfi gradually changed over the years. Many features of the old Fiat industrial model and management practice — based on the strict enforcement of hierarchical and authoritarian rule — were slowly reintroduced into the integrated factory. The joint union–management committees — the hallmark of Fiat's 'new way' in industrial relations — were no longer convened. Old hands quit the factory and were replaced by new ones, often hired on a temporary basis; turnover reached high levels. Consequently, worker participation declined and the 'participative' model of work organization faded away. At the same time, the hierarchy returned as a form of governance. On the shop floor, the UTE heads changed from team leaders into line bosses connected more closely to top management than to their UTE workmates. A new line position with controlling and supervising functions was introduced into the UTE: the team speaker, who reported to the UTE head. Moreover, the speed of the assembly line was accelerated to accommodate productivity, and work shifts became increasingly stressful. The workers complained about their excessive workloads, especially the six-night double shift, which required 12 nights of work in a row. Breakdowns on the production lines became more frequent and discipline was repeatedly enforced by authority rule, to the point that 2,500 disciplinary measures were taken against workers in the year 2003 alone, and up to 9,000 sanctions were imposed in the five years before the strike. The workers accused Fiat of becoming increasingly unilateral in the management of the factory, thereby betraying the early participative spirit of the Melfi factory and the rationale underlying the Melfi model:

'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, *La Repubblica*, 5 May 2004)

However the strike may be interpreted, we submit that it was a major discontinuity in the ongoing process of institutionalization. It pointed up unresolved problems in the chain of inscriptions and delegations, which cast doubt on Fiat's design and the belief that such a complex production system could be ruled by endogenous self-reproductive routines. In spite of the clockwork-like control mechanisms inscribed in the system, governance proved to be problematic. As one worker put it:

'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*, 13 May 2004)

Discussion

Full appraisal of the Melfi story requires answers to two basic questions: on the one hand, what made Fiat's design experiment so effective in the early phases; and, on the other hand, what was it that did not work out as expected in the institutional establishment of the factory? In this section, using the data of the Melfi story, we apply the conceptual framework outlined earlier to map the processes and patterns underlying the institutionalization of technical and organizational knowledge at Melfi. We then spell out the strengths and weaknesses of the factory's institutional order.

The Inscription–Delegation Chain and the D/A Template

Figure 1 summarizes the chain of transformations that occurred in the process of making the factory as we tracked them in our fieldwork and articulated them in the foregoing account.

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 in artifacts to which component programmes of action were transferred via delegation mechanisms. Each round of inscription–delegation entailed the emergence of a particular sign–agency–meaning configuration. Something that stood for something else produced certain consequences that conveyed particular meanings to the agents. The progressive enactment, enchainment and sedimentation of sign–agency–meaning configurations eventually led to the establishment of a self-sustaining institutional order embodied in the material and cognitive fabric of the plant. As we see it, the inscription–delegation chain is both an activity map and a knowledge map. It shows, at the same time, the network of heterogeneous materials deployed in the making of the factory (signs), the programmes of action embedded in such materials (agency) and the cognitive and sense-making activities resulting from the interaction between materials and programmes of action (meaning).

At the core of the knowledge making process surrounding the design experiment, was an underlying pattern based on the D/A concept and functioning as a generative template. The D/A template supported the recursive acts 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, but also a powerful cognitive device for ordering the world and bestowing meaning upon it. Assembling is both a way to make things and a way to see things. Each way entails different kinds of knowledge, which in the early phases at Fiat Melfi seemed to be awkwardly aligned.

The activity map surrounding the Melfi story suggests that knowledge-making 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, and then they assembled the factory, which in the end became the context and the tool for assembling the car. While

Figure 1. Creating and Institutionalizing Knowledge at Melfi: A Map of the Inscription–Delegation Chain

Delegation	PHASES	SIGN	AGENCY	MEANING
	MAKING THE WORKFORCE	The classroom and the laboratory, the textbooks and the simulations, the value matrix, 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 greenfield site.
	MAKING THE PLANT	The greenfield site; the enclosure for the plant; the walls and physical buildings; the functional containers. WBS, pits, cables and wires, power lines, plants and machinery.	The act of drawing the boundaries of the construction site formed an identifiable place where action would be different from what lay outside. The act of assembling the factory through WBS enacted an activity system for manufacturing cars on a large scale.	The foundation and the construction. New activities and identities produced and assembled in a dedicated place. 'Writing' the organization and developing a map of the factory. Sorting things out. Building a classification system for ordering work practices and human interaction.
	MAKING THE CAR	Car, components, assembly line.	The repetitive act of Disassembling/Assembling incorporated and enacted the set of programs for manufacturing the car.	Appropriating the product and the production process: division of labour, sequential structure of the task, interdependence coordination and cooperation, problem solving.
	CLOSING THE BOX	The factory, the fully operating production system, the internal customer model.	The act of closing the box started up the production system and activated a set of self-reproducing processes.	The factory as an institution, a technological regime, a self-contained world, a cosmology. A knowledge system that is shared and taken for granted, a background for daily practices and routines.
Inscription				

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 *the necessary infrastructure* for the workers and the practical

background 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.

