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Discipline and Change: How Technologies and Organizational Routines Interact in New Practice Creation

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Abstract

In this paper we study the development and implementation of a technology over a long period of time, with a particular focus on how its disciplinary effects interplay with and change organizational routines and actors' capacities, thus producing new patterns of action. To identify these processes of change and emergence of practices, we propose a combinative theoretical analysis at the interface between institutional and practice-based approaches. Drawing on a rich ethnographic case study, we show how the fact of considering technologies as the combination of three dimensions (technical substrate, managerial philosophy and organizational model) furthers our understanding of institutional change and the creation of new practices. In particular, we examine the internal dynamics between the three dimensions of these technologies and the duality of organizational routines (their ostensive and performative aspects). This enables us to reintroduce practices and agency analysis into an institutional approach to technological change, and to put social history, designers' assumptions and disciplinary effects of technologies back into the analysis of the micro-dynamics of routine changes. We identify several factors which partially explain divergent technological trajectories concerning institutionalization and emerging structures in two different settings.

Keywords

disciplinary effects, institutional change, organizational routines, practice, technology

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Introduction

One of the most intriguing aspects of recent developments in organization studies is the increasing effort at linking up institutional and practice-based approaches, to further our understanding of the 'how and why' of organizational change, and the origin of new practices (Lounsbury, 2008; Lounsbury & Crumley, 2007). How novel innovations and new practices emerge and become taken for granted, and how they change organizational structures and broader institutions, is neither an exclusively top-down nor an entirely bottom-up process. In this perspective, various authors have stressed the importance of a better understanding of the organizational processes involved and of the interrelations between the micro-dynamics of practices and organizational change. The intention behind this 'practice turn' is to go beyond the deterministic approach to collective action, in which 'practice' is an unreflective term associated with the diffusion of blackboxed objects (Barley & Tolbert, 1997; Chia & Holt, 2006; Feldman & Orlikowski, 2011; Jarzabkowski & Seidl, 2008; Lounsbury & Crumley, 2007; Nicolini, 2009; Whittington, 2006). With this aim, authors in the Scandinavian tradition of institutionalism have, for example, started to reintroduce fine-grained mechanisms into the study of institutional processes, as a way to further their understanding of the emergence of new practices and new patterns of action (Czarniawska, 2009; Joerges & Czarniawska, 1998). Recent approaches to organizational routines (D'Adderio, 2008; Feldman, 2000, 2003; Feldman & Pentland, 2003; Pentland & Feldman, 2005, 2007, 2008), using the notion of performativity (Callon & Muniesa, 2005; MacKenzie & Millo, 2003) are signalled as one of the promising avenues for building this research project (Kaghan & Lounsbury, 2006). These approaches have emphasized the importance of studying agency in organizational routines, if the creation and reproduction of new institutionalized practices are to be understood. They have examined organizational change and new practices creation through the mutual adaptation between formal rules, artefacts and divergent performances.

Despite this progress, voices in the literature have recently stressed two main shortcomings in the organizational routine-based programme. First, the practice turn in organization studies has sometimes emphasized local action at the expense of broader historical, socio-political processes and external origins of internal practices. Yet we should see organizational practices as both shaped by, and shaping, wider social processes (Chapman, Cooper & Miller, 2009) or 'higher-level entities' (Salvato & Rerup, 2011). Second, the role of technologies remains under-theorized in performativity studies of routines that often consider the term 'technology' in the narrow sense of passive artefacts and blackboxes with no institutional and historical substance (Leonardi & Barley, 2008; Whittington, 2006). This relatively limited view has been challenged by Foucauldian studies that associate 'technologies' with a broader meaning in which codified bodies of knowledge, ideological structures and new forms of actorhood are embedded in material and cognitive settings that shape individual and organizational practices (Hatchuel & Weil, 1995; Hopwood & Miller, 1994). In this perspective, it is assumed that technologies, being managerial, political or technical, have disciplinary effects on the most detailed practices by means of instruments and routines. Technologies not only constrain or enable actions, but have unexpected outcomes compared to their original purposes. In our opinion, understanding these unexpected dynamics, in particular 'why people do the things they do with technology and why organizations and practices acquire the forms they acquire' (Leonardi & Barley, 2008, p. 172), requires a more detailed look at how technologies interact with routines, perform actions and ultimately contribute to the institutionalization of new practices. We believe that there is great potential in bringing together these two bodies of literature (organizational routines and Foucauldian studies of technologies) to further understanding of practice creation, change and institutionalization in different settings. In this respect, our

research question is the following: 'What is the interplay between the disciplinary effects of technologies and actors' performances in changes to organizational routines?' To address this question, we propose a theoretical perspective that combines long-term analysis of change in practices with an ethnography of how the design and internal components of technologies interact with the micro-dynamics of actual performances.

For that purpose, this paper is based on a longitudinal case study on the emergence and crises of a science-based technology, namely the genetic selection technology in two different settings where it had divergent outcomes. The genetic revolution has profoundly transformed the selection and productivity of cultivated plants and domestic animals over the last 50 years. Dairy productivity, for instance, measured in terms of milk production, has increased almost fourfold in less than 50 years in developed countries. These gains stem from the large-scale, purposeful design and implementation of a scientific technology designed to discipline breeding practices in the finest detail by creating adequate breeding routines. This technological project has involved deep changes in practices and institutions, rendering nature 'knowable' and 'manageable'. Based on an empirical study of animal breeding technologies and the emergence of new breeding practices in the sheep industry in two French regions, we analyse the process of co-emergence of new technologies and new breeding routines, the crises observed in their enactment, and the new practices and institutions created to overcome those difficulties.

The paper is organized as follows. In the following section we argue for a more detailed framework for in-depth analysis of the dynamic interplay between organizational routines and technologies in the origin and diffusion of new practices. We then describe the research method used in our study. The third part, based on historical and empirical data, is a descriptive analysis of the technological breeding routine, how it has changed the organizational structure of collective breeding activities, and how actual performances have diverged from the technological prescription and ended up producing new patterns of action. To conclude, we discuss the outcomes of our analysis and the contribution and further implications of our framework.

Theoretical Orientation

The dynamics between technologies and new practices creation has been a long-standing problem in understanding institutional change, and one that requires the relative importance of materialism and agency to be weighed up (Leonardi & Barley, 2008; Orlikowski & Barley, 2001; Pentland & Feldman, 2008). Yet institutional theory, for example, has been recognized as inadequate for describing patterns of action and 'patterns-in-variety' (Cohen, 2007, p. 781) 'characteristic of any live routine' (Pentland & Feldman, 2008, p. 244) in organizational change. On the other hand, the latest developments in routine studies afford a different perspective on institutional processes that departs from a deterministic view of technological diffusion and institution building (Schneiberg & Lounsbury, 2008).

The internal dynamics of new practice creation: routines as generative systems

In the past decade, a growing number of studies focused on micro-processes and practices have shown that routines act as generative systems involved in organizational change (Feldman, 2000, 2003; Feldman & Pentland, 2003; Howard-Grenville, 2005; Pentland & Feldman, 2008). These approaches have investigated the internal dynamics of routines to explain their capacities to evolve and change, and have brought the study of agency back to the analysis of organizational change. Feldman and Pentland (2003) have adapted the language of Latour to the organizational routines

theory, considering that organizational routines consist of both ostensive and performative aspects, the dynamics between the two being a source of changes in practice. The ostensive aspect of routines is their abstract pattern, a script used by participants to guide their action (Pentland & Feldman, 2005). According to Feldman and Pentland (2003, p. 94), 'the ostensive aspect of a routine embodies what we typically think of as the structure'. However, it can vary widely among participants of the routine. Feldman and Pentland (2003) argue that there are multiple ostensive patterns of any organizational routine, and that they are created and recreated through practice (here understood as performance). The performative aspect of routines is constituted by actual practices for performing a task: 'performances are the specific actions taken by specific people at specific times when they are engaged in what they think of as an organizational routine' (Pentland & Feldman, 2005, p. 795). The performative aspect of a routine exists in an institutional and organizational context, and is carried out against a background of rules. However, it also allows members to choose a particular course of action (Feldman 2000; Feldman & Pentland, 2003; Pentland & Feldman, 2005; Pentland & Rueter 1994). For example, Feldman (2000) identified three types of actions and discrepancies between ostensive and performative aspects (repairing, expanding and striving), through which participants might change routines and thus create new practices as institutions (i.e. providing order and meaning to a set of otherwise trivial activities; Lounsbury & Crumley, 2007). Highlighting this role of agency in the evolution of organizational routines is important in understanding the micro-processes of institutional change and the role of agency in the creation of new practices.

Recent advances on two shortcomings

Recent developments in this theoretical field have started to address two of the shortcomings of previous routines studies: first, the interaction between routines and higher-level entities; and second, the understanding of the roles of artefacts and technologies in routine dynamics. Even if the ostensive aspects of routines imply understandings at different levels, little is actually known about 'how the enactment of routines links to the operation and evolution of higher-level organizational entities' (Salvato & Rerup, 2011, p. 485), and how what is sometimes only considered as 'the institutional and organizational context' affects the performance of routines. A major step in the direction of filling this first gap identified in the literature has been achieved by authors such as Rerup and Feldman (2011). They have examined the connection between organizational routines and firm-level organizational interpretive schema, defined as a set of shared assumptions, values and frames of reference that give meaning to everyday activities and guide how organization members think and act (Rerup & Feldman, 2011). According to these authors, the higher-order structure, the schema, is constituted from a broader set of actions than the lower-order structure, the ostensive aspects of routines. With a micro-analysis of individual practices, they have identified trial-and-error processes that strengthen the theory of co-constitution of organizational interpretive schema and routines, showing how both the ostensive aspects of routines and the enacted schema are 'surfaced, discussed, and changed' (Rerup & Feldman, 2011, p. 605) through the enactment of routines.

While this approach has provided important insights on top-down and bottom-up processes of schema and routine change, the role of technologies – whether managerial, scientific or political – through which schema are enacted in this process remains underexplored. Technologies (for example, total quality management, benchmarking, standard operating procedure, etc.) aim to adapt ways of doing things in organizations to match managerial discourses and to enact organizational schemas, but nevertheless have a life of their own. They rarely have the exact outcomes planned by their designers, and the variety of uses participants can develop is always much wider than what is written in the 'use model'. It has been shown that they can

be interpreted and used in ways that contradict the intentions of the technology designers (DeSanctis & Poole, 1994). This is why we argue here that, for organizational routines approaches to be a promising avenue for building a research project that reintroduces fine-grained mechanisms into the study of institutional processes, we need to further our understanding of the interaction between artefacts and organizational routines. To this end, artefacts need to be considered as part of broader technologies reflecting higher-level institutional processes.

The specific roles of technologies in organizational routines has started to be addressed in recent routines studies, where technologies are taken as an example of 'artefacts' that affect the interaction between ostensive and performative aspects of routines and provide a better understanding of organizational change (D'Adderio, 2008, 2009). Based on performativity theory, these approaches go beyond the 'enable/constrain' view of technologies (Barley, 1986; DeSanctis & Poole, 1994; Garud & Rappa, 1994), stressing how the ways artefacts are used and interpreted in the course of action leaves different possibilities open, thus generating variety within routines (D'Adderio, 2009).

