

The influence of knowledge in the replication of routines

Markus C. Becker
Department of Marketing
University of Southern Denmark
DK-5230 Odense M
Denmark
Tel. +45-65503350
Fax +45-66155129
mab@sam.sdu.dk

and

Nathalie Lazaric
Latapses, CNRS IDEFI
250 rue Albert Einstein
06 600 Valbonne
Sophia Antipolis, France
Tel + 33- 4 93 95 43 88
Fax + 33-93 65 37 98
Lazaric@idefi.cnrs.fr

The influence of knowledge in the replication of routines

Markus C. Becker and Nathalie Lazaric

Abstract

From a resource-based perspective, one of the most important levers of firm strategy are resources that are difficult to imitate. A crucial challenge for managers then is to replicate these resources within the firm, while at the same time protecting them from imitation by competitors. Organizational routines are often named as candidates for such resources. A good understanding of the replication of organizational routines is therefore of great strategic interest. This article focuses on one aspect that seems to play an important role in the replication of routines: knowledge. The objective of the article is to identify knowledge-related aspects that have an influence in the replication of routines. In this and by defining routines in their social and cognitive dimensions, it contributes to a better understanding of their duplication process.

Key words: Organizational routines, replication, knowledge, tacit knowledge, codification, resource-based view

Supprimé : ¶

Résumé :

Dans les travaux d'inspiration Penrosienne, le problème fondamental réside dans la capacité à générer des ressources spécifiques. Un des défis pour la stratégie réside, en effet, à créer et à répliquer de telles ressources au sein de la firme, tout en la protégeant de ses concurrents. Les routines jouent souvent ce rôle. On peut donc comprendre pourquoi leur copie est cruciale. Cet article tente de souligner une variable essentielle dans le problème de la réplication des routines : la connaissance. L'objectif est d'observer différentes dimensions de la connaissance et son impact sur le transfert des routines. En partant d'une définition des routines sous leur double dimension -cognitive et politique-, et en soulignant les limites des processus de codification, nous tenterons d'offrir un cadre analytique suffisamment riche pour observer les problèmes de duplication.

Mots clés : routines organisationnelles, réplication, connaissance, connaissances tacites, codification, ressources.

Introduction

From a resource-based perspective, one of the most important levers of firm strategy are resources that are difficult to imitate (Barney 1991; Peteraf 1993). A crucial challenge for managers then is to replicate these resources within the firm, while at the same time protecting them from imitation by competitors (Winter and Szulanski 2001; Szulanski and Winter 2002).

Organizational routines¹ are often named as candidates for such resources (Grant 1996). In the business literature, the notion of an 'organizational routine'² denotes repetitive, stable activity. Many social activities in the realm of the economy, such as production and exchange, are carried out in much the same way every time. What makes these activities stable and persistent is the fact that when routines are repeated, there is not much variation from one repetition to the next. What are the sources of variation between one manifestation of a routine and the next repetition? The answer to this question holds the key to understanding organizational and economic change and stability. By analyzing how organizational routines change, we can open the 'black box' of the firm and trace the processes taking place within the organization structure as they unfold over time³. Our perspective will be that of routines being replicated from one time period to the next. In such a perspective, to understand how the replication process works, and how variation arises in the replication process (making the copy different from the template) is crucial for understanding organizational change. It also helps understand such concrete issues as the transfer of successful business practices, for instance of manufacturing processes from the 'mother plant' to a newly founded plant.

Understanding how the replication and imitation⁴ of routines work therefore is an important strategic question, due to the role of sources of inimitability for the resource-based view of the

¹ On organizational routines see Nelson and Winter 1982; Winter 1990; Hodgson 1992; Langlois 1992; Nelson 1994; Cohen and Bacdayan 1994; Cohen *et al* 1996; Pentland and Rueter 1994; Pentland *et al* 1996; Egidio and Narduzzo 1997; Coombs and Metcalfe 1998; Amit and Belcourt 1999; Knott and McKelvey 1999; Costello 2000; Karim and Mitchell 2000; Betsch *et al.* 2001. On the history of the concept see Becker (2003 forthcoming).

² Routines are social, not individual, phenomena. They involve multiple actors. Repetitive activity of an individual actor is a habit (Hodgson 1993b). There has been confusion about the individual or social character of routines. Since the recent article by Dosi, Nelson and Winter (2000), however, such confusion should not persist any more. Throughout this article, we mean organizational routines when we speak of 'routines'.

³ As has been noted, the relationship of structure and activity is a recursive one (Giddens 1984, Archer 1995). See also Feldman (2000) and the passages later in the paper.

⁴ In line with the use of these terms by other authors (Winter and Szulanski, 2001), 'replication' is used where the replication effort is made inside the firm, and 'imitation', if the imitator is another firm.

firm (Barney 1991; Peteraf 1993). In their recent overview of 'Research Directions for Knowledge Management', Nonaka and Teece (2001) have also identified imitation and replication as one of the key research topics.

A body of recent research has focused on the replication of routines (Nelson and Winter 1982; Winter 1990; Winter and Szulanski 2001; Szulanski and Winter 2002; see also Rivkin 2001). One of the principal findings is the strategic importance of what Winter and Szulanski (2001) call "an 'Arrow core' – an abstract, quasi-informational source of economic merit that can be replicated by embodiment in new resources at new locations". They argue that the 'Arrow core' has the characteristic, like information, to be non-rivalrous in use while the template routine itself is rivalrous in use. Access to the template routine therefore is what distinguishes replicability (by the firm itself) from imitability (by other firms) – a question of great importance from a strategic point of view, namely of protecting the sources of sustained competitive advantage. Focusing on the knowledge-related aspects of replication therefore helps recognize public-good characteristics of routines replication. A main challenge for managers is to enhance the public-goods character of the productive knowledge contained in organizational routines *inside* the firm, while blocking it from extending to the whole industry (Winter and Szulanski 2001).

This finding shows how taking knowledge-related aspects of routines into explicit consideration improves our understanding of the replication of routines. Yet, although both the replication of routines and the role of knowledge in business have received attention, the role of knowledge in the replication of routines – and its impact on the replication outcome – is not yet fully understood. The paper therefore builds on Winter and Szulanski's (2000; 2001) argument. While Winter and Szulanski (2001) have focused on aspects such as the public-good character of information, the remainder of this article has the objective to identify other knowledge-related aspects that make a difference for the outcome of the replication of routines. This article therefore focuses on *the role of knowledge in the replication of organizational routines*.

The article draws from two different literatures in order to cast light on the role of knowledge in the replication of organizational routines. On the one hand, it reports a framework for conceptualizing replication processes, building on such frameworks in the philosophy of

science⁵. As other authors have shown (Knudsen 2001; Knudsen 2002a; Knudsen 2000b), these frameworks provide a consistent conceptualization of the replication process. On the other hand, the article draws on the conceptual and empirical literature in the field of management and strategy, which has been concerned with the overlap between studying knowledge and studying processes of replication or (more widely understood) transfer of such knowledge.