The D/A Template as a Source of Institutionalization

Two major factors explain the initial success of the design experiment: the code-like character of the D/A template and its historical anchoring. These factors supported the progressive transformation of the factory into a self-reproductive cognitive and institutional order.

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. Much human agency was delegated to action programmes and to self-reproductive processes embodied in the factory's production system. These programmes and processes all shared a common code and were operated within the same technological regime. The code ruling the factory was the D/A 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 on 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 owing 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 1962). In Fiat's design, the D/A template was a source of systemic understanding; it was 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 with which 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 is designed to fulfil the regulative and prescriptive functions that are usually performed in a society by a system of laws or by any other set of principles or standards. At 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. Areas of competence

and responsibility were marked out within the regime, and the boundaries between them established, which facilitated positioning and the mutual recognition of roles, 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 displayed, in its most perfected and transparent form, the institutional character of the division of labour 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 layered sedimentation 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). Thus, for its builders, the factory became a historical object that had a clear point of origin in the greenfield site and whose every component or building phase made sense inasmuch as it was placed in a stream of ongoing developments (David 1992).

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 up its operations, not before. 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 to its foundation: the next-next-next sequence of the construction process was then reversed in time, so that it reverted upstream to the early phases of the process.

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.⁶

Sources of Institutional Vulnerability

In spite of its many strengths, the cognitive and institutional order enacted by Fiat at Melfi turned out to be less durable than expected. The strike revealed the limitations of the D/A template as a mechanism for institutionalization. These limitations concerned essentially the incomplete reach of the D/A template in mediating the alignment of the factory's social and technical systems: that is, in balancing the contrasting forces of technology, knowledge and power. When the plant moved into full volume production, the fast pace and tight synchronicity

of operations, and the new requirements for complex on-line coordination, required a different kind of collective ability to learn, as well as resilience. While the internal logic of the D/A method had remarkable structuring and cognitive capacity for problem-solving, it did not work as a mechanism able to support the reproduction and governance of an industrial knowledge system. In other words, the D/A template may have been 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, but it was not equally effective in aligning the factory's social system with the technical one.

The strike highlighted limits to the capacity of technology to act as authority: that is, to function as a technology of managing (Munro 1999). The mounting tensions and the events leading up to the workers' protest indicated 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 governance of the production system. Recall what was involved in the ultimate act of closing the box: control was delegated to technology by inscribing self-regulating and self-diagnosing devices in the machinery. Through such acts, the technical equipment was supposed to assume basic governance functions of the factory's social system. But the delegation did not work as expected. Gaps and ambiguities were generated which opened spaces for discretion (Weick 1990). For instance, detecting and tracking anomalies in the assembly line and in the associated knowledge system involved a search for their causes and their understanding, the attribution of individual or group responsibility for problem-solving and, finally, the discretionary enforcement of sanctions and rewards. The system located and signalled the error, but did not (could not!) attribute the fault and responsibility for problem-solving to a specific individual or team (UTE) in the organization. This task was to be performed by an authoritative human agent able actually to enforce or defer the sanction. In other words, the capacity of machines to exert control on behalf of humans was confined to the technical domain, and it required the support of collective sense-making and heedful cooperation (Weick and Roberts 1993) along the production lines. But such support was difficult to obtain because the D/A-based organization of the assembly line and the internal customer model generated a competitive game among the UTEs, especially when the attribution of responsibility for errors was at stake.

The strike challenged the idea of the factory as an inscribed world populated by intelligent machines and requiring minimal human intervention. In such a world, power relations are apparently effaced and technology is assumed to embody neutrality, transparency and authority. For instance, Sewell and Wilkinson (1992) have argued that the lean production model produces a sort of *panopticon* where the traditional struggle between management and workers is somehow concealed and 'neutralized' through delegation to impersonal devices.⁷ In similar vein, Bonazzi (1993) has described Melfi's integrated factory model as a 'crystal pipeline', an image that evokes the ideas of transparency and fragility at the same time. Transparency (i.e. the perfect visibility of the workflow resulting from the delegation of human agency to technological implements) is obtained at the price of fragility. This technical fragility must be counteracted by the social system. If breakdowns or other even minimal

contingencies along the line disrupt the flow, the technical efficiency of the assembly line becomes highly dependent on the workers' willingness to collaborate, to avoid conflict and to self-activate. Thus, the practical application of the D/A method for diagnosis and problem-solving depends on the quality of social relationships along the production line. If this quality is deficient, then the effective enactment of the 'shared knowledge platform' in everyday work becomes problematic. As a former manager of the plant remarked when reflecting on the strike, 'the Melfi model and the "social intelligence" underlying it needed maintenance over the years, and that was not done'.