However – and this leads us to the second gap identified in the literature – how do managerial technologies actually link organizational schema and broader institutional changes to the microdynamics of routines? This issue is still underexplored, and most studies look at artefacts and their rationale as 'given', barely unravelling the genealogy of their design, embedded knowledge systems and theories, social and economic assumptions, and their interactions with the micropractices of their uses. Whereas institutional aspects of technologies in use are often considered only as organizational context (Howard-Grenville, 2005), in this paper we subscribe to the argument of Hopwood (1983) that context should not be seen as something external to organizations.

Understanding the relations between the disciplinary effects of technologies and changes in routines

In this perspective, Foucault's theory has contributed meaningfully to organization theory, revealing both positive and negative disciplinary effects of technologies. Instead of providing an 'organizational context', technologies are seen as a nexus of assumptions, rational myths, belief systems, hypotheses and material constraints which stem from broader institutional forces, intervene in the building of patterns of actions, and open new performance possibilities and inventions. Based on Foucault's notion of governmentality, a strand of literature has used genealogical analysis to show how technologies reflect wider institutionalization processes, and how they participate in establishing domains of practices and distinct forms of actorhood (Hatchuel & Weil, 1995; Hatchuel, Pezet & Starkey, 2005a; Hopwood, 1987; McKinlay & Starkey, 1998a; Miller & O'Leary, 2007; Moisdon, 1997; Power, 1996; Townley, 1993). Hasselbladh and Kallinikos (2000) have already emphasized how this tradition provides a bridge 'between the idealistic formulations encountered in the theoretical contributions of neo-institutional research on organizations and a new and needed direction for empirical studies' (p. 703). These approaches have tended towards historical analyses, in which technologies are considered at the level not only of changes in micro-practices but also of broader processes of rationalization whose dynamics are studied over longer periods of time.

Foucauldian approaches to managerial technologies go beyond the diffusion of managerial discourses. They have observed the more mundane modes of management through the analysis of these technologies defined as 'apparatus designed by organizations to steer individuals and objects toward assigned goals' (Moisdon, 2006, p. 135). Mobilizing these approaches in our analysis allows us to consider that technologies are not mere artefacts disconnected from broader intentions, knowledge systems and rationalities; they incorporate 'upstream' forms of knowledge to prescribe, to a certain extent, what should be done 'downstream', and constitute a contraction of

power/knowledge (Moisdon, 2006). These approaches are relevant for bridging micro-practices with institutional processes because they focus, not on normative discourses or what participants and managers say or think, but on what they do in their day-to-day practice, and on the most detailed effects of managerial technologies.

In this tradition, a series of French studies (Hatchuel & Molet, 1986; Hatchuel & Weil, 1995) seems particularly relevant here, although these works are not widely known or readily accessible because most of them are not in English. These authors focus on managerial technologies, considering them not as independent entities but rather as part of rationalization projects based on rational myths (Hatchuel & Molet, 1986; Kaghan & Lounsbury, 2006; Meyer & Rowan, 1977; Scott, 1987). In their study in the late 1980s on the wave of rationalization of expert systems based on artificial intelligence, Hatchuel and Weil (1995) analysed the intervention and diffusion of new managerial technologies as inextricably linked to the professionalization of new management occupations (accountant, engineer, quality control manager, etc.). From the point of view of this genealogy, they studied the simultaneous birth of new management objects and new managerial techniques, new social and organizational institutions and new practices.

Three dimensions to analyse managerial technologies and their relations to organizational routines

Artefacts, as studied in previous works on organizational routines, are only one dimension of what should be integrated into the analysis of the role of materiality and higher-level entities in routines change. To understand the rationalization projects under which technologies have been designed to discipline specific practices, a richer framework is needed. Hatchuel and Weil (1995) consider technologies not only as artefacts but as the combination of three dimensions. This resonates with the arguments developed elsewhere by other scholars. Let us briefly consider each of these dimensions and their links to organizational routines.

First, the '*technical substrate*' means the set of techniques, material aspects and rules mobilized in the technology: models, databases, algorithms, etc. It relates to the notion of artefact in the analysis of routines proposed by Feldman and Pentland, as detailed above. It is also close to what DeSanctis and Poole (1994) called the *features* which govern how the technology can be used and the information gathered. They both enable and constrain participant action, and influence to some extent the building of ostensive aspects of routines, as general understandings of what should be done (but do not define them). Artefacts often go with a user's guide, which is different from but influences the creation of ostensive aspects of routines (Pentland & Feldman, 2008). On the other hand, thanks to the various affordances of artefacts (Cook & Brown, 1999), participants may enact a variety of performances and, through practice, create ostensive aspects that differ from designers' expectations.

The second dimension is the '*managerial philosophy*'. It defines the system of concepts that denote the objects and objectives constituting the targets of a rationalization (Hatchuel & Weil, 1995); for instance, the optimization of decisions for operational research, and the modelling of knowledge for expert systems. This dimension corresponds to the performance logic (Lounsbury, 2007) assigned to the targeted routine. It can be linked to what DeSanctis and Poole (1994) call the 'spirits of the technology', supplying 'a normative frame with regard to behaviours that are appropriate in the context of the technology' (DeSanctis & Poole, 1994, p. 126). Here the managerial philosophy integrates the designers' intentions and wills but also reflects broader rationalization projects in which the technology is set.

Third, the '*organizational model*' may describe the roles and collective scenes, the way the work involved in organizational routines is 'divided up among individuals and organizational subunits through the use of the technology' (Becker, Lazaric, Nelson & Winter, 2005, p. 778). This

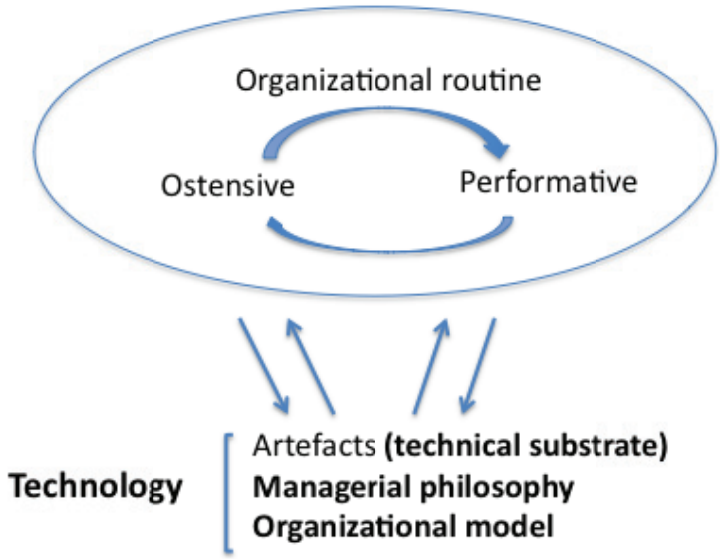

Figure 1. Integrating institutional dimensions of technologies in the routine as generative system framework (adapted from Pentland & Feldman, 2005, p. 795).

dimension is reminiscent of the demonstration by Leonardi and Barley (2008, p. 165), that 'when technologies are used in ways that allow people to do new things that would have been impossible before, tasks and roles frequently change'. This also shifts the social network that defines the structure of an organization.

These three dimensions are not exhaustive but they can be viewed as creating a conceptual 'whole' providing a fruitful account of the processes through which technologies have disciplinary effects and enhance the usual analysis of the role of artefacts in internal routine dynamics. Every technological change (the artefact dimension, its constraints and possibilities) affects and is affected by both sides of collective action (Hatchuel, Pezet, Starkey & Lenay, 2005b): knowledge (criteria of values, competencies, logics of performance, and rationalization, detailed in the *managerial philosophy*) and relations (social roles, and division of work, defined through the *organizational model*). This framework allows us to focus on how fields and technologies are comprised of multiple forms of institutionally-based rationalities, thus providing insight into the analysis of the dynamics of micro-practices and institutions.

A theoretical combination to analyse disciplinary effects and change dynamics

Analysing not only the artefactual dimension of technologies but also the managerial philosophy and organizational model underpinning them affords a richer understanding of the relations between technologies and routines. It explains some of the links between the duality of organizational routines (ostensive/performative aspects) and broader institutional processes. Figure 1 illustrates this theoretical combination, adapting the representation of routines as generative systems proposed by Pentland and Feldman (2005, p. 795).

Considering technologies as three dimensions facilitates access to ostensive aspects of routines by integrating design processes (and not only artefact uses) into the analysis. In this context we consider as *ostensive* (in a broad sense) the participants' numerous and diverse interpretations of

how a specific task should be done. The ostensive dimensions can be identified through the discourses that take shape around the use and objectives of a technology: the rules, resources, ideas and values that the different participants with heterogeneous roles (designers, users, salespersons, technicians, managers, etc.) develop around it. These interpretations are partly influenced by the use model and institutional logics embedded in technologies defined by the three dimensions above, but are also recreated in practice. Through their technical substrate, their managerial philosophy and their organizational model, technologies partially influence the creation of patterns of routines. As Feldman and Pentland (2003) show, the ostensive aspect of a routine is often aligned with managerial interests, like dominance, for example through designers' or managers' prescriptions on how to use a technology or perform a routine. They may, however, also result from the participants' interpretation and be based on different knowledge systems than the ones embodied in the technology. These interpretations may not stick to the use model, and may confirm or contradict it. The variety of performances observed, and in turn the evolution of patterns of action, can be understood more fully if we study the differences in the ways in which the participants take up technologies and the three above-mentioned dimensions, as well as the conflicts between local patterns, local and individual performance logics observed in practice, and those conveyed by these technologies. This framework provides insights on performance divergences among settings for the same technology.

Breeding Technologies and Routines in Livestock Farming

Contrary to a still widespread belief that agriculture remains a traditional sector, it has in fact become one of the most innovative and knowledge-intensive areas of the economy. After the Second World War, the 'modernization of agriculture' was declared a national priority in several countries. This modernization process needed the development of new, knowledge-intensive regimes of cooperation between heterogeneous actors (farmers, scientists, farmers' associations, food-processing industries and various R&D organizations – public or private – supported by specific norms and routines) (Aggeri & Hatchuel, 2003; Chesbrough & Spohrer, 2006). Based on a model of innovation-diffusion that has since been called into question (Nowotny, Scott & Gibbons, 2001), the development of this 'knowledge-intensive' regime consisted primarily in the implementation of new technologies designed to spread scientific knowledge and increase agricultural productivity. In the livestock sector one of the most important areas of innovation has been breeding activities. Breeding programmes fit into the scheme of 'rapid productivity growth, associated with the bringing into operation of methods of production – new technologies or routines – that came to be called "mass production"' (Nelson & Nelson, 2002, p. 270). This intensive, knowledge-based regime is facing new challenges: after a long period of intensification, the reduction of input costs and the increase of output qualities with less intensive production techniques have now emerged as the new logic of production. Breeding technologies therefore have to face rapidly changing environments and their role in the emergence of new practices provides a relevant case study of this trend.