In the first part, we define routines with their social and cognitive dimensions in order to consider the problem of replication with these two constituents parts. In the second part, we focus on the conceptualisation of the replication process. In the third part, we will explore extensively the role of knowledge for the replication of routines, insisting on differences and links between replication and codification. In the fourth part, we describe the forms and dimensions of replication, insisting on technical and human aspects. Finally, a general discussion and conclusions follow.

(1) The implication of the definition of routines on the replication process

We will start by defining routines in both their political and cognitive dimension, in order to identify the implication of this conceptualization on the replication debate.

(1.1) Routines as reservoirs of knowledge

The first step in gaining a better understanding of the replication process is a clear definition of routines. If there are ambiguities in our understanding of what a routine is, our understanding of the replication of routines will be muddled. Routines are present at two levels (in their potentiality and in their expression) because at the same time, they are reservoirs of knowledge encapsulated in organizations, and a concrete representation of this knowledge: the repertoire of knowledge activated and performed daily (Lazaric 1999, Lazaric and Mangolte 1999, Lazaric 2000). Understanding replication also requires an understanding of the visible or invisible part of the knowledge as different ontological levels are present in the routine concept (rules in their abstract form and some recurrent part of action). The problem of change in micro constituents is therefore immediately connected to change at the

⁵ The frameworks are thus not dependent on any simple analogy to biology.

macro levels (Feldman & Rafaeli, 2002). For example, in an institutional perspective, routines and habits have to be maintained in order to establish patterns of life associated with ways of thinking.

As Nelson (1995) has reminded us, routines sometimes remain stable because of implicit contracts embedded at their establishment, producing a kind of truce among organizational members. It is true that change in the expression of routines may imply a move in social position, leading people to take a new look at their role inside the hierarchical structure. This change is sometimes avoided by a transformation of hierarchical order or by the explicit refusal to follow the new rules of the game. For example, in our study of the implementation of a new ISO 9002 norm, the rules of the game were interpreted in different ways by the various actors. Furthermore, the new routines to be implemented were working not all smoothly partly due to the new effort convention to be found inside the firm, but also due to willingness of some actors to refuse the settlement of new social coalition, notably for maintenance technicians who saw their discretionary power tend to diminish and tried to slow down the process in this way (Lazaric and Denis, 2001 b).

(1.2) Routines as reservoirs of creativity

Actors are not automats even if they need to acquire automatisms to gain efficiency. This implies that even if they do a job in a certain way, human creativity exists and hierarchical power has some limits to impose routines at higher or lower levels if they are not explained and justified (Leibenstein 1986). This leads actors to follow the rules but to interpret them in such a way as to exercise their discretionary power for doing their job. That is to say, up to which point people are really intended to change the routines and until which point they deviate from the template is a question that remains quite open because of the difficulty to observe this process. As Nelson and Winter have written, “a routine may involve extensive direct interactions with the organization’s environment and the making of numerous choices that are contingent both upon the state of the environment and the state of the organization itself, but these choices involve no process of deliberation by the top management. The intervention of top managers in the detailed functioning of lower levels is ordinarily symptomatic of an attempt to modify routine or difficulties in the functioning of existing routines - just as conscious awareness of detail and attempts of articulation are symptomatic of new learning or trouble in the case of individuals” (Nelson and Winter 1982, p. 125).

Action, thus, is not entirely determined by external circumstances (Hodgson 1988). Actors do have an influence on their actions. They can be creative, and one of the major reasons for creativity is social links embedded in routines. In this way, routines change because they are also emergent accomplishments and “work in progress rather than finished products” (Feldman 2000, p. 613). “Routines are performed by people who think and feel and care. Their reactions are situated in institutional, organizational and personal contexts. Their actions are motivated by will and intention. They create, resist, engage in conflict, acquiesce to domination. All these forces influence the enactment of organizational routines and create in them a tremendous potential for change” (Feldman 2000, p.614). The nature of this change is linked to the intrinsic and personal visions of their members inside organizations and the instability of individual and organizational goals enacting a process of transformation which has to be negotiated at individual and collective levels. New employees may introduce some change in the way of doing things as Nelson and Winter (1982, p. 116) remind us. This is due to the explicit or implicit willingness to perfectionise routines in operation, which is introducing some variation. This error-prone process, not always conscious, is due to a learning process which is based on experience that in a world of bounded rationality is neither perfect nor without ambiguity (Levinthal and March 1993)⁶. This implies that even if individuals inside organizations are engaged in a process of replication of existing routines, nothing proves that they will succeed in copying the routine precisely.

(1.3) Implication for the replication debate

All the characteristics of routines described above lead to two types of considerations for observing the replication of routines. First, if routines are “non-finished products and work in progress”, this clearly means that replication in the sense of ‘making a perfect copy’ are difficult and incomplete, and that the codification of some parts of knowledge is subject to diverse sources of imperfections due to the difficulty of extracting and capturing tacit knowledge. As Foray and Steinmueller recognize, “[i]f routines and the jobs performing were stable, the underlying sources of difficulty in making knowledge sufficiently explicit to improve the technologies of inscription would only be a matter of scholastic debate” (Foray and Steinmueller 2001, p. 16). This means that the problem of instability of routines leads to serious problems notably for their codification as we will explain later.

⁶ Levinthal and March (1993) reported that learning processes are difficult due to factors such as bounded

Second, an important point in the definition of routines is that routines could be present at two levels. The first one is the concrete level: the routines in operation. In this case, the replication of routines can be conceived as a web of coordinating relationships connecting specific resources. This means that without these interlinked resources (material and immaterial) routines in operation could be difficult to replicate (Winter 1995, Winter and Szulanski, 2001). Routines could also be present at a more abstract level, involving more difficulty in the replication process because the same routine may be in operation at different locations, with a diverse state of resources surrounding it in each location (Winter and Szulanski, 2001).

(2) The replication of routines

We will define the notion of replication by joining diverse pieces of the literature coming from philosophical and biological debates. After having defined replication in the social sciences, we will see why the content and the levels of replication may differ.

(2.1) Conceptualizing replication

What happens when a routine is replicated? A fine-grained framework of replication will be helpful for understanding the effect that different knowledge-related characteristics have on the success of routines replication (for instance, how precise the copy will be, or whether the new routine will work as smoothly as the original one).

A fine-grained framework of replication can be borrowed from the philosophy of science. It is known as the 'replicator-interactor model' (Hull 1980; 1981; Dawkins 1982a; 1982b; Knudsen 2001; Knudsen 2002b; Hodgson & Knudsen 2003). This framework distinguishes two elements of the replication process, 'replicators' and 'interactors'. A *replicator* is an 'entity which passes its structure directly in replication' (Hull 1981, 41). Its characteristics are longevity (potential immortality through copies even if the individual copy has a short life), fecundity (a high number of copies), and fidelity (accurate production of copies). An *interactor* is an entity that interacts as a cohesive whole with its environment in such a way that this interaction causes replication to be differential. Two different entities are thus

rationality, simplification /specialization of experiences, temporal, spatial and failure myopia.

involved in the replication process, and they play different roles. The *relationship* between interactors and replicators is that replicators are carried by those interactors that were selected. In other words, interactors are constituted by replicators. The replicator-interactor model enables us to trace the steps of evolution closely and with a minimum of unexplained exogenous interference (Knudsen 2002b). The first step involves a (direct) *replication* of structure, and the second the (direct) *interaction* of the entity of interest with the environment in a way that results in differential replication (Knudsen 2002b). These two different steps are distinct, and involve different entities, replicators and interactors.