Admittedly, the frictions and asymmetries between management and workers, and between workers and machinery, which built up throughout the process were not easy to observe, in that they were hidden in the transformations and often disguised as technical mismatches. During the regime-like operation of the plant, they were embedded in the technological system, and were exposed only by the strike. Thus, 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 cede large components of their autonomous agency and knowledge to the technology running the operations. At one point, the workers' representations of their own roles as autonomous agents clashed with the meanings consistent with the D/A template: the sense of pride at being 'authors' of the Melfi factory was countered by the growing feeling of being held at bay by the requirements of technology and the hierarchy. Halting the line was, for the workers, a way to withdraw from the delegation, unsettling a stable sign-agency-meaning configuration, and finally questioning the factory's institutional order.

In the end, the strike showed that the institutional machine built by Fiat had become a machination (Latour 1988b). It had turned into a subtle way of enrolling the workers and their agency not only in the task of industrial production, but also in carrying over Fiat's pre-existing institutions.⁸ Perhaps, notwithstanding Fiat's deliberate intentions and aims, the experiment assumed an ambivalent meaning, because it was at the same time an effort at innovation and a design to enforce an industrial order. 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 conceive of. In this perspective, Fiat's design was constitutive rather than regulative. This constitutive design turned into a kind of cunning stratagem. 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 human agents; on the other hand, the very same process also worked as a way to conceal the hierarchical asymmetry between managers and workers under the covering rule of the technology and the task system. Thus, multiple interacting forces were cast into the machinery, producing effects that went beyond human intentions. This is what made it a machination. Yet, in the end, the D/A template was unable to deal effectively with the political processes that stemmed from human agency and social relations and could not be fully transformed along the chain of inscriptions and delegations.

Concluding Remarks

What makes Fiat's strategy at Melfi different from standard approaches to production management is its powerful and distinctive institutional flavour. Starting from the greenfield site, the workers were directly involved as primary actors in building the factory and making an industrial world. At its core, the Melfi case is a story of institution-building. It tells about the establishment of a cognitive and institutional order, where specific forms of practical knowledge and agency were developed and institutionalized in the work setting, while the work setting itself took shape from the greenfield site. While the young novices were engaged in making the factory, they also crafted their own agency, knowledge and identity in order to become Fiat workers.

At the same time, Melfi is a story of institutional vulnerability. Our study shows how institutionalization depended on forms of socio-technical closure, chiefly developed by a series of inscription–delegation moves, which in the end resulted in a particular form of regime. In spite of its many strengths, however, Fiat's institutional design could not sustain itself and was finally challenged by the workers. In this connection, the strike should not be viewed simply as a critical episode in Fiat–unions industrial relations, but as a breakdown in Fiat's industrial model for the Melfi factory, and as a major discontinuity in the process of knowledge institutionalization. The core question raised by the strike was not so much why ongoing labour relations were challenged, but why the factory's institutional order could not be sustained and reproduced. The strike tells us more about the nature and limits of an institutional and cognitive order than about the workers' contingent claims. It marked the interruption of a sense-making and myth-making cycle for both the workers and the managers. Indeed, the strike reveals that, at stake at Melfi, was not who should have control over what or whom, but rather what kind of collective sense-making should have taken place in the factory, and what kind of industrial knowledge system should have been created and reproduced, and how.

Although the Fiat–Melfi case is so peculiar that it might be regarded as a unique institutional experiment, it has helped us develop insights into the dynamics of a knowledge system supporting the operations of a large automotive factory. Problems of reproduction, institutionalization and durability of knowledge have been discussed. Specifically, our study has analysed the workings of a generative template as a mechanism guiding both the material construction of the factory and the inscription of a complex knowledge system in the production machinery. Also, it has spelled out the limitations of such a template, which became sources of vulnerability for the cognitive and institutional order enacted by Fiat at Melfi. In short, the basic finding is that the D/A template displayed remarkable power in structuring and reproducing the technology-based knowledge system, but it failed to work as a code of conduct and 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 theoretical considerations that can only be sketched here. In building our framework, we have brought together concepts from two distinct research traditions, namely neo-institutional theory and actor network theory, in order to provide a richer account of the process of institutionalization of technical and organizational knowledge in the work setting. By introducing the idea of a generative template and combining it with the notions of inscription–delegation, we have attempted to overcome some of the limitations to the adaptivist or diffusionist models of institutionalization proposed by neo-institutional theories. We suggest that further research on templates can be helpful, both in the organizational and other domains (social, political, cultural), for explaining processes of institutionalization as the progressive anchoring of human agency and knowledge in complex functional networks. First of all, templates are *generative* and therefore they are linked to processes of institution-building and institutional emergence. We have shown how simple templates can play a part in generating, embedding and reproducing complex knowledge structures in material and organizational artifacts. Second, templates are *normative*. They provide powerful cognitive mechanisms, based on codes and programmes of action, that orient sense-making and prescribe collective behaviour. Third, the study has shown that specific templates have shortcomings as codes for handling the subtle relationship between knowledge, meaning and power. As a result, templates may generate institutional structures and configurations with in-built tensions and instabilities that may eventually lead to controversies, breakdowns and revisions. Specifically, the erosion of established templates — as well as the practices and identities associated with it — may result from the failure of organizations and their members to accept what was once a shared understanding of legitimate organizational conduct, or to reproduce previously legitimated and taken-for-granted organizational actions (Oliver 1992).