In what some authors have called the 'industrialization of nature' (Schrepfer & Scranton, 2003), traditional livestock breeding practices (based on individual evaluations of animals by farmers) have tended to be replaced by organizational routines stemming from the diffusion of technological and organizational innovations such as artificial insemination or collective performance recording. These routines depend on cooperation between breeders (farmers), breeding companies and scientists, and complex technologies whose operations are distributed across diverse organizations and heterogeneous work communities (D'Adderio, 2008). The generic breeding routine that we analyse in this paper consists mainly of the following subroutines which are repeated every year from October to May in each regional industry:

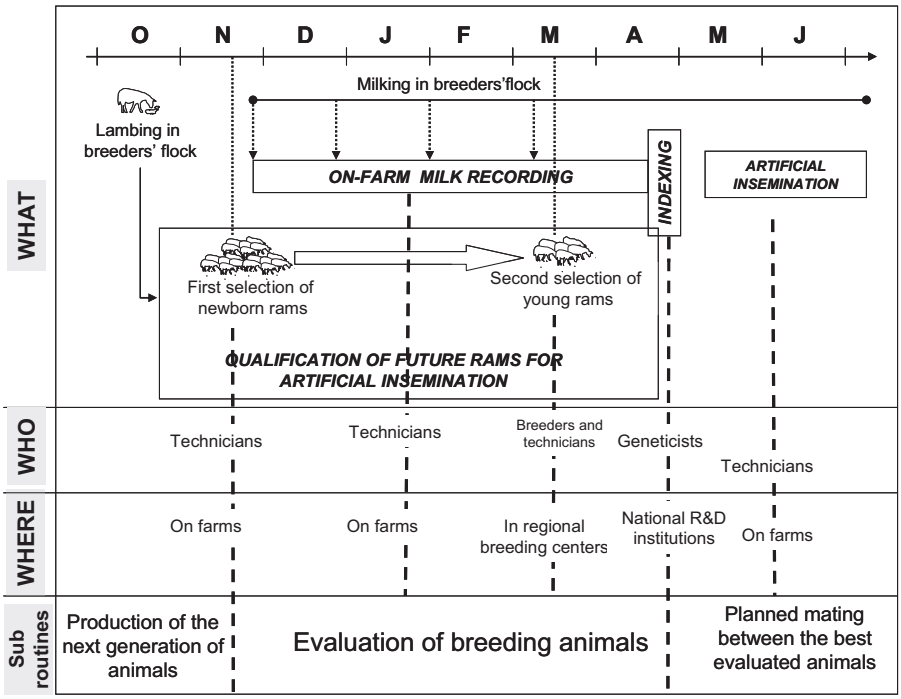

Figure 2. The technological breeding routine and its subroutines.

Step 1: the evaluation of animals' performances on each farm, through on-farm milk recording performed during the year by the technicians of the breeding centre, and through collective morphological evaluation by farmers (called 'qualification') twice a year, in order to determine the best animals according to defined criteria. Data are then transferred to a national system of information where scientists calculate the genetic worth of animals through breeding values (genetic indexes);

Step 2: the collective planned mating of the best animals via artificial insemination (according to genetic indexes) by technicians on each farm, to ensure genetic gain between the previous and next generations;

Step 3: the production and rearing by farmers of the next generation of breeding animals to be evaluated.

These subroutines are interdependent but occur in different places (from farms to local breeding companies and the national research institute) and involve different types of participants, including the designers of the technology (from farmers to geneticists), as detailed in Figure 2. This representation of the routine, however, leaves out much of the detail about how these actions were performed and how the ostensive patterns were formed. We will consider them more closely in the description of our results.

These breeding technologies have had different outcomes and have not enjoyed the same institutional success in every local setting where they have been introduced. How can these unexpected outcomes be explained? How have new technologies and routines changed organizational practices and institutions in this field? How have participants used the technology and enacted this routine to produce new patterns of action?

Research Design

This work is based on an ethnographic case study methodology (Eisenhardt, 1989; Feldman, 2000), used here to analyse the divergent outcomes of a technology and its correlated routines in two different settings: the one in which it was first designed (the Roquefort sheep milk and cheese industry in central France) and the one in which it was later diffused (the Western Pyrenees sheep milk and cheese industry in south-western France). These two cases are particularly meaningful because of their contrasting logics in terms of institutionalization of a new routine: whereas the technological routine had great success in the Roquefort region and came to be taken for granted, in the Western Pyrenees that was far from the case. There, traditional breeding practices and the new technological routine are still competing and the legitimacy of the breeding technology to determine animals' value is at stake. Few empirical studies of routines and practice changes in organizations have run parallel field work in different settings and locations, and few institutional studies have focused on unsuccessful cases of technology diffusion (Lounsbury, 2007). Yet such comparative work enables us to analyse how differences in the institutional, social, cultural and geographical context can influence the way in which the technologies are used, and how new practices emerge and are taken for granted or not (Barley, 1990), especially as a result of interactions between various institutions, materials, and the rationales of participants. This affords insight into the relationship between everyday practices and organizational and institutional dynamics. The Roquefort case furthers our understanding of how the technology was designed, and of the assumptions and knowledge systems influencing its disciplinary effects. The analysis of the routine dynamics in the Western Pyrenees is more detailed in terms of performance variation, for that is where the breeding technologies were a controversial issue.

Field settings

The Roquefort and Western Pyrenees regions are France's two largest sheep-milk-producing areas. However, these two settings have very different geographical, economic and cultural realities. In the Roquefort region the lack of arable land and the cold winters preclude agricultural activities other than livestock farming. Cheese is produced from the milk of a local breed of sheep, the Lacaune, and has been commercialized nationally and internationally by a few large firms since the late 19th century. In contrast, the Western Pyrenees region in the south-west of France is a multifaceted and fertile region, characterized by cereal crops and livestock farming based on extensive use of local environmental resources like summer mountain grazing. Three local breeds (Manech Red-face, Manech Black-face and Basco-Béarnaise), each with different colours and morphologies, can be found there. Breeders are strongly attached to these local breeds which are associated with migrant breeding systems and have played an important role in forging the territory's identity. This economic sector is structured by multiple distributed organizations and linked by social networks of farmers and cheese factories in each valley. The commercialization of cheese outside the Western Pyrenees region began only in the 1960s. Today 2,500 farms and eight cheese industries produce and process 12,000 tons of high-quality local sheep cheese per year.

Data collection

We conducted an in-depth longitudinal field study (Pettigrew, 1990) of what we defined as traditional and technological breeding routines. For a year and a half we collected a rich variety of data from various sources, in parallel with a broader, six-year intervention-research project in this empirical field.

Interviews. We held 45 interviews with three types of actors who viewed the focal phenomena from diverse perspectives (Eisenhardt & Graebner, 2007) and had heterogeneous roles in the routines:

(a) designers, managers and promoters of the breeding technologies and routines (mainly scientists); (b) participants who perform the breeding routines daily (scientists, technicians, farmers); and (c) stakeholders concerned with the local breeds, as well as actors from various functional areas (cheese processing industries, professional organizations, local governments).

The first type of interview was held with some of the main scientists who designed the breeding technologies and who have participated to their implementation in the two regions, from the 1960s up to today, along with managers and technicians of breeding organizations in each setting. Our objective was to identify their intentions, discourses, values and even hidden hypotheses, as elements of the construction and diffusion of the rational myth underlying the breeding technologies. Even more importantly, we set out to investigate the evolution of their discourses over time, in relation to their integration of the unexpected outcomes of the technology that they had designed and helped to implement, and their involvement in the yearly routine (calculation of genetic indexes). In addition to these interviews, we had almost daily interactions with the scientists, as we both worked in the same research centre (INRA, the French National Agricultural Research Institute) and were engaged in intervention-research activities with them.

The second type of interview provided more information on why and how the breeding routines were performed, and how they evolved after the implementation of breeding technologies. We interviewed both retired and active practitioners (breeders, agricultural technicians, scientists), to help us identify the long-term co-evolution of practices and institutions. The samples included farmers who had predominantly been involved in the technological routine, as well as those who had refused it. In these interviews, we asked farmers why and how they were involved or not in the technological routine, how they had performed breeding routines before the implementation of the scientific breeding technologies, and what had changed for them in their daily practices. Our objective was to identify discrepancies between the ostensive aspects of the routine (what heterogeneous participants thought the routine should be) and actual performances. We identified when they refused certain changes or invented new practices to adapt the prescriptions of managers and technicians (designed to be universal) to their particular situation. We also identified whether their social position in the local community of farmers had changed or not, as a result of changes in their breeding practices. We also focused on breeders who purposely went from one routine to another, to understand why, despite increases in animal performance with the technological routine and its apparent efficiency, they chose to return to the traditional routine. Finally, we conducted and recorded 30 semi-structured interviews with farmers.

The third type of interview, with field-level actors, provided information on the institutional context of the breeding routines, on how the local industry was organized, and on whether there were strategic alignments or divergences between the various stakeholders involved in the production of sheep milk and cheese processing. We tried to identify the differences of industry structure between the two settings studied (Roquefort and Western Pyrenees), in order to infer some insight on how these factors might affect breeding routines and organizational structures.

These interviews usually lasted between 1 and 4 hours. Most of them were held in the Western Pyrenees, where we undertook the more in-depth study and sought to understand the creation and recreation of breeding practices. In the Roquefort region we identified fewer key participants for each type of interview, and used more archival and organizational documents (see below).

Direct observation. We used direct observations to gather data on the collective sequences of breeding routines and to follow situated performances. We attended every important meeting of the breeding centre (16 meetings during a year and a half, lasting from 4 to 7 hours), and followed the various stages of the breeding activities, both on the farm and at the breeding company (milk recording on farms, artificial insemination, animal qualification, etc.), for both routines (traditional and technological).

During observation with technicians from the breeding company, who performed the technological breeding routine, we had them explain the meaning they derived from their practices. We registered their discourses on the technological breeding routine, and the advice and prescriptions they gave to farmers. Direct observations revealed discrepancies between what people had said during the interviews and what they actually did. Moreover, the first author's technical background allowed for full immersion in the micro-level interactions among practices, participants and technologies.

Archival research. We also conducted archival research to define the historical and long-term processes of change in breeding activities and the long-term construction of overlapping patterns. We collected two types of documents: internal (from the breeding companies in Roquefort and the Western Pyrenees) and external (from scientific databases, scientists' personal archives, etc.). We collected and read numerous animal genetic science articles and reports to identify the hypotheses (both technical and organizational or economic) and knowledge systems embedded in the design and use model of scientific breeding technologies.

This historical approach aimed to capture the mechanisms and long-term disciplinary effects of normalization of the breeding technology on the emergence of new practices. It also helped in identifying the long-term creation, in action, of a variety of ostensive aspects of breeding routines (the understandings of scientists, managers or users, all participating in different steps of the same routine). This was achieved by clarifying the rational myths (original projects, values and hypotheses) under which participants have developed breeding practices (Becker et al., 2005; Garud & Rappa, 1994). The ethnography of participants' actual practices was chosen to identify the gap between a diversity of ostensive and performative aspects in the implementation of the technological routine, as well as the divergences between the variety of routine performances and what designers (here, scientists) expected from the technology. It also enabled us to see how the participants had influenced redefinition and institutionalization of the technology.