In his work, Aunger has added a set of criteria that specify the replication process more precisely (Aunger 2002; see also Hodgson 2003):

Causation: the original replicator should be causally involved in the production of the copy excluding by this fact unintended copies depicted by Winter (1995).

Similarity: the copy should be similar to its source.

Information transfer: the process of copies involves a process of producing and transferring information from the source.

Duplication: the process of replication creates one or several new entities.

The conditions of replication described in Aunger (2002) yield a very precise definition of replication. Of course, it has to be adapted to the realm of the economy. One particularity of replication in the economy is that perfect replication (a close copy) is up against some limits arising from knowledge-related aspects (for instance, replication of knowledge is more complicated than replication of information). Also, there are problems due to intentionality as we could also envisage some unintended process of replication.

(2.2) Conceptualizing replication in the economy

So far, we have very briefly introduced a rather abstract conceptual framework of the replication process. How does it map onto the field of the economy? Concretely speaking, what are the replicators, and what are the interactors?

Different entities have been proposed as *replicators* in economic evolution: while routines have been the most influential candidates (Nelson and Winter 1982), they are not the only

candidates. Other proposals have been the *set* of routines and practices, formal and informal, codified and tacit, which defines the operation of the business unit (Metcalf 1998), or tacit and relatively durable knowledge components (Knudsen 2002a). Various entities have also been proposed as *interactors*. For Nelson and Winter (1982), firms are the interactors. For Metcalfe (1998), the interactor is the business unit associated with the particular activity. Knudsen (2002b) suggests that the interactors are social identities, i.e., a conception of self that enable social action.

Consensus on what are to be considered the equivalents to replicators and interactors in the realm of the economy has been emerging only recently, after debates and shifting positions (mainly due, it appears, to the fact that articles that deal with the issue are mostly pioneering efforts that touch upon a whole bundle of complex questions at the same time)⁷.

Supported amongst others by new research into the nature of economic selection, Hodgson and Knudsen (2003) have forcefully argued that to identify routines as replicators and firms as interactors is consistent both with the requirements of models of evolution, and with the subject matter (economic life as we know it).

(2.3) Sources of differential replication

In this article, our interest lies in understanding the influence of knowledge in the replication of routines. On the basis of the concept of replication described above, we can thus frame the question in a more specific way: How does differential replication in the replication process come about? An answer to this question will identify the ways in which knowledge can have an impact on the replication outcome. This will aid our task of identifying which characteristics of knowledge have an impact on the outcome of the replication process.

From a conceptual point of view, there are two types of sources of variation in a population of routines over time. First, there can be sources of variation impacting on the replication process, leading to variation arising in the replication process (and thus a copy that is not 'close' to the original). Second, variation in the population can arise because some of the interactors that hold the replicators are selected out, and thus the replicators they carried also disappear. In our case, firms, which can be interpreted as bundles of organizational routines,

⁷ Cf. Alchian (1950), Winter (1971), Winter (1975), Nelson & Winter (1982), Winter (1995).

are selected out by competition on markets (see Hodgson & Knudsen, 2003, for a detailed account; see also Knudsen 2003).

As regards differential *replication*, we can distinguish two types of variation: recombination or mutation. In *recombination*, the elements of the replicators themselves remain unchanged, but are arranged in new ways. *Mutation*, on the other hand, involves a change in the components of the replicator themselves. Do these abstract notions also make sense in the realm of the economy? Indeed they do. Schumpeter's definition of innovation as 'introduction of new combinations' (Schumpeter 1934) fits the abstract concept of recombination. Clearly the introduction of new combinations is common in the economy. Further corroboration is to be found in the literature on new product development. In a seminal article, Henderson and Clark (1990) introduce a distinction of architectural and component knowledge, pointing out that technological change can have an impact either on the components themselves ('mutation'), or on the way in which they are arranged ('recombination'). From empirical research on routines, we further know that another important distinction pertaining to the replication of routines is between replication by the firm itself and by outsiders. The difference is that in the first case, the imitator has access to the template, in this way generating an intended process of replication, while in the second it does not.

In the *process of the interaction* of interactors with the environment, variation (for instance different ways of forming a piece of steel into a screw) *is being limited* by ejection⁸ of interactors (and thereby the replicators carried by these interactors). Such ejection takes place through selection mechanisms. Different selection mechanisms can be at work. In the case of the economy, there are market selection (competition), and managerial selection (internal to firms) (Knudsen, 2002b). For instance, the technique by which steel is formed into screws can be selected through a tender offer, i.e. by abiding to administrative rules, through allocating the decision rights to an experienced engineer (with his knowledge of steel), or through a manager who holds the decision rights, but follows some criterion that is connected neither to steel nor to screws.

The replicator-interactor model thus allows us to distinguish two *occasions* in which variation in a population can be influenced: the (i) *replication* process (the 'copying', or transmission) of the replicators, i.e. routines and (ii) the *interaction* of the interactors with the environment,

⁸ We take the notion of selection as 'ejection' from Thorbjørn Knudsen (2002b).

i.e. of firms on markets. Note that because it is firms that are the ‘carriers’ of routines (Hodgson and Knudsen 2003), the second process has an effect on variation of a particular *routine in the population*, due to the fact that some firms (and with them their organizational routines) are selected *out* of the population, while others enter the population. For tracking the variation-reducing mechanism, it is therefore important to apply a population-perspective (regarding populations of routines), and to analyze the selection *of* firms, which are considered as bundles of routines, and which are eliminated from markets by competition, their routines thus disappearing with them⁹.

(3) The role of codification in the replication process

We will now focus our attention on the role of knowledge in productive activity for seeing why replication goes beyond the aggregation of commodity. Once this statement clear enough, we will define replication and codification as two complementary parts necessary for duplicating routines. Some problems are enlightened the ‘causal ambiguity’ and the modes of conversion of knowledge during codification process.

(3.1) The knowledge dimension of productivity activity and its consequences for routines replication

One could have the impression that in the entrepreneurial drive to diffuse good practices and to copy well-working “industry recipes” (Spender, 1989), routines could be replicated easily. However, this is not the case even where the entrepreneur tries to codify the recipes in order to achieve that goal. The problem of the “non additivity principle” matters, because the inputs cannot be reproduced in a perfect manner. Winter (1982) shows that one problem with the neoclassical framework resided in the fact that neoclassical authors could define *ex ante* inputs in very general and abstract ways but define the nature of the outputs very precisely. The question, of course, is how diverse inputs are used in a different way, for example in another spatial or temporal dimension. What is very important in this context is that the result could be very different. For Winter, the problem resides not in the perfect additivity of input (and the creation of new quantitative inputs as the neoclassical framework tries to introduce

⁹ On the competitive process from a Nelson and Winter perspective see Metcalfe and Gibbons (1986). These authors combine the Schumpeterian debate and Austrian insights in a model of technological variety’s selection. For diverse models focused on Fisher’s replicator, see also Metcalfe (1993). For a more general issue about

by putting for example the social capital or the 'elementary regions' in order to take into account the spatial dimension or the human dimension), but in the conceptual definition of production. According to Winter, production should not be envisaged as a potential additivity and proportionality of inputs but a qualitative process building productive capability, something difficult to produce and difficult to replicate¹⁰.