We have also sought to go beyond some limitations of actor network theory. The latter has been criticized for focusing mostly on the development and legitimation of mundane artifacts, thus showing little interest in the bigger picture of complex organizations and institutions (Walsham 1997). The Melfi story provides an instance of how actor network analysis can be usefully applied to macrophenomena through concepts such as institutionalization of knowledge, generative template and institutional order. By explicitly shedding light on the generative mechanisms supporting the constitution and institutionalization of a large- scale organization, our template-based analysis contributes to the broader agenda of current ANT research, which takes organizations, economics, spatialities, subjectivities and globalities as its main analytical focus (e.g. Law 1994, 2002; Czarniawska and Hernes 2005).

Finally, by applying the above framework to document processes of knowledge institutionalization in the work setting, we have opened up the cognitive dimension implicit in actor network theory. Our findings suggest that creative linkages to relevant strands in organizational research can be established, such as the study of knowing-in-practice (Orlikowski 2002), distributed knowledge (Hutchins 1993; Tsoukas 1996) and sense-making (Weick et al. 2005).

Hopefully, exploration of these new connections will go beyond the scope and the limitations of our study, yielding more thorough understanding of how knowledge and agency in organizational settings are embedded in networks of interactions among a set of heterogeneous materials. As a consequence, a more accurate picture of the institutional dynamics of organizational knowledge systems could also be developed.

Notes

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- 1 Our conceptualization of templates differs from the definition commonly adopted by neo-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 on 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 on 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 behavioural pattern across a work setting. In this respect, our definition is consistent with Mary Douglas's notion of cognitive analogy (Douglas 1986).
- 2 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.
- 3 This is in line with contemporary trends in actor network theory, which emphasize variation and fragmentation of networks and the entities that constitute them. From this perspective, entities and networks are considered to be also an effect of local ordering practices (Law 1994). For instance, entities and artifacts may contingently assume variable forms and identities depending on the network of relations in which they happen to be embedded (Law and Mol 2002; Mol 2002). In this connection some authors (e.g. Singleton and Michael 1993) have gone so far as to suggest that multiplicity, variation, and ambivalence, often associated with large-scale networks, can serve to hold such networks together rather than place them at risk.
- 4 A well established stream of research in organizational knowledge and professional practices maintains that knowledge and agency do not reside only in ideas and actions, but also in the things with which the agents deal and work (Hutchins 1993; Schon 1983; Scribner 1987). From this perspective, knowledge and agency are not 'free-standing' in organizations. Rather, they are expressed in the agents' transactions with the material, the artifacts made, the conditions under which they are made, and the manner of their making. The artifacts built are, at the same time, 'holders' of practical knowledge, 'vehicles' to make it travel in space and time, and 'tools' with which to think and act. These qualifications are perhaps more than enough to call them 'non-human actants'.
- 5 The estimated loss of production was about 40,000 cars with an average value of 10,000 euros each.
- 6 This latter point adds to Berger and Luckmann's (1967) explanation, according to which institutionalization takes place as the origins of a social construction gradually shift to the background with the passing of time and are almost forgotten, thus taking the status of a taken-for-granted reality. In the Melfi case, the strength of the factory's cognitive and institutional order seemed to lie in its manifest 'template-driven assembling', where the beginning and the history were explicitly constructed and then recalled, carried over and cyclically re-enacted.
- 7 Fiocco (2000) 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 of production is driven 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 indisputable.

- 8 Machination does not necessarily imply deliberate intention or strategy. The idea of machination suggests that attention should be paid to effects and interacting forces rather than to intentions or plans. As we use the term here, 'machination' resided in the unfolding chain of inscriptions and delegations, of which Fiat management was only partially aware as it unfolded.

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