Data analysis

Our aim was to identify not only how and why people used the technology, and what changes it allowed for in their daily practices, but also how it had been designed. What were the scientists' assumptions and the technical services' discourses when they designed and accompanied the uses and development of the technology in the two settings: Western Pyrenees and Roquefort? This was useful to identify the knowledge systems that were conveyed by the technologies and involved in their disciplinary effects. Our underlying question was broader than simply the internal dynamics of breeding routines. We jointly:

- built a genealogy of breeding practices and technologies, and a history of the implementation of the technological routine in Roquefort and in the Western Pyrenees. We identified several key steps and crises in how this technology had been implemented in Western Pyrenees and how the roles of participants and institutions co-evolved with its development (see upper part of Figure 3);
- defined a typology of farmers' breeding practices (Labatut, Girard, Astruc, Bibé & Boisseau, 2008), according to how they performed the breeding routines and used the technologies. We identified unintended performances, counter performances, and changes over time (see lower part of Figure 3).

Figure 3 shows some examples of how we connected raw data to analytical categories and theoretical concepts, adapting the audit trail proposed by Rerup and Feldman (2011).

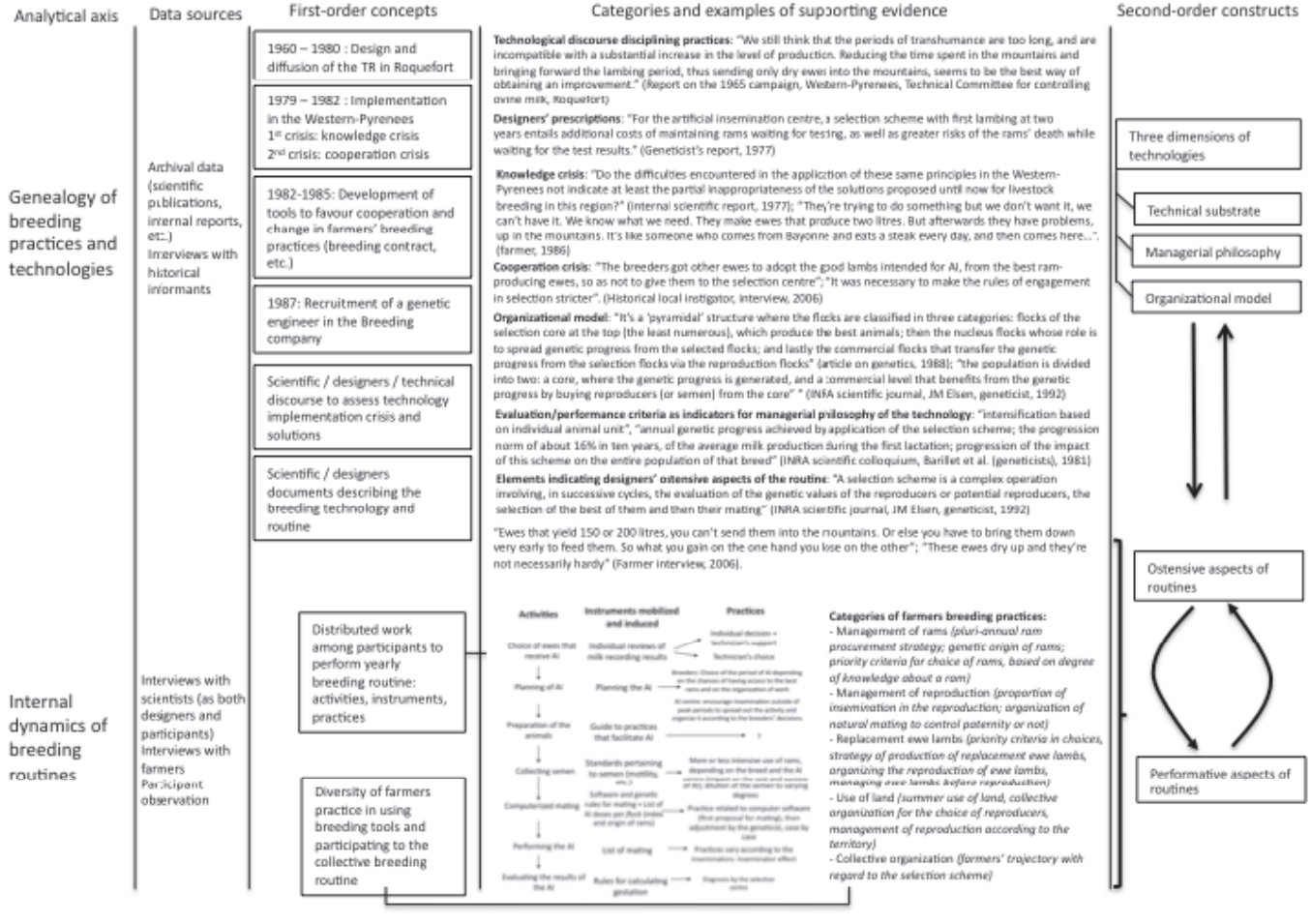

Figure 3. Data structure and examples of supporting evidence.

From Traditional Practices to the Emergence of a New Technological Routine

The limits of traditional practices

Breeding practices for improving animals used for livestock production have existed since humans first started to rear livestock. Initially these practices were simply individual farmers' habits concerning their flock or herd. Later (mid-18th century), in order to avoid consanguinity and to improve animal performances, farmers developed practices consisting in annual buying and exchanging of breeding animals from other herds or flocks, and participation in collective activities around animal contests. Before the modernization of agriculture, informal organizations and shared conventions supported this collective activity, which was embedded in traditions and farmers' habits. Breeding animals were collectively evaluated at marketplaces and country fairs by means of shared tacit conventions on their quality. Farmers who participated in these events were acknowledged as good breeders on the basis of their capacity to produce good-looking animals, which defined their professional identity, and they usually sold animals on the local market. The animals' quality was defined on morphological and aesthetic criteria, which then set the price of breeding animals. Milk productivity was not farmers' only objective, as other economic models existed as well (i.e. the sale of lambs, lower input or large flocks). Morphological and aesthetic criteria may not have been economically valuable, but they were of key importance to farmers' social and professional identity. The organization underpinning this traditional breeding routine relied mainly on interpersonal relations between farmers, as extension services and professional organizations did not yet exist. Only implicit membership rules based on reputation and trust were supposed to organize the functioning of this social network and routine.

These individual habits and collective routines turned out to have several limits, especially when it came to rapidly increasing animals' productivity to meet the needs of a growing industry in the 1950s. The practice of selling animals at country fairs and markets proved to be impractical when unexpected events such as the spread of diseases among flocks had to be dealt with. Moreover, the purely visual evaluation of the animals limited genetic progress. As an INRA geneticist pointed out, 'the drawbacks of phenotype selection are known: the characteristics observed are hardly reliable because they depend only partially on genes' (Vissac, 2002, p. 69). Moreover, benefits in terms of milk production were not sufficient to ensure the economic sustainability of livestock production units and the cheese processing industry: 'in the 1960s, the situation was worrying the cheese plants because of the stagnation in milk production' (geneticists Barillet, Marie, Jacquin, Lagriffoul & Astruc., 2001, p. 18). Sales of breeding animals mostly took place annually between the same farmers. The general improvement of the whole breed was thus limited, and consanguinity could still exist. Since the animals' quality was based on non-formalized evaluation criteria, high asymmetries of information existed between sellers and buyers. Buyers had no means of assessing the hidden qualities of an animal, such as potential milk production or sanitary problems.

Designing new breeding technology and routines to discipline farmers' practices: a tale of success?

In the 1950s, as a consequence of these limitations of traditional breeding practices, milk productivity was not increasing enough to meet the objectives of agricultural modernization. Pressed by the national French Breeding Act in 1966 and the food processing industry's needs, the INRA

developed its research on breeding selection and animal genetics. The 1966 law 'attempted to rationalize the use of the major breeds, [and] codified and standardized the methods and means of selection in order to optimize animal performance' (Steyaert, 2006, p. 87). It helped to render animal genetic resources governable and calculable, and thus to normalize farmers' practices. With a view to improving breeds' productivity, as part of a global project of rationalization of farming activities, geneticists designed a generic breeding model based on technological and organizational innovations to overcome the limitations of traditional breeding practices. A new technology was thus implemented for the first time in the 1960s in the Roquefort region (Barillet & Flamant, 1977, geneticists' document). Its adoption and the development of a shared technological routine achieved a tremendous collective performance: more than 80 percent of farmers adopted the new breeding tools, participating in the technological routine mainly as planned by designers to ensure the most efficient use of the technology, and milk production per sheep increased fourfold over the next 50 years. As a result, the local breed (Lacaune sheep) acquired one of the highest milk production potentials in the world (Barillet et al., 2001), and the continuous increase of milk production went hand in hand with the rapid development of the production and sale of Roquefort, as also happened for locally produced cheeses (Perail, Feta, etc.) in other parts of the world. This intensive, knowledge-based economy generated high economic rents for farmers and cheese processing industries. Researchers involved in the design of the routine consequently acquired an international reputation and are now world leaders in the field of sheep genetic science (see, for example, Barillet, 1997, *Handbook of Sheep Genetics*).

This technological and organizational routine needed to recruit a large number of participants to succeed. From a rational point of view, after this unquestionable success, one would have expected – as the designers did – this technological routine to have spread universally and to have replaced traditional practices, since it was the more efficient in terms of productivity gain. This was indeed the case in the Roquefort region, and based on this successful experience the breeding technology and its associated routines became the reference to guide performances (Bardini, 1991). Researchers formalized this innovation and technological routine through written procedures to make it applicable to any sheep-farming context: 'Very quickly, this new organization was considered as a model in France and throughout the world' (geneticist Flamant, 2002, p. 10). More importantly, as this technological routine was considered more efficient in terms of milk production, it could be predicted that, once introduced into a sheep farming area, it would rapidly replace other, 'non-scientific' routines, thus becoming the 'dominant design' (Utterback, 1994).

Unexpected outcomes of the diffusion of a practice model

This success story attracted the interest of farmers, local authorities and the food industry throughout the world, including in the Western Pyrenees. In the 1970s, several young farmers and agricultural advisers in the Western Pyrenees requested the intervention of the INRA geneticists who had designed the technology in the Roquefort region, as farmers and cheese-processing industries wanted to increase local breeds' productivity. Their plan was to apply the 'Lacaune' breeding model to the three local breeds. The success of the technological breeding routine in Roquefort had caused some to believe that a replication of this model (the technology and its correlated routine) in the Western Pyrenees would be easy. A geneticist explained: 'looking at the Lacaune experience, we knew that genetic gain was exactly what we had planned in the theoretical model. We therefore thought that, in the Western Pyrenees, the genetic gain would increase in the same way' (geneticist, 13 July 2006). Yet, despite the geneticists' and local innovators' predictions, the technological routine was not taken up as easily as it had been in the Roquefort region. A comparison of results

Table 1. Comparison of genetic results between Roquefort and Western Pyrenees according to age of first lambing.

	Age of first lambing	Theoretical genetic gain	Efficiency (%)
Roquefort	1 year	0.210	100
Western Pyrenees	2 years	0.156	74

Source: INRA Scientific Report, 1977

in the Western Pyrenees with the Roquefort model, considered as '100%' optimal, showed differences between planned outcomes and actual performances obtained (Table 1).