This principle is due to the fact that knowledge is not information and requires specific attention for its replication. This means that while information can be transferred easily without damaging its content, knowledge is dependent on its carriers (notably, human carriers). This implies that routines exist with two constituents: an *inert form* (some procedures which have been codified or partly articulated) and, on the other hand, an '*alive*' or *activated form of knowledge* for making sense of the codified one. As the two parts are mutually inter-dependent, this means that the degree of stability and persistence could be partly correlated to the degree of codification embedded in knowledge even if there is a permanent co-evolution of tacit and articulated knowledge.

Tacit elements may be difficult or even impossible to articulate (Winter 1987). Cognitive and economic arguments are present as articulation and codification are very costly and may be some time confronted to a risk of losing sense introduced by problems of transmissions and more specifically differences of languages (as each language has its own way to represent knowledge - oral vs. articulated). This may involve some technical difficulties in capturing and transferring knowledge with a risk of losing some crucial tacit elements that are needed to make sense of the codified knowledge (Lazarcic, Mangolte and Massue 2003; Zollo and Winter 2002). Because articulation is one way to communicate a template (e.g., having a description of an activity sequence), when such a description cannot be made, replication of the template is more difficult. Higher variation is therefore likely, as the person involved in the replication act has to infer what is unarticulable. In doing so, errors or misunderstanding

competitive market, see Metcalfe (1998).

¹⁰ For Winter, the neoclassical vision of productive introduced by Wicksteed has some limits. He shares consequently Hahn's statement that "the common sense proposition that duplication of a given industrial process (together incidentally with a duplication of entrepreneurs or entrepreneurial function) will lead to a doubling of the output is unassailable" (Hahn, 1949 in Winter 1982). Winter is also quite sceptical about the standard vision of defining commodity a "good or service completely specified physically, temporally and spatially" (Debreu p. 32.) and to introduce by this way time divided in 'elementary intervals' and space into 'elementary regions' that are "chosen small enough for all the points of one of them to be indistinguishable from the point of view of the analysis" (Debreu p.24). This device allows some abstraction and generality for treating space and time on the same footing as all other commodities. Nevertheless in the spirit of the productive knowledge, the physical characteristics of commodities, and their conditions of production are not the same as well as the distinction of time and space.

can happen.

(3.2) Replication and codification: two constituent parts?

At this stage we could ask ourselves what are the differences between codification and replication. Indeed it seems that some similarities are present between Aunger's proposal which focuses on the replication of information, and the process of codification depicted notably by Cowan and Foray (1997). In fact, the codification process is certainly more complex than it first looks. There are three reasons for this:

Cowan and Foray (1997) see the process of codification as including three aspects: model building, language creation and writing the message. They are of the opinion that technological change can create some dynamic in the process of codification by decreasing the costs of this process. Nevertheless, for them and some others (Cowan, Foray and David, 2000), the problem of codification resides in the model creation and notably the capacity to articulate knowledge in order to codify it, as well as the development of language for building a shared and generic language to go beyond local jargons. Needless to say, investments in this process are very high because the diffusion of codified language depends on the capacity of implementing investments for building a community able to read the codes (Arrow, 1974).

This process is distinct from the process described by Aunger's criteria because it does not rely on a copy of information but more extensively on the development of models and languages. By this way, we could consider that codification is part of the replication process because it participates in the process of the articulation of knowledge and its articulation through the investment in shared language. Perhaps a small but important difference resides in the way of conceiving this process. For David, Cowan and Foray (2000) the problem is related to a problem of incentives and costs. These authors are also quite sceptical about that interest of tacit knowledge, seeing it as a brake for this process. On the contrary, for Winter (1987) and others authors (Johnson, Lorenz and Lundvall, 2002), tacit knowledge and codified knowledge are not opposite but complementary because these two kinds of knowledge are the intrinsic parts of the codification process. Codified knowledge has little added value without human intelligence and human judgment for making sense of codes and

for activate them in an innovative way. This problem has been examined in many case studies of the introduction of expert systems. In this case, tacit knowledge still remains and is still important for maintaining and for updating diverse forms of knowledge, notably codified ones (Lazaric, Mangolte and Massue, 2003).

The concrete implication for our argument here is that codification and replication are interlinked and are two constituents of the same process even if the different authors do not see it in the same way. For some authors, tacit knowledge is an obstacle to replication and tacit knowledge has to be domesticated (Foray and Steinmuller, 2001), whereas for us and other authors, tacit knowledge is not seen in a pejorative way and is considered as two complementary forms of knowledge expressed in different ways. According to us, codes are typically incomplete and the codification in itself does not guarantee the replication because this relies on the relation between the recipient and the receptor. This leads to a difficult process of knowledge extraction from individuals and from groups during the explicitation of tacit knowledge (Nonaka 1995) and some difficulty in the codification due to diverse modes of knowledge conversion with some potential mismatch between the emitter and the receptor (Ancori *et al* 2000).

This means that replication is based on investment in building codes, and at the same time on the absorption of knowledge in order to make sense of and to adapt the codes to another context. Winter and Szulanski summarize this point:

“[I]leveraging knowledge by replication of routines necessarily involves an investment in communication infrastructure, at least in the form of training in the organization’s specialized language. Adequate command of the language requires, however substantial knowledge of organizational context: the link of information to action typically depends on the knowledge based interpretative powers of human beings. Hence the organizational use of symbolic information depends on the stocks of knowledge held by participants; much of this is tacit and/or context dependent and it reflects the accumulation of local experiences. Under these circumstances, the creation of requisite knowledge stocks a new outlet can be accomplished only through a variety of costly processes that are substantially less straightforward than a standard notion of transmission of information would suggest. It often includes processes that both require support from a template site and involve a significant component of new organizational learning at the new outlet” (Winter and Szulanski, 2001, p. 24).

For these authors, the problem is not to deny the impact of codification which is as important as the encoding/decoding processes for providing suitable information. Nevertheless, if replication could produce some valuable template and an abstract quasi-informational source

of economic merit, called the “Arrow core“, this does not deny the strategic role of knowledge and causal ambiguity in learning and knowledge transfer.

(3.3) Causal ambiguity

In the information paradigm, the main idea is to show that information is cheap to reproduce. This belief is based on three points: 1) The “non rivalrous” character of information , i.e. the fact that reproduction does not decrease the information content of the source, 2) the absence of ambiguity about information content of the original which is reproduced, and 3) the relatively low cost of the reproduction process.

The examples of replicating routines show precisely which problems are involved in the process when there is ‘causal ambiguity’. This condition arises because of knowledge tacitness but also because of difficulties in replicating important technological systems where systemic relations between elements are important: “in complex highly interdependent human and technological systems, the causes of success and failure are difficult to assign ...and the establishment of cause effect relationships can be very difficult and the concomitant assessment of performance may be highly ambiguous. In short, causal ambiguity ensues from complexity and potential imitation by rivals through observation is limited“ (Reed and Defillippi, 1990, p. 92).