Although progress in animals' performance was observed, the technological routine did not become a 'dominant design', a 'taken-for-granted' practice (Lanzara & Patriotta, 2007), and a wide variety of performances could be observed. How can these unexpected outcomes be explained? How can we better understand the disciplinary effects of the technology on organizational routines and its limits? How can we explain divergences of performance and go beyond explanations in terms of resistance to change? How did these discrepancies lead to changes in how participants (designers and users of the technology) saw how the routine should be performed? While this historical analysis allows us to understand the broader institutional context and rational myths underlying the emergence of a new practice, answering these questions fully means going into the details of both the technology design (rationale, assumptions, knowledge systems) and uses, and the ostensive and performative aspects of the routine in the Western Pyrenees.

The Disciplinary Effects of Technologies: Hidden Assumptions on How Routines Should Be Performed

From the 1960s to the 1990s, consequent to the introduction of scientific breeding technologies in the Western Pyrenees, the nature and daily practices of the participants in breeding routines changed radically, as did the tools and performance criteria that they used. This led to the emergence of new patterns of action influenced, initially, by their success in Roquefort and the discourses of designers and managers. To unravel these changes, we analyse the three dimensions of the technologies and their consequences on breeding routines, through the practices that they implicitly prescribe.

Three artefacts to rationalize the evaluation of animals and to shape breeding practices

The breeding technology was designed on the basis of three main specific artefacts: on-farm milk recording, breeding values and artificial insemination. On-farm milk recording measures the milk performance of animals, and these data are then used to calculate breeding values. The breeding values serve to estimate the genetic worth of each animal, which is then used to choose the best animals for planned mating through artificial insemination. The aim is to produce a new generation of breeding animals statistically expected to be more productive than the previous one. Compared with traditional breeding practices detailed above, these three technological artefacts radically impact individual and collective practices.

With *on-farm milk recording*, the evaluation of animals' performance on the basis of the 'skilled vision' (Grasseni, 2009) of the farmers and daily interaction with their animals is no longer considered valid for 'proper' selection. This traditional mode of evaluation, deemed to be subjective, is

replaced by measurements of the milk produced by each animal according to mandatory scientific procedures based on the laws of statistics. These measurements are performed by technicians, six times per lactation. According to scientific theory, this huge amount of objective data allows for the calculation of genetic indexes which ensure objective evaluation and selection of animals.

Genetic indexes (or breeding values, i.e. the predicted performance of the animal) may include a large number of criteria, from the simplest (milk quantity and quality) to the most complex (morphological criteria). It takes at least 10 years after the implementation of a new breeding criterion before measurable results are obtained. At the beginning of the process, when morphological criteria were not yet included in the formula, the evaluation of animals by breeding values was supplemented by a visual qualification procedure which ensured that breeding animals matched the aesthetic and morphological criteria of the breed that farmers were aiming for. This new collective qualification procedure, which took place at the breeding company and on breeding farms, was supposed to replace the traditional collective practice of animal appraisal at country fairs. It entailed a shift from a public visual qualification (in the open space of country fairs) to a private evaluation (in the breeding company) where only breeders chosen by the breeding company, specially trained technicians and geneticists got together once or twice a year to evaluate the aesthetic quality of the breeding animals.

According to the 'Roquefort model', *artificial insemination* should replace most traditional practices of natural mating and the local breeding animal market, to produce the next generation of breeding animals. In this model, the mating plan to obtain collective breeding animals is chosen by the breeding centre, and no longer by the farmer. Due to technological constraints in sheep, artificial insemination is necessarily carried out by skilled technicians and cannot be done by individual farmers.

These artefacts allowed for the construction of animal populations and their genetic worth as a collective management object, through the mutual constitution of measurement systems and practices, and social participants in the economic activities of animal breeding.

Increasing animals' individual performance as a unique managerial philosophy

The managerial philosophy of this technology was to upgrade animals by criteria which had a real economic function, as the first criteria to be measured were milk yield and milk quality. To ensure a high level of genetic gain, the technological routine concentrated breeding efforts on a small number of quantitative criteria and ascribed less importance to the qualitative ways of estimating animals' value. The aesthetic criteria used in traditional breeding routines were no longer useful or relevant to the economic objectives of the technological routine, as a seminal scientist in breeding innovations said at a Rural Economics Society meeting in 1959: 'We never insist enough on how stupid it is to eliminate excellent animals according to genetic criteria which do not comply with aesthetic criteria of the breed, like, for instance, details such as colour spots on undesirable places!' (Poly, 1959). Modernizing discourses were promoted by agricultural advisers and breeding companies in order to switch from inefficient farming practices to scientific criteria. These discourses sometimes went further than the written rules needed to implement the technology. For example, first lambing when young ewes reached the age of two, a traditional practice in the Western Pyrenees, particularly for the Manech Black-face breed and the flocks that graze on summer mountain pastures, was said to limit the optimum efficiency of the technological breeding routine.

> A selection plan with first lambing at the age of two: entails additional costs of maintaining the rams, waiting for progeny testing; entails higher risks of disappearance (death or sanitary reason) of rams waiting for the test results or while genetic progress is being diffused. (Report from an INRA geneticist, 1977)

> The rate of early reproduction, … has to progress in the Manech Black Face. (*Le Sillon*, local agricultural extension journal, 24 May 1991)

Summer mountain grazing practices were also recognized as an impediment to a greater increase of animals' performances:

> We still think that the periods of transhumance are too long [and] are incompatible with a substantial increase in the level of production. (Report of the 1965 milk recording campaign in Western Pyrenees)

These two examples reveal how a technology disciplines practices not only through official written rules. Discourses on the managerial philosophy accompany the technology diffusion and participate in building general understandings on how the technology should be used and what its correlated routine should be. Lambing at the age of one year instead of two years was not a compulsory written rule for using the technology; however, as the common practice in Roquefort was one-year lambing and had been recognized as the most efficient by designers and prescribers of the technology, technicians pushed for a change of practice in the Western Pyrenees when they first implemented the technology, to follow the Roquefort model.

An organizational model of distributed competences and service relations

The design of breeding technologies is attached to organizational assumptions which contribute to conforming practices and organizing social relations. In the embedded organizational model of breeding technologies (Figure 4), as indicated in geneticists' publications and technical documents, breeding organization should rely on a division of labour (see Figure 2) required for artificial insemination and milk recording, and to produce genetic indexes. It is acknowledged that a small part of the farmer population – the breeders – have to put a pool of ewes at a breeding centre's disposal. The breeding company then evaluates breeding rams by means of a national information

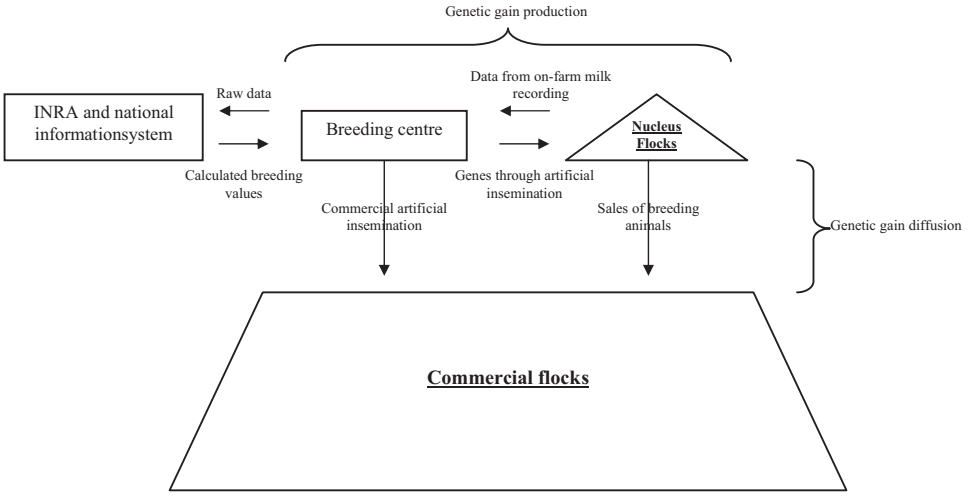

Figure 4. The organizational model of the technological routine. (adapted from Barillet, 1997)

Table 2. Material, institutional and organizational dimensions of technologies influencing the construction of ostensive aspects of breeding routines.

	Technological breeding routine
Technical substrate	Animal evaluation by on-farm milk recording and index, use of artificial insemination (scientific evaluation of animals)
Managerial philosophy	Improving farmers' income by increasing animals' performances
Organizational model	Service relation, division of labour, distributed knowledge and competences between farmers, technicians, scientists in the breeding scheme, cooperative system
	Isolation of flocks and individual management of mating

system which calculates breeding values and designs their mating plan to produce genetic gain. This genetic gain should finally be disseminated to the 'base population' (which scientists call 'commercial flocks', but we call them 'ordinary farmers').

The organizational model embedded in the technology changes the very nature of relations between participants in the breeding routine, due to distributed competences and a division of labour. In this abstract model, breeding activities rely mainly on service relations between farmers and breeding centres, which radically change the professional identity of participants. Technicians and geneticists become the only ones to really master the technological routine procedure, and farmers become customers of an organization (the breeding company) that provides genetic gain and genetic services, and performs the most important part of the routine. Some farmers are appointed to represent the profession's needs on the administrative board of the breeding centre.

Table 2 summarizes the three dimensions of the scientific breeding technologies described above. These three dimensions explain designers' assumptions and advisers' discourses on an espoused managerial project and on broader institutional beliefs pertaining to performance management and farmers' well-being. Moreover, these three dimensions of technologies participate in disciplining animals and humans, in shaping practices that should be implemented to support the technology, and in influencing the creation of general understandings of what the routine should be.

The efficiency of the breeding technology and its correlated routine in respect of milk production criteria should have ensured its legitimacy and wide adoption. But despite undeniable technical results through genetic gain, the analysis of the variety of performative aspects of this technological breeding routine in the Western Pyrenees has revealed some unexpected outcomes and difficulties. It has also revealed how participants interpreted and took actions to change the prescription of the technology, leading to new understandings of how the routine should be performed.

From a Diversity of Performances to the Production of New Ostensive Patterns: Dynamics of Change

How is the technological breeding routine enacted in practice by participants in the Western Pyrenees? In this section we describe the discrepancies between the ostensive aspects of the routine (the variety of understandings built on how the routine should be performed) and its enactment – the performative aspect – that we observed in daily practice. We consider each of the three dimensions of the technology, to show how this analytical framework affords us a better understanding of these discrepancies and the new patterns of action produced.

The emergence of new practices to adapt to artefacts

Contrary to what occurred in the Roquefort region, in the Western Pyrenees only a minority of farmers used these technological artefacts. Since outside of the nucleus flocks (which were expected to produce the genetic gain) the use of technological breeding artefacts was not compulsory, technical data indicated that only 20 percent of the overall population of farmers used on-farm milk recording services and artificial insemination. Even in the nucleus flock, breeders often used artificial insemination at the minimum level required by the breeding centre in the breeding contract (i.e. on 40 percent of their ewes), instead of using it on more animals. Thus, scientific knowledge was not integrated into the majority of farmers' practices, as they did not always use genetic indexes calculated by scientists as relevant tools to evaluate an animal's quality. Using the typology proposed by Feldman (2000), which defines three ways in which participants may change a routine (repairing, striving and expanding), we identified changes in the performances of the technological routine and in the uses of artefacts according to the following kinds of unexpected outcomes.

Repairing. Due to the differences between the technological breeding routine and traditional routines in the local Western Pyrenees context, such as transhumance, unintended practices appeared with the use of technological artefacts. For instance, artificial insemination was shown to be contrary to local territorial organization: it proved to be difficult to perform in mountainous areas because it required the isolation of animals which are usually shepherded collectively with several flocks. Sheep farmers were moreover criticized by their peers for the ugliness of their animals (as animals from the breeding centre where selected on production rather than aesthetic criteria), even though in terms of breeding values they were excellent.

> We used to have great rams, genetically-speaking, and I was openly criticized by the shepherds, who said they were ugly. (farmer L, in the breeding scheme, 15 March 2007)

Participants tried to find compromises which jointly allowed for the use of technological artefacts and corresponded to their farming practices, for instance, shifting transhumance dates in order to carry out artificial insemination on the plains, or keeping in their flock specific rams with a low index but high aesthetic value, dedicated to going with the ewes on collective summer pastures.

> So, you know what I kept? Rams from bad ewes who'd mated with lower index rams. No one does that. Why? Because it's a ewe that's not of much use to me, so she won't produce any milk in the year, she's just going to produce the ram, and if the ram has a bad index, it doesn't enable me to do anything worth much. (farmer L, 15 March 2007)

This example illustrates how understanding the system of routines (here the interrelations between breeding routines and summer grazing routines) in which a specific procedure is implemented helps to explain crises and changes in the development of new patterns of action.

Striving. Some farmers altered the technological routine to carry out breeding in a way that they considered to be better. While the ostensive aspects of the routine, according to the scientists and technicians who performed a part of it, and to some farmers, was to follow the prescription of the breeding centre, other farmers went further than the requirements of the genetic indexes in terms of reproducers' choice criteria. These farmers integrated additional criteria and performed artificial insemination on more animals in their flocks than they thought was required, to accelerate the

process of genetic gain. In so doing, they participated in shaping the way in which the breeding company determined mating, by altering the way in which the routine was prescribed. They also asked for genetic data on the rams whose sperm was used on their ewes, whereas the geneticists felt that such information should remain at the breeding company, as in Roquefort, and did not need to be supplied to the breeders. By doing so, farmers could maintain their personal knowledge of their animals and their competencies and professional identities as 'breeders'. From year to year, this has oriented to building new ostensive patterns of the routine and it would be unthinkable now for managers of the breeding company not to give the genetic indexes with the semen they prescribe to farmers in planned mating schemes.

Expanding. Artefacts involved in the technological breeding routine afforded new economic opportunities for farmers, which defied designers' intentions. Selection tools made it possible to achieve mating between animals that would otherwise have been impossible, and to respond to a sanitary crisis that could have decimated the flocks in the Western Pyrenees. In fact, genetic indexes are not only a technical tool for evaluating breeding animals in the breeding scheme. Just as grammar rules facilitate communication, so too genetic indexes perform and regulate to a certain extent the breeding-animal market outside the breeding scheme, affording farmers the opportunity to produce breeding animals for sale. Some of them developed unexpected practices and became the new providers of good animals on the market, selling collectively more rams than the breeding company. This was contrary to the assumptions of designers and managers, who expected all farmers to buy semen and rams from the breeding company in order to ensure its return on investments.

This interplay between the first dimension of technologies (artefact, technical substrate) and routines already gives fruitful insights on the co-evolution between ostensive and performative aspects of routines, and on participants' capacities to influence the disciplinary effects of technologies. The other two dimensions help in identifying how the managerial philosophy and organizational model conveyed by technologies are reproduced and changed through participants' ongoing practices.

From cost-saving performances to low-input managerial philosophy

Whereas the managerial philosophy of the breeding technology presupposed a single model of farmers' welfare, their practical understandings of the technological breeding routine revealed various possible ways of creating value. The target performance (improving farmers' incomes by increasing milk yields) conveyed by the managerial philosophy of the technology turned out to be outdated and not necessarily valid for all farmers when milk production reached a high enough level to ensure a sufficient return on investment. Systems that were sparing with inputs appeared to be as profitable as those based on milk yield maximization. Farmers also saw the promotion of the market value of milk through on-farm processing or specific practices (elimination of silage from animals' feedstuff, promoting raw milk) as another means of optimizing their income. Some farmers furthermore sought to reduce working time and preferred to lower the duration of lactation, or to let their ewes grow for two years before lambing. During interviews, farmers often mentioned animals' hardiness (resistance to harsh environment), which saved on time and input, as a justification for their reduced use of the technology. Some of them even considered it not worth producing more milk, due to the consequent increase in charges:

> Today, increasing income comes from cost control. … Thus, cost control depends on the farming system, and for me the transhumant system is the basis of our income, our culture, our cheese, Ossau-Iraty. (farmer P, 20 June 2006)

> I try to have costs as low as possible. I avoid using artificial insemination because it's too expensive. I avoid using purchased feeds, scanning my ewes, buying fertilizers. (farmer B, 13 March 2007)

They also considered it very important to find a balance between productive and less productive ewes.

> I prefer attenuating the risk and have a dead ewe at 110 litres of milk per lactation rather than a dead ewe at 220 litres, I prefer having two ewes at 90 litres per lactation than one at 180 litres! (farmer B, 13 March 2007)

This quote illustrates the general understanding given to the technological routine (high production performance of individual animals per production unit) and how farmers developed divergent practices and rationales. The analysis of performances revealed this diversity, which sometimes differed from the economic rationality underpinning designers' and managers' ostensive patterns of how the routine should be performed. As a reaction, these local and individual modifications led to changes in broader institutional beliefs and espoused values, which spread through discourse on the technological routine. For instance, in an attempt to counter such opposition, scientists later tried to spread the general understanding that the technology could be used for a wide variety of farming practices and objectives, and not only for increasing milk productivity, and to influence ostensive patterns for the breeding routine:

> Genetic progress in milk production can have other objectives than simply increasing production. So breeders have several choices: making the most of their ewes' production potential by feeding them a lot to get the maximum milk production, or having a profit logic and trying to maximize their profit margin: less feed for the ewes, who will respond better to less feed because they will have a better genetic potential, and so be more profitable. It is important to get this message across to the breeders, to show them that genetic selection is not necessarily based only on a productivist logic, that there can be several strategies around the same selection scheme, around the same criteria such as increasing milk production. (geneticist from INRA during the general assembly of the National Committee for Sheep Milk Production, 20 April 2006)

Organizational model and power conflicts and changes in local communities

The local performances of the routine also changed the distribution of roles in the farming community and, above all, enabled the creation of new identities or roles for farmers participating in the technological routine. In Roquefort, in the articulated ostensive patterns that designers and 'upstream' participants had of the routine, the sale of breeding animals had to be reserved for the breeding centres, to ensure the financial balance of the schemes and to offset the costs of milk recording tools. In contrast, sheep farmers in the Western Pyrenees developed a parallel market for breeding animals, resulting from their participation in the technological routine. A new form of professional identity of breeders and a new type of power in the community of farmers thus appeared in the Western Pyrenees. While some breeders retained the professional identity corresponding to the traditional routine (being capable of selecting good-looking animals as a criterion of quality on the sheep market), the participants of the technological routine were granted power related to their capacity to propose animals from parents with scientific breeding values resulting from on-farm milk recording, as a new criterion for qualifying animals on the market.

Table 3. Synthesis of analytical elements defining some of the ostensive and performative aspects of the technological breeding routine according to the three dimensions of technologies.

	Elements influencing ostensive aspects of the technological breeding routine from geneticists' point of view (designers and participants to the routine)	Observed performances of the technological breeding routine
Technical substrate	Animals' evaluation by on-farm milk recording and index, diffusion of genetic gain, wide use of artificial insemination	Low diffusion of technological artefacts Wide variety of artefact use New opportunities for mating animals
	Public standards	Development and regulation of a market for breeding animals
Managerial philosophy	Improving farmers' income by increasing milk yields	Diversity of farmers' rationalities, from low input to high input farming systems Farmers' wish to define their own performance criteria and knowledge relevancy Importance of aesthetic criteria
Organizational model	Service relation, division of labour, distributed knowledge and competences between farmers, technicians, scientists in the breeding scheme, cooperative system	Change in meaning of farmers' job Difficulties in separating technologically improved flocks from 'traditional' flocks according to collective practices of mountain grazing and collective shepherding
	Isolation of flocks and individual management of mating	Parallel market of breeding animals and genetic resources

However, the enactment of the specific organization needed to implement the technological breeding routine produced several unexpected outcomes and changes in routine performance. These can be understood through the tensions between local institutions and the organizational model of the breeding technology. The organizational model that was required, with its division of labour and breeding knowledge, encountered difficulties as the technology implies changes in individual and collective flock management. In fact the specificity of collective mountain grazing practices in the Western Pyrenees contrasted with the technological routine, as it relied on an individual management of flocks. Social and relational problems appeared when controlled flocks (using the breeding technology) and non-controlled flocks (following traditional practices) were mixed on the same mountain pastures, as traditional farmers did not want their ewes to mate with genetically indexed rams considered to be of poor aesthetic value (see *Repairing* above). According to the local rules of the community of shepherds, the criteria of being a good shepherd in collective pastures still amounted to having an attractive flock, knowing how to manage and drive a flock in an open space, and knowing how to make the most of natural resources (free mountain grass). There is consequently tension in mountainous areas due to the mixing of flocks whose owners still consider the beauty of the flock to be an essential criterion, and those who favour performance by using breeding technologies.

Table 3 synthesizes the divergences between the institutional dimensions of breeding technology which intervene in the creation of ostensive patterns of the routine, and the diversity of performances developed by participants in the enactment of the routine.

Producing Concordance Between Technologies and Routines in the Emergence of New Practices

In this section we draw on our comparative study to discuss the actions taken locally in the Roquefort case to orient to ostensive patterns closer to the technological model of breeding. This affords insight into the difficulties encountered in the Western Pyrenees. We identify some of the reasons why the institutionalization of new breeding practices based on scientific models has been different in these two contexts. We emphasize both the exogenous and the endogenous factors of the emergence, evolution and institutionalization of new practices.

The emergence and institutionalization of a new technological routine in the Roquefort region has been favoured both by structural exogenous factors with internal implications and by actions carried out by local key participants.

In this case, local farming practices and land tenure institutions were close to the model underpinning the technological routine which made artefacts of the breeding technology far easier to use. First, the absence of summer grazing practices facilitated the use of artificial insemination. As the flocks remained on pastures close to the barn, it was easier to watch over them and to prepare them for artificial insemination. The ewes did not have to endure the long walk up into the mountains at the beginning of their pregnancy – something that can be problematical for the foetus due to the change of food. Second, the local land tenure system, private ownership of pastures, resulted in individual management of flocks and corresponded to the breeding technology organizational model. Third, this limitation of land resources and the difficult climate in the Roquefort region facilitated the emergence of individual performance logics, in phase with the performance philosophy of the technology, i.e. maximizing yields per production unit.

Apart from these structural specificities, the change from traditional to technological breeding routines in Roquefort also stemmed from specific actions and performances developed by local participants, which allowed for the construction of ostensive patterns of the routine close to the prescribed technological model.

Ostensive patterns creation: a long-term process

The production of synergistic ostensive patterns, i.e. allowing for coordination among participants, is a long-term process, especially when the routines at stake rely on democratic, large-scale organizations such as farming communities involved in a collective breeding programme across a whole territory.