Causal ambiguity (which can be connected to uncertainty or complexity) makes it difficult to attribute properties to (elements of) templates. Deliberate replication attempts might therefore be frustrated, as it is not clear what precisely has to be copied, or what about a template is the crucial part that has to be copied exactly (Lippman and Rumelt 1982; Reed and Defillippi 1990). This shows that others elements (technological complexity or relational assets like notably the relations between firm and customers) than just knowledge tacitness present difficulties in the replication of routines.

(3.4) Knowledge absorption and knowledge receptivity

Knowledge replication also relies on the receptor’s ability to absorb and to integrate new knowledge. This is because knowledge has different properties from information. Some prior knowledge and some absorptive capacity has to be developed for assuring knowledge

receptivity (Cohen and Levinthal 1990). Knowledge is not absorbed by individuals, but structured by them because each piece of knowledge should be integrated in individual cognitive frameworks. This leads to some structuration of knowledge and some coherence and inertia inside memory, notably when some cognitive automatisms are implemented and used (Loasby 1999).

This problem has also to do with the structure of memory at the individual and organization level (Cohen and Bacdayan 1994). It has been argued that before knowledge can be transformed in a procedure and in automatisms, it has to be exercised. This explains the reasons why when automatisms have been engaged, some levels of organizational inertia may prevail as members of the organization prefer not to learn new automatisms and not to unlearn old ones in order to change existing routines. Furthermore, as Gersick and Hackman (1990) have reminded us, sometimes cognitive automatisms are so deeply embedded in organizational members that they are difficult to forget even if environmental conditions require some change. For example, the Air Florida Accident in 1982 was mainly due to the basic application of habitual routine in the cockpit despite a drastic environmental change introduced by snowfall. The crew was unable to modify the habitual task in order to adapt it to a new situation. This inertia was partly due to the lack of activation of the anti-ice procedure in order to deal with snowfall. This tends to show that sometimes, habitual routines activated in a certain way are difficult to de-activate because they are crystallized in procedural memory which by repetition gives some feeling of security and stability, thus impeding transformation required by the environment. In this way, empirical studies show the difficulty of maintaining constituent elements in the same way and inertia coming from prior knowledge.

4. Forms and dimension of replication

The complexity and difficulty in routines replication depend also on the nature of the replication, its scope, its superficial or profound nature as well as its spatial or temporal dimensions.

(4.1) Replication of mental instead of physical structure

One reason for the lack of clarity in our understanding of replication might be that different levels are being confounded. For example, we could investigate the activation of routines and their concrete form which would lead to an investigation of behaviour, namely recurrent interaction patterns persistent in organizations. We could also investigate routines in an abstract form (rules of behaviour). Clearly, these two levels of analysis need to be distinguished, also because the level of analysis leads to the choice of empirical method. This could be the formal rules behind routines or interactions around routines, a point that is directly correlated to the philosophical perspective on knowledge and the reality we want to observe, notably the way we define cognition (see Lazaric 2000, Lorenz 2002).

A long-standing argument in the literature on routines has been whether routines are representations (for instance, rules, procedures, heuristics), or behaviours that express such mental or articulated representations. As Knudsen has argued (Knudsen 2002b), if routines are to be replicators, they have to be representations. They have to be some kind of information-set. So much we know from the abstract framework. In the case of routines, where is the information-set represented?

There are two possible levels of representation: external and internal (mental) representation. Only on the level of external representation, are replicators bound in physical structures – on the mental levels the memorised 'contents' obviously are not represented by the physical structure of the brain in the same way that DNA is. In this sense, the level of internal (mental) representation is very much *unlike* the biological realm. In the case of internally represented rules, the template is a mental instead of a physical structure. The articulation of mental structures, however, is subject to limits to articulation (or rather, the precision of such an articulation is subject to limits). This is due to the fact that knowledge has to be communicated to others to be articulated, and that human beings may lack the willingness to do so (in order to protect the template), or may do it quite imperfectly because the articulation is subject to personal re-interpretation. If there are no correction mechanisms, error might be incorporated in what is passed on. The notion of replication *as in the philosophy of science* appears to apply to the level of external representation (a physical replication of physical structure is possible for example by way of photocopying). Rules that are represented internally (mentally), however, are substantially different in that they do not have a physical structure that could be replicated. *Different* replication mechanisms are therefore required. Replication in the realm of the economy has to *also* refer to some kind of replication of

mental, rather than physical structure. At least for (exclusively) mentally represented rules (i.e., necessarily tacit, unarticulable ones), the 'philosophy-of-science-inspired' replication concept seems inadequate in the realm of the economy. Note also another implication of mental structures as replication units: being cognitive, they depend on perception. Perception, however, is bound to change when social circumstances change, but also when cognitive biases and other mechanisms make themselves felt (Schechner 1985).¹¹

(4.2) Spatial dimensions of replication

According to Nelson and Winter (1982), problems with conceptualizing replication stem from the definition of routines as both the genes and the organizational memory of firms. In fact, by defining routines as organizational memory, Nelson and Winter have attempted to introduce the knowledge problem – an explicit critique of neoclassical production and the “non-additivity principle” (Winter, 1982). Clearly, it has been shown that the problem was not to deal with a perfectly defined input that could be transferred in another production set - such as information - but rather a qualitative transformation of these inputs along space and time. One of the main problems is to deal with knowledge in diverse forms (codified or tacit) and to see why the same inputs, after transformation, could generate important mutation. A major cause is different organization structures, formal and informal, and the knowledge embedded within firms, which makes production quite distinct from one firm to another one (Nelson and Winter 1982, Dosi, Nelson and Winter 2001). For example, when attempting replication of routines, “replicability” will be imperfect mainly due to: local specificities (each site has some peculiarities), obstacles to perfect replication due to cognitive and motivational aspect of the routine, and interactions of the routines with the site involved (some sub-constituents may be difficult to reproduce, notably “particular raw material sources, environmental contaminants, labour pool or customer population”, Winter 1995, p. 162).

As Winter (1995) has reminded us, a change of micro components may alter the nature of replication. In a case study conducted by one of the authors (Lorenz and Lazaric, 2000), we observed this process with the creation of Japanese transplants trying to replicate their

¹¹ In the same vein, Goody introduces some fundamental distinction between a “first degree of codification” involving the facsimile reproduction of oral and visual images requiring not a real complex representation of knowledge and a “second degree of codification” requiring a model to express this knowledge (Goody in Foray and Steinmueller 2001). In the second degree of codification the replication is also internal and this implies the creation of cognitive structures of generating and absorbing this new form of codification going beyond physical replication.

organizational practice in Europe (UK and France). The major problem of this replication was not the content of the organizational practice which could be reproduced more or less conform to the template (with a high degree of socialization in Japan to give some sense and value to organizational practices oriented to quality change), but rather the labour force which differ radically regarding their institutions. For example, implicit contract incentives systems were totally different and so was the motivation of the individuals to activate the organizational practice in question (Fabry and Lazaric, 2000). Notably, the long-term term engagement of Japanese employees is perceived quite differently in French and British contexts because industrial relations are different and because implicit contracts concerning hiring and promotion are institutionalised in a different manner giving a different meaning of personal engagement, individual performance, and organizational efficiency. This means that the expression of routines is very different from the original because human creativity has different ways of integrating some organizational routines and these are always embedded in social contexts and institutions giving opportunities for change when they are transferred out of their original context. As a matter of fact, the replication of organizational practices was recombined according to the nature of the labour force, but also according to the characteristics of the size of the local firm (which in France or in UK was smaller than in the case of the template). All these small mutations introduced some new learning paths and new routines were activated, with important differences in terms of efficiency and practices.

As the main carriers of knowledge are human, there is always a personal interpretation when knowledge is transferred (Nonaka and Takeuchi, 1995). This provides some alteration of the old routines and some mutation of its constituents. Even if the efforts dedicated to codification are high in order to achieve great replication potentiality, the transfer of routines always has to deal with some element of personal appropriation and collective acceptance which shows the limits of the transfer from an initial routine (Lorenz and Lazaric, 2001). As Winter has pointed out, due to the political aspects of routines “such a replication effort involves not merely the establishment of the appropriate physical setting, but also the replication of a hierarchical structure of organizational routines” (Winter, 1995, p. 157).

Interpretation may also arise from a lack of understanding. This is notably due to newcomers that try to espouse routines activated with a more or less planned outcome:

“Mutations are not always deleterious. To put it another way, maintenance of prevailing routine is often an operational target but it is not an ultimate objective. Modifications of

routine that involve improvements in role performance are presumably welcome. However in functioning complex systems with many highly differentiated and tightly interdependent parts, it is highly unlikely that undirected change in a single part will have beneficial aspects of the systems; this, of course, is the basis for the biological proposition that mutation tend to be deleterious on the average. An organizational member trying to do a better job can presumably accomplish something more than “undirected change”, but changes that seems like obvious viewed from a particular role can easily have adverse effects elsewhere in the system. With the aid of comprehensive understanding of the system as a whole, beneficial directed change in a part might reliably accomplished. But since nobody in a complex system organization actually has that sort of comprehensive understanding, it is clear a fortiori that new employees does not have it” (Nelson and Winter, 1982, p. 116).

(4.3) Involvement in the replication process and compatibility with diverse habits and values

Behind the notion of replication in its spatial dimension and the problem of adaptation to local is also a problem of the nature of the replication. In the definition of routine, we insisted on the fact that routines are non-finished products that are still in progress, and that people are individuals who feel and care. This point is important in the replication process, in order to accept and integrate new organizational practices. In fact, certain practices coming from outside conflict with local habits and practices, and the social process of routines replication is going to be disturbed. Nevertheless, if the value proposed by the routines that are to be copied does not enter in conflicts with pre-existing one, the process could be successful. This aspect has been very well summarized by Kilduff (1992), who points out that the replication of American routines in Japan was a real success in some cases, whereas in other case this was a failure.

“The opening of the Tokyo Disneyland was a surprise to many observers because compared to the Los Angeles original, the Japanese copy was in many respects more faithful to Disney’s philosophy. In Tokyo, the grounds were more spotless, the crowds more neatly dressed and better behaved and the whole park more efficient. The differences from the original tended to consist of deliberate concessions to Japanese preferences (such as subtitles in Japanese beneath certain signs) rather than unexpected deteriorations in performances (...) What makes the Disney story of the more than perfect duplication even more fascinating is the fact that the Tokyo Disneyland was an autonomous local unit, owned by investors who simply paid Disney royalties from receipts? It was the Japanese investors and executives who insisted upon a facsimile, not Disney headquarters. The lesson seems to be that a complete set of organizational practices can be successfully transplanted if the guiding philosophy governing these routines is fully compatible with the habits of those responsible for day to day implementation. The Disney philosophy of cleanliness, orderliness efficiency, and cooperative behaviour was fully acceptable to the Japanese (Kilduff, 1992, p. 137).

(4.4) Broad or narrow scope of replication

The extent of replication matters. In fact, the transfer of large routines may create some important change redefining the organizational context of the firm, whereas if replication is reduced to narrow scope – such as for instance only one organizational practice and not the routine in its abstract form – the organizational context where the routine is replicated could remain relatively stable. The transfer of a large routine will greatly modify the organizational context redefining its identity and social links surrounding routines. This could reactivate latent conflicts and disrupt some routines in operation. In contrast, a transfer of a small routine could be considered of narrow scope because the organizational context of target organization will remain stable (Winter and Szulanski 2001). In a transfer of narrow scope, the locus of adaptation will be limited as well the relation with inner and outer organizational environments. Indeed, in a narrow scope replication this involves sets of practices of key systems rather than an entire business model. In some cases, dysfunctions can be observed between the new ways of doing things and the old ones, and sometimes some accommodation could be found. Sometimes organizational changes can be easily absorbed, sometimes they are not leading to difficult conflicts impeding the firm to find some good compromise. When a new establishment is created, in the case of broad replication the legacy of the past has a low weight. The broad scope of replication could be more difficult to achieve where there are conflicts between old values and new ways of doing things. This could be one argument for creating Greenfield activities that avoid the problem of two conflicting systems of industrial relations.

(4.5) Access to the template

The replication of routines has recently been investigated by Winter and Szulanski (e.g., Szulanski and Winter 2002). One of the major findings of their empirical studies is that access to the template matters for how much variation is induced in the replication process. The role of the template is to guide replication. The better access to the template (and thus the possibility to study it), the better the chance to receive a precise copy. Without access to the template, one has to infer elements of the template that one cannot access, thereby giving rise to additional variation. Another function of access to the template is the possibility of checking if problems in the replication process arise, allowing the correction of copying

errors. Rivkin (2001) has added the insight of the role of complexity, pointing out that moderate complexity can achieve a similar effect to access to the template, namely, to enable replication of the routine within the firm but restrict imitation by outsiders.

(5) Discussion

The paper has tackled the question of the influence of knowledge in the replication of routines, according to the arguments of the resource-based view a question of high strategic importance for firms. We have attempted to contribute to the question by scrutinizing one aspect of the replication of routines, namely the influence of knowledge and knowledge-related aspects in the replication of routines. In order to do so, we have first built up a framework that adds clarity to our endeavour and sharpens our analytical perspective by highlighting the cognitive and social dimensions of routines.

The clarity added by the interactor-replicator framework is that if we are interested in explaining variation in a population of routines (e.g. of manufacturing practices in a particular industry), replication is only one part of the explanation. The other part of the explanation is selection, which takes place in the interaction process. In this process, interactors (which contain the replicators) interact with the environment and in doing so, some are ejected from the population, they are selected out. As Hodgson and Knudsen (2003) have argued, in the economy, routines are the replicators and firms are the interactors. As firms are selected out by competitive pressure, so are the particular routines that these firms had formed (for instance Toyota's quality management routines).

If we are interested in understanding the replication process itself, the replicator-interactor distinction makes clear that we should not confound replication (in which variation is introduced) with selection (in which population-level variation is reduced) – simply because what is being replicated is not what is subjected to selection. While routines are replicated, it is firms that interact on markets, not routines. The importance of that argument is that it disentangles the problem and enables us to focus on a particular aspect: the replication process of routines for explaining how variation arises in the replication process (with some degree of crudeness, we could say, on a micro level), and the interaction (selection) process of firms for explaining the variation of routines in the population of, say, firms in an industry.