In the Roquefort region, collective and rationalized breeding practices were developed from the end of the 19th century, through the organization of country fairs and animal competitions recognized and funded by the then recently created Department of Agriculture. Designing and developing the new technological routine, in the 1960s, could not be effective without integrating these local practices. The instigators of the technological breeding routine included retired breeders who had previously been involved in the traditional breeding routine and were recognized for their skills in evaluating (and defining) good animals on morphological and aesthetic criteria (skilled vision; Grasseni, 2009). These breeders, guarantors of traditional and local practices, knowledge and skills, and repositories of the shared definition of the breed, participated in the collective qualification of breeding animals in the technological routine. In this sense, the technological breeding routine integrated patterns of local and traditional breeding practices. Managers were able to construct successful arrangements of participants, tools, rules and shared knowledge at the collective level, enabling the development of the technology and a construction of a correlated routine. In contrast, in the Western Pyrenees, traditional breeding routines were not institutionalized through

official organizations and common patterns; very few breeders participated in local animal contests, and there was no shared definition of the local breeds. Moreover, the fact that instigators of the technological breeding routine did not include breeders recognized for their traditional competencies in visually evaluating animals did not favour the legitimacy of the new routine.

Building a shared managerial philosophy on strong relations with the industry

To understand the construction and reinforcement of the technological breeding routine in the Roquefort region, it is important to stress that the initial cooperation between scientists who designed the technology and the local actors was not built on nothing. This cooperation was possible because local actors had built 'strong ties' (Granovetter, 1973), at least since the creation in 1925 of a protected Appellation d'Origine Controlée (AOC) for Roquefort cheese, and were therefore able to build a project and work for a 'common purpose' (Barnard, 1938). This agreement, signed by all the partners, enhanced solidarity and cooperation among actors who thus had to promote a highly valued 'common good', that is, Roquefort cheese (Aggeri & Hatchuel, 2003). The distribution of roles was well defined. Farmers produced milk only for the cheese industries (none of them actually processed the cheese), two or three of which made up the bulk of an oligopolistic and international cheese market. Thus, the managerial philosophy of the breeding technology and its correlated routine was consistent with the shared managerial philosophy of the local industry in Roquefort: increasing milk quantity and quality.

In contrast, the production of a shared managerial philosophy was far more difficult in the Western Pyrenees, as farm structures and farmers' production models were more diverse. While some farmers produced milk to sell to cheese industries, others also processed cheese. Tens of small cheese factories sold cheese in local or regional markets while three or four giant cheese firms sold Ossau Iraty and industrial brands in the national market. Moreover, local actors and enterprises participated in several inter-professional organizations in which they developed divergent strategies. For example, the local deficit of milk pushed towards the intensification of local production, while managers of some cheese processing plants preferred to buy cheaper milk from other regions, rather than promoting local production. On the other hand, due to consumers' concerns, the farmers' union for protection of the typical Ossau Iraty cheese sought to limit production in order to maintain its quality and reputation. Through this comparative analysis we can thus see how both the characteristics of the organizational structure and institutional forces, and the relevance of actions taken by local participants, interact with an organization's capacities for institutionalizing routines and building a 'common purpose'. Managerial discourses and technologies are part of orientation to patterns. In this regard, further analysis needs to be done to identify more clearly how a diversity of contrasting managerial philosophies can have negative impacts on the creation of synergistic routine patterns.

Contributions and Further Lines of Inquiry

The aim of this paper has been to propose a combinative analysis of new practice creation, by bridging institutional and practice-based studies of technologies and routines in a rich empirical case study. The main contribution of our work is to map interrelationships across time and levels of analysis, in the study of the dynamics between technologies, organizational routines and new practice creation.

Three main results can be derived from the case study. The first result concerns the understanding of the dynamic interaction between technologies and organizational routines: practices and

other institutions are not external to technologies but constituent parts of them. In other words, the practices and belief systems of the designers and users of technologies are part of those technologies and of broader institutions which define what is considered as 'good performance', 'economic value' or 'benefit'. The genealogical analysis of the origins of new breeding practices and of the design of breeding technologies allows us to understand and integrate into the analysis the historical context that made the emergence of new practices and new technologies possible. This genealogical analysis affords insight into the institutional aspects of the design of technologies. If scientific technologies not only represent reality but also intervene in it (Hacking, 1983), some of the reasons for this intervention can be found in the internalized institutional dimensions of technologies: the models, rationales, assumptions and bodies of knowledge they convey, thus influencing practices.

Second, the use of Foucauldian approaches allows us to understand the disciplinary and generative effects of technologies and their roles in the emergence of new practices and new actorhood. Breeding technologies have rendered animals, and more specifically their genetic worth, 'calculable' and 'marketable'. They have participated in changing the professional identities of participants (in our case, what is a good breeder or a good shepherd), by giving them opportunities for new practices and new spaces of action, through the development of breeding services.

The third result is about identifying how unexpected outcomes retroact on the design of organizational routines and the broader technology. In the cases studied, disciplinary effects are not smooth or automatic, and do not entirely determine what actors can do. The historical and process approach developed in this paper has helped us to show how the collective belief in the success of the technology strengthened designers' assumptions of its universality, and participated in the construction of the designers' and managers' understandings of how the technology should be used. Those multiple ostensive aspects differed from and went further than the written rules accompanying the technology. For example, 'lambing at one year' was prescribed and considered to be how the work should be done, even though this was not written in any procedure and not even compulsory for performing the routine. But there was a general understanding of a higher efficiency of this practice, according to specific criteria, in use in the first successful context.

The analysis of the variety of routine performances affords a better understanding of actors' capacities to produce change through their daily practices, in repairing, expanding and striving (Feldman, 2000) towards the technological routine. There is a need to define better how this diversity of performances and this expansion have a recursive effect, not only on users' ostensive patterns of how the routine should be performed, but subsequently on designers' and managers' patterns of action and finally on broader institutional changes. We draw some lines of inquiry in showing how changes in practices have, through a long process, led to technicians', managers', and designers' comprehension and integration of the diversity of users' rationalities and justifications for change. After several years, in our case, prescribers started to consider a diversity of performance models for which the technology could be used. Further research needs to be done in this respect.

Finally, the comparative analysis provides fruitful insights for identifying the role of context, organizational structure and practices in the construction of synergetic ostensive patterns allowing for participants' coordination. In one case (Roquefort), we identified the integration of actors with specific institutional roles or positions in the routine, and the implementation of specific procedures to favour the building of synergistic ostensive patterns of how work should be done. We also identified in this case the role of an aligned institutional context to favour stable routine performances. In the other case, we showed how the routine under study was interconnected with other routines and local institutions which encouraged users to create divergent performances.

This type of comparative analysis, we argue, should be developed further as it affords an excellent opportunity to better unravel the links between routines as generative systems and organizational structures through divergent trajectories.

Our contribution to the literature is twofold.

First, we contribute to the 'routine as generative systems' literature (Feldman, 2000, 2003; Feldman & Pentland, 2003; Howard-Grenville, 2005; Pentland & Feldman, 2008), specifically with regard to its recent efforts to (a) understand the role of artefacts in routine dynamics (D'Adderio 2008, 2009; Howard-Grenville, 2005) and (b) bridge micro and macro understandings of routines and new practices creation (Rerup & Feldman, 2011).

We extend understandings of technology-embedded rules and assumptions (D'Adderio, 2009) and researches on sociomaterial practices (Orlikowski, 2007) in considering the mechanisms of surveillance, examination and normalization as important mechanisms of the disciplinary power of technologies. Foucauldian approaches contradict both the ideas that managers will determine how a routine should work, and that actors have a large ability to create, alter and transform routines independently of prescribers, of the disciplinary effects of technologies, and of broader institutional forces. Technologies, be they scientific, managerial or financial (MacKenzie, 2003), cannot be divorced from broader institutional forces, which structure thought, discourses and practices into categories such as correct/incorrect or desirable/undesirable (Cooper & Burrell, 1988). The ostensive aspects of routines not only emerge from performance; they are also influenced by institutional dimensions such as the complex web of historical local institutions and systems of routines in which subroutines are involved, as demonstrated in the case study.

This richer framework of technology design, uses and embedded rational myths (Meyer & Rowan, 1977) also allows us to build on recent developments to micro/macro analysis of routine dynamics (Rerup & Feldman, 2011), in taking into account the role of what these authors call organizational schemata in shaping routines. We extend this literature by showing how espoused schemas are enacted through technologies which have both expected and unexpected outcomes regarding organizational schema. Our approach also clarifies the institutional and historical origin of these 'higher-level entities'. We argue that this approach can provide routine scholars with what Lounsbury and Crumley (2007, p. 1007) call a 'richer conceptualization of agency which accounts for how practitioners are constrained by wider theories and belief systems that not only supply meaning to activity, but also prescribe roles for actors that delimit the scope for performativity'.

Our proposal also highlights a useful direction for Foucauldian studies. Over the past decade, a research perspective has been opened on how disciplinary power is both creative and repressive. One of the avenues opened is the study of liberating practices as opposed to the constraints of discipline, by McKinlay and Starkey (1998a). Little has been done in that direction since these authors argued that 'in fully assessing Foucault's contribution to organization theory we need to devote more attention to … the ways in which Foucault examines liberating practices as opposed to the constraints of discipline' (McKinlay & Starkey, 1998b, p. 238). Choosing to analyse the micro-dynamics of practices through the routine framework allows us to follow up and further develop the proposal of Townley (1998) for an analysis of the 'how' of power, that is, the practices rather than the intents, thus allowing for 'a recognition of the negative and the positive in all practices and an evaluation of their effects' (Townley, 1998, p. 207).

By means of this combinative theoretical positioning, we were thus able to make valuable progress towards an improved characterization of institutional and micro-practice dynamics and the fundamental influence that technologies (as combinations of artefacts, managerial philosophy and organizational model) and agencies have on their co-evolution. Future research should integrate a richer framework of materiality and technology-embedded rules into the analysis of new practice creation.

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References

Aggeri, F., & Hatchuel, A. (2003). 'Socioeconomic orders' and the polarization of research in agriculture: For a critique of the relations between science and society. *Sociologie du travail*, *45*, 113–133.

Bardini, T. (1991). *Modèle technique et modernisation: Le cas du lait de brebis dans le Rayon de Roquefort, 1950–1985.* PhD thesis, Université Paris X.

Barillet, F. (1997). Genetics of milk production. In: L. Piper & A. Ruvinsky (Eds.), *The genetics of sheep* (pp. 539–564). Wallingford, UK: CAB International.

Barillet, F., & Flamant, J.-C. (1977). Principes de la sélection laitière, application à l'espèce ovine. *Pâtre*, special issue *246*, 21–31.

Barillet, F., Marie C., Jacquin M., Lagriffoul G., & Astruc, J.-M. (2001). The French Lacaune dairy sheep breed: use in France and abroad in the last 40 years. *Livestock Production Science*, *71*, 17–29.

Barley, S. R. (1986). Technology as an occasion for structuring: evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, *31*, 78–108.

Barley, S. R. (1990). Image of imaging: notes on doing longitudinal field work. *Organization Science*, *1*(3), special issue, 220–247.