The second body of literature the paper has drawn on then be connected to some insights on the role of knowledge in the replication process that were gained in empirical research. One insight that the material assembled in this paper has yielded is that *knowledge-related* aspects have an impact on *many different levels*: (i) the institutional framework (of the organization as well as the wider institutions it is embedded in), (ii) the individual actor involved in the execution and replication of the routine, and (iii) knowledge-characteristics of the routine itself. This is perhaps somewhat counter-intuitive, as the most obvious way in which knowledge has an influence in the replication process seems to be the *characteristics of the template* routine (notably, the degree to which it is tacit).

On the level of (i) the institutional framework, the empirical studies provide a strong argument for taking the institutional context into account, and for taking it seriously, in order to attain an understanding of the replication of routines. A number of ways have been identified in the paper in which the institutional context has an influence on the outcome of the replication process. The *activation* of routines (the execution of rules and standard operating procedures, for instance) relies on the institutional framework within which this activation takes place. Different industrial relations and different ideas of work ethic are examples of how the institutional level influences the activation of routines. Note that what would be required in order to produce a 'perfect' copy of the original template would be detailed knowledge about these institutions. Empirical studies indicate that to the extent that the background knowledge that actors draw on in activating the routine is not the same, the replication outcome will not be a close one. A second knowledge-related influence that the institutional framework has on the replication process is by way of *compatibility* of the knowledge contained in the routine with the higher-order knowledge of the organization (embedded for instance in assumptions, values and beliefs common to all organization members). The broader the scope of the routine to be replicated, the more likely the organization will react to incompatibilities. The higher-order knowledge of the organization, shared by the organization members, also represents a mental framework that is locally specific. All these points support an institutional perspective on the replication of routines.

This point becomes important for the second level, (ii) the human actor. As soon as human actors are involved in the replication of routines, the individual characteristics of the actors involved in the routine and its replication have an influence on the replication outcome. (This

is why the question of whether a mental or a physical template is involved is important) . As soon as human actors are involved, *perception and interpretation* are always involved, and because they can be individually different, variation is introduced in the replication process. Other ways in which actors have an influence on the replication of routines is by their *willingness and capacity to absorb*.

The perhaps most obvious (iii) characteristic of the template routine that impinges on the replication process is its *tacitness*. This point has been developed most in the extant literature. To the extent that the knowledge contained in the routine is characterized by *causal ambiguity* and *complexity*, higher variation in the replication outcome can in principle be expected. The *access* to the template routine also matters because it determines the possibility to fill in missing knowledge in case the replica does not come out close to the template. A final characteristic of the template that matters is whether it is a *mental or physical template*. The difference matters because in order to imagine a replication without the influence of human actors and the (substantial) possibility of variation introduced by way of error, interpretation etc., one would need to argue for a purely physical replication process of a purely physical template. Provocatively, one could ask the question whether it would not be more appropriate to speak of ‘recreation’ of a template routine rather than its replication where human actors are involved (Becker 2001), as descriptions of human learning often point out that the successful acquisition of knowledge involves some degree of reconstructing an argument rather than its mere ‘repetition’.

Conclusion

The objective of the paper was to scrutinize the influence of knowledge in the replication of routines. Maybe the most fundamental conclusion to be emphasized here is that a multi-level perspective on the replication of routines is required in order to capture the influences of knowledge in the replication of routines. Namely, the levels of the institutional environment, the individual human actor, and the characteristics of the template routines. The first task is to identify what knowledge-related aspects there are on each of these levels. The subsequent challenge is to identify the mechanisms by which these have an influence on the replication of routines. The list of knowledge-related aspects drawn up in this paper is indicative and, we strongly suspect, not comprehensive. Our investigation of the mechanisms by which they influence the replication of routines is still more preliminary. Our intention was to provide a

framework for tackling the issue and do the first step in filling and illustrating this framework. Many interesting research opportunities, both conceptual and empirical, remain in filling in the framework and gaps in our understanding.

Bibliography

- Alchian, Armen A. (1950): Uncertainty, Evolution, and Economic Theory. *Journal of Political Economy*, Vol. 68, 211-221. Reprinted in: Hodgson, Geoffrey M. (ed.): *The Foundation of Evolutionary Economics: 1890 – 1973*, Vol. 2. Edward Elgar, Cheltenham, 253-263
- Amit, Raphael and Monica Belcourt (1999) 'Human Resources Management Processes - A Value-Creating Source of Competitive Advantage', *European Management Journal*, 17, pp. 174-181.
- Archer, Margaret S. (1995): *Realist social theory: the morphogenetic approach*. Cambridge University Press, Cambridge
- Arrow K. (1974), *The limits of organization*, New York , Norton.
- Aunger, Robert (2002) *Three Roads to Cultural Recurrence*. Sperber, Dan (ed.): *The Epidemiology of Ideas*.
- Becker, Markus C. (2001): The Role of Routines in Organizations – An Empirical and Taxonomic Investigation. Unpublished PhD Thesis, Judge Institute of Management Studies, University of Cambridge
- Becker, Markus C. (2003, forthcoming): *Routines - A brief history of the concept*. Ioannides, Stavros and Nielsen, Klaus (eds.): *Economics and Social Sciences: Complements, Competitors, Accomplices?* Edward Elgar, Cheltenham.
- Barney, Jay (1991): Firm Resources and Sustained Competitive Advantage. *Journal of Management*, Vol. 17, No. 1, 99-120
- Betsch, Tilmann, Susanne Haberstroh, Andreas Glöckner, Thomas Haar and Klaus Fiedler (2001): The Effects of Routine Strength on Adaptation and Information Search in Recurrent Decision Making, *Organizational Behavior and Human Decision Processes*, Vol. 84, No. 1, 23-53.
- Cohen, Michael and Paul Bacdayan (1994): Organizational Routines Are Stored as Procedural Memory: Evidence from a Laboratory Study', *Organization Science*, 5, 554-568.
- Cohen, Michael D., Roger Burkhart, Giovanni Dosi, Massimo Egidi, Luigi Marengo, Massimo Warglien, and Sidney Winter (1996): Routines and Other Recurring Action Patterns of Organizations: Contemporary Research Issues', *Industrial and Corporate Change*, 5, 653-698.
- Cohen, Wesley M./Levinthal, Daniel A. (1990): Absorptive Capacity: A New Perspective on Learning and Innovation., *Administrative Science Quarterly*, Vol. 35, 128-152
- Coombs, Rod and Stanley Metcalfe (1998): Distributed Capabilities and the Governance of the Firm, mimeo.