Barley, S. R., & Tolbert, P. S. (1997). Institutionalization and structuration: studying the links between action and institution. *Organization Studies*, *18*, 93–117.

Barnard, C. I. (1938). *The functions of the executive*. Cambridge, MA: Harvard University Press.

Becker, M., Lazaric, N., Nelson, R. R., & Winter, S. G. (2005). Applying organizational routines in understanding organizational change. *Industrial and Corporate Change*, *14*, 775–791.

Callon, M., & Muniesa, F. (2005). Peripheral vision: economic markets as calculative collective devices. *Organization Studies*, *26*, 1229–1250.

Chapman, C. S., Cooper, D. J., & Miller, P. B. (2009). Linking accounting, organizations, and institutions. In: C. S. Chapman, D. J. Cooper & P. B. Miller (Eds.), *Accounting, organizations, and institutions* (pp. 1–29). Oxford: Oxford University Press.

Chesbrough, H., & Spohrer, J. (2006). A research manifesto for services science. *Communication of the ACM*, *49*(7), 35–39.

Chia, R., & Holt, R. (2006). Strategy as practical coping: a Heideggerian perspective. *Organization Studies*, *25*, 635–655.

Cohen, M. D. (2007). Reading Dewey: reflections on the study of routine. *Organization Studies, 28*, 773–786.

Cook, S. D., & Brown, J. S. (1999). Bridging epistemologies: the generative dance between organizational knowledge and organizational knowing. *Organization Science*, *10*, 381–400.

Cooper, Robert, & Burrell, Gibson (1988). Modernism, postmodernism and organizational analysis: an introduction. *Organization Studies*, 9, 91–112.

Czarniawska, B. (2009). Emerging institutions: pyramids or anthills? *Organization Studies*, *30*, 423–441.

D'Adderio, L. (2008). The performativity of routines: theorising the influence of artefacts and distributed agencies on routines dynamics. *Research Policy*, *37*, 769–789.

D'Adderio, L. (2009). The influence of artefacts and distributed agencies on routines' dynamics: from representation to performation. In: M. C. Becker & N. Lazaric (Eds.), *Organizational routines: Advancing empirical research* (pp. 185–222). Cheltenham, UK: Edward Elgar.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology used: adaptative structuration theory. *Organization Science*, *5*, 141–147.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy Management Review*, *14*, 532–550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: opportunities and challenges. *Academy of Management Journal*, *50*, 25–32.

Feldman, M. S. (2000). Organizational routines as a source of continuous change. *Organization Science*, *11*, 611–629.

Feldman, M. S. (2003). A performative perspective on stability and change in organizational routines. *Industrial and Corporate Change*, *12*, 727–752.

Feldman, M. S., & Orlikowski, W. J. (2011). Theorizing practice and practicing theory. *Organization Science*, *22,* 1240–1253.

Feldman, M. S., & Pentland, B. T. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly*, *48*, 94–118.

Flamant, J.-C. (2002). Histoire de races animales, histoires de sociétés humaines. *Les cahiers de la Mission d'Animation des Agrobiosciences*, *1*, 1–17.

Garud, R., & Rappa, M. A. (1994). A socio-cognitive model of technology evolution: the case of cochlear implants. *Organization Science*, *5*, 344–362.

Grasseni, C. (2009). *Developing skill, developing vision: Practices of locality at the foot of the Alps*. New York: Berghahn Books.

Hacking, I. (1983) *Representing and intervening: Introductory topics in the philosophy of natural science*. Cambridge: Cambridge University Press.

Hasselbladh, H., & Kallinikos, J. (2000). The project of rationalization: a critique and reappraisal of neo-institutionalism in organization studies. *Organization Studies*, *21*, 697–720.

Hatchuel, A., & Molet, H. (1986). Rational modelling in understanding and aiding human decision-making: about two cases studies. *European Journal of Operational Research*, *24*, 178–186.

Hatchuel, A., & Weil, B. (1995). *Experts in organizations: A knowledge-based perspective on organizational change*. Paris: De Gruyter.

Hatchuel, A., Pezet, E., & Starkey, K. (2005a). *Gouvernement, organisation et gestion, l'heritage de Michel Foucault*. Quebec: Les Presses de l'Universite de Laval.

Hatchuel, A., Pezet, E., Starkey, K., & Lenay, O. (2005b). Pour une epistemologie de l'action collective. In: A. Hatchuel, E. Pezet & K. Starkey, *Gouvernement, organisation et gestion : l'héritage de Michel Foucault* (pp. 1–18). Quebec, Les Presses de l'Université de Laval.

Hopwood, A. G. (1983). On trying to study accounting in contexts in which it operates. *Accounting, Organizations and Society*, *8*, 287–305.

Hopwood, A. G. (1987). The archeology of accounting systems. *Accounting, Organizations and Society*, *12*, 207–234.

Hopwood, A. G., & Miller, P. (1994). *Accounting as a social and institutional practice*. Cambridge: Cambridge University Press.

Howard-Grenville, J. A. (2005). The persistence of flexible organizational routines: the role of agency and organizational context. *Organization Science*, *16*, 618–636.

Jarzabkowski, P., & Seidl, D. (2008). The role of meetings in the social practice of strategy. *Organization Studies*, *29*, 1391–1426.

Joerges, B., & Czarniawska, B. (1998). The question of technology, or how organizations inscribe the world. *Organization Studies*, *19*, 363–385.

Kaghan, W. N., & Lounsbury M. (2006). Artifacts, articulation work and institutional residue. In: A. Rafaeli & M. G. Pratt, *Artifacts and organizations: Beyond mere symbolism* (pp. 259–275). London: Lawrence Erlbaum Associates.

Labatut, J., Girard, N., Astruc, J. M., Bibé, B., & Boisseau, E. (2008). From individual practices to cooperation modes in a collective breeding organization: the case of local breed management in Western Pyrenees. *European Symposium of the International Farming System Association*, Clermont Ferrand.

Lanzara, G. F., & Patriotta, G. (2007). The institutionalization of knowledge in an automotive factory: templates, inscriptions, and the problem of durability. *Organization Studies*, *28*, 635–660.

Leonardi, P. M., & Barley, S. R. (2008). Materiality and change: challenges to building better theory about technology and organizing. *Information and Organization*, *18*, 159–176.

Lounsbury, M. (2007). A tale of two cities: competing logics and practice variation in the professionalizing of mutual funds. *Academy of Management Journal*, *50*, 289–307.

Lounsbury, M. (2008). Institutional rationality and practice variation: new directions in the institutional analysis of practice. *Accounting, Organization and Society*, *33*, 349–361.

Lounsbury, M., & Crumley, E. T. (2007). New practice creation: an institutional perspective on innovation. *Organization Studies, 28*, 993–1012.

MacKenzie, D. (2003). An Equation and Its Worlds: Bricolage, Exemplars, Disunity and Performativity in Financial Economics. Social studies of science 33:6, 831–868

MacKenzie, D., & Millo, Y. (2003). Constructing a market, performing theory: the historical sociology of financial derivatives exchange. *American Journal of Sociology*, *109*, 107–145.

McKinlay, A., & Starkey, K. (Eds.) (1998a) *Foucault, management and organization theory: From panopticon to technologies of self*. London: Sage.

McKinlay, A., & Starkey, K. (1998b). Afterword: deconstructing organization – discipline and desire. In. A. McKinlay & K. Starkey (Eds.), *Foucault, management and organization theory: From panopticon to technologies of self* (pp. 230–241). London: Sage.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: formal structure as myth and ceremony. *American Journal of Sociology*, *83*, 340–363.

Miller, P., & O'Leary, T. (2007). Mediating instruments and making markets: capital budgeting, science and the economy. *Accounting, Organizations and Society*, *32*, 701–734.

Moisdon, J.-C. (1997). *Du mode d'existence des outils de gestion*. Paris: Seli Arslan.

Moisdon, J.-C. (2006). Sur la largeur des mailles du filet: savoirs incomplets et gouvernement des organisations. In : A. Hatchuel, E. Pezet, K. Starkey & O. Lenay (Eds.), *Gouvernement, organisation et gestion : l'héritage de Michel Foucault*. Laval: Les presses de l'université de Laval.

Nelson, R. R., & Nelson, K. (2002). Technology, institutions, and innovation systems. *Research Policy*, *31*, 265–272.

Nicolini, D. (2009). Zooming in and out: studying practices by switching theoretical lenses and trailing connections. *Organization Studies*, *30*, 1391–1418.

Nowotny, H., Scott, P., & Gibbons, M. (2001). *Re-thinking science: Knowledge and the public in an age of uncertainty*. Cambridge: Polity.

Orlikowski, W. J. (2007). Sociomaterial practices: exploring technology at work. *Organization Studies*, *28*, 1435–1448.

Orlikowski, W. J., & Barley, S. R. (2001). Technology and institutions: what can research on information technology and research on organizations learn from each other? *MIS Quarterly*, *25*, 145–165.

Pentland, B. T., & Feldman, M. (2005). Organizational routines as a unit of analysis. *Industrial and Corporate Change*, *14*, 793–815.

Pentland, B. T., & Feldman, M. (2007). Narrative networks: patterns of technology and organization. *Organization Science*, *18*, 781–795.

Pentland, B. T., & Feldman, M. (2008). Designing routines: on the folly of designing artifacts, while hoping for patterns of action. *Information and Organization*, *18*, 235–250.

Pentland, B. T., & Rueter, H. R. (1994). Organizational routines as grammars of action. *Administrative Science Quarterly*, *39*, 484–510.

Poly, J. (1959). Talk delivered at the Rural Economic Society, 15–16 December 1959.

Power, M. (1996). Making things auditable. *Accounting, Organizations and Society*, *21*, 289–315.

Rerup, C., & Feldman, M. S. (2011). Routines as a source of change in organizational schema: the role of trial-and-error learning. *Academy of Management Journal*, *54*, 577–610.

Salvato, C., & Rerup, C. (2011). Beyond collective entities: multilevel research on organizational routines and capabilities. *Journal of Management*, *37*, 468–490.

Schneiberg, M., & Lounsbury, M. (2008). Social movements and institutional analysis. In R. Greenwood, C. Oliver, K. Sahlin and R. Suddaby. The Sage Handbook of Organizational Institutionalism, Sage Publications Ltd, 650–672.

Schrepfer, S. R., & Scranton, P. (Eds.) (2003). *Industrializing organisms, introducing evolutionary history*. New York and London: Routledge.

Scott, R. W. (1987). The adolescence of institutional theory. *Administrative Science Quarterly*, *32*, 493–511.

Steyaert, P. (2006). The Maraîchine breed: a biological object mediating various forms of knowledge. *International Social Science Journal*, *58*/187, 87–96.

Townley, B. (1993). Foucault, power/knowledge, and its relevance for human resource management. *Academy of Management Review*, *18*, 518–545.

Townley, B. (1998). Beyond good and evil: depth and division in the management of human resources. In: A. McKinlay & K. Starkey (Eds.), *Foucault, management and organization theory: From Panopticon to technologies of self* (pp. 191–210). London: Sage.

Utterback, J. M. (1994). *Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change.* Harvard, MA: Harvard Business School Press.

Vissac, B. (2002). *Les vaches de la République*. Paris: INRA Editions.

Whittington, R. (2006). Completing the practice turn in strategy research. *Organization Studies*, *27*, 613–634.

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