- Costello, Neil (2000): *Stability and Change in High-Tech Enterprises - Organisational Practices and Routines*. London: Routledge.
- Cowan, Robin and Foray, Dominique, (1997): The economics of codification and the diffusion of knowledge , *Industrial and Corporate Change*, (6,) 3, 595-622.
- Cowan, Robin., David, Paul.A. and Foray, Dominique, (2000): The explicit economics of codification and tacitness, *Industrial and Corporate change*, (10) Number 2, 211-253
- Dawkins, Richard (1982a) *The Extended Phenotype*. Oxford: Freeman.
- Dawkins, Richard (1982b): Replicators and Vehicles, in *Current Problems in Sociobiology*, edited by King's College Sociobiology Group. Cambridge: Cambridge University Press, 45-64.
- Debreu, G. (1951): *Theory of value*, New York, John Wiley and Sons.
- Dosi, Giovanni, Richard R. Nelson, and Sidney G. Winter (2000): Introduction: The Nature and Dynamics of Organizational Capabilities. in *The Nature and Dynamics of Organizational Capabilities*, edited by G. Dosi, R. R. Nelson, and S. G. Winter. Oxford: Oxford University Press, 1-22.
- Egidi, Massimo and Alessandro Narduzzo (1997): The emergence of path-dependent behaviors in cooperative contexts, *International Journal of Industrial Organization*, 15, 677-709.
- Fabry, Nathalie and Lazaric, Nathalie (2000): Les transplants japonais en France : des investissements directs au transfert de compétences , in Delapierre M., Moati P., Mouhoud E.M. (eds), *Connaissance et mondialisation* , Economica, Paris.
- Feldman, Martha S. (2000): Organizational Routines as a Source of Continuous Change. *Organization Science*, Vol. 11, No. 6, 611-629
- Feldman, Martha S. and Anat Rafaeli (2002): Organizational Routines as Sources of Connections and Understandings. *Journal of Management Studies*, Vol. 39, No. 3, 309-331
- Foray, Dominique and Steimueller, Edward W. (2001): Replication of routine, the domestication of tacit knowledge and the economic of inscription: a brave new world ?, Mimeo prepared for the conference in Honour of R. Nelson and S. Winter , Aalborg 12- 15 June, Denmark.
- Gersick, Connie J.G./Hackman, J. Richard (1990): Habitual Routines in Task-Performing Groups. *Organizational Behaviour and Human Decision Processes*, Vol. 47, 65-97
- Giddens, Anthony (1984): *The constitution of society*. University of California Press, Berkeley, CA.
- Grant, Robert M. (1996): Toward a Knowledge-Based Theory of the Firm, *Strategic Management Journal*, Vol. 17, Winter Special Issue, 109-122
- Hahn, Frank. H. (1949): Proportionality divisibility and Economics of scale : comment, *Quarterly Journal of Economics*, 63, February, 131-37.
- Henderson, Rebecca M. and Kim B. Clark (1990): Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, Vol. 35, 9-30.
- Hodgson, Geoffrey M. (1988): *Economics and Institutions*. Oxford: Polity Press.

- Hodgson, Geoffrey M. (1992): Thorstein Veblen and post-Darwinian economics, *Cambridge Journal of Economics*, 16, pp. 285-301.
- Hodgson, Geoffrey M. (1993a) *Economics and Evolution*. Cambridge: Polity Press.
- Hodgson, Geoffrey. (2003) : The mystery of the routine : the Darwinian destiny of an evolutionary Theory of Economic Change, *Revue Economique*, Volume 54, n° 2 , 355-384.
- Hull, David (1980) 'Individuality and Selection', *Annual Review of Ecology and Systematics*, 11, pp. 311-332.
- Hull, David (1981) 'Units of Evolution: A Metaphysical Essay' in *The Philosophy of Evolution*, edited by U. L. Jensen and R. Harre. Brighton: Harvester Press, 23-44.
- Johnson, B., Lorenz, Edward. and Lundvall, Bengt.-Å. (2002) :Why all this fuss about codified and tacit knowledge?, *Industrial and Corporate Change*, Vol. 11, No. 2, 245-262.
- Karim, Samina and Will Mitchell (2000): Path-Dependent and Path-Breaking Change: Reconfiguring Business Resources Following Acquisitions in the U.S. Medial Sector, 1978-1995. *Strategic Management Journal*, Vol. 21, 1061-1081.
- Kilduff, Martin (1992) 'Performance and Interaction Routines in Multinational Corporations', *Journal of International Business Studies*, 23, 133-145.
- Knott, Anne Marie and Bill McKelvey (1999): Nirvana efficiency: a comparative test of residual claims and routines', *Journal of Economic Behavior and Organization*, 38, 365-383.
- Knudsen, Thorbjørn (2001) 'Nesting Lamarckism within Darwinian Explanations: Necessity in Economics and Possibility in Biology?', in Laurent, John and Nightingale, John (eds) (2001) *Darwinism and Evolutionary Economics* (Cheltenham: Edward Elgar), 121-59.
- Knudsen, Thorbjørn (2002a): The Significance of Tacit Knowledge in the Evolution of Human Language', *Selection*, 3(1), 93-112.
- Knudsen, Thorbjørn (2002b): Economic selection theory. *Journal of Evolutionary Economics*, Vol. 12, No. 4, 443-470.
- Knudsen, Thorbjørn (2003):General Selection Theory and Economic Evolution: The Price Equation and the Genotype/Phenotype Distinction', University of Southern Denmark, mimeo.
- Langlois, Richard N. (1992): Transaction-Cost Economics in Real Time, *Industrial and Corporate Change*, 1, 99-127.
- Lazaric N. (1999): Routines et apprentissage dans la théorie évolutionniste : portées et limites des fondements cognitifs, *Approches évolutionnistes de l'entreprise et de l'industrie* , M. Baslé, R. Delorme, J.L Lemoigne and B. Paulré (eds), l'Harmattan, Paris.
- Lazaric, Nathalie (2000): The role of routines, rules and habits in collective learning : some epistemological and ontological considerations, *European Journal of Economic and Social Systems*, Vol. 14, n° 2, 157-171.
- Lazaric, Nathalie and Denis, Blandine. (2001a): How and why routines change : some lessons from the articulation of knowledge with ISO 9002 implementation in the Food industry, *Economies et*

Sociétés, n° 6, 585-611.

- Lazarcic, Nathalie and Denis, Blandine (2001b): Implementing en new effort convention when routines change : some lesson from a case study, forthcoming, in Becker M., Knusden T. and Winter S. (eds) *Organizations, capabilities and routines*, Edward Elgar.
- Lazarcic, Nathalie, Mangolte, Pierre André and Massue, Marie-Laure (2003): Articulation and codification of knowledge : some evidence form the blast furnace control, forthcoming in *Research Policy*.
- Leibenstein, H., (1987):*Inside the firm: the inefficiencies of hierarchy*, Cambridge, Harvard University Press.
- Levinthal, Daniel. and March, James G. (1993): The myopia of Learning, *Strategic Management Journal* , Vol. 14, 95-112.
- Lippman, Steven A. and Richard P. Rumelt (1982): Uncertain Imitability: An Analysis of Interfirm Differences Under Competition. *Bell Journal of Economics*, Vol. 13, 418-438.
- Loasby, Brian (1999): *Knowledge, Institutions and Evolution in Economics*, Routledge.
- Lorenz, Edward (2000): Organisational Routines In the Light of 'Old' Evolutionary Economics: Bringing Politics Back into the Study of Organisational Learning, *European Journal of Economic and Social Systems*, 191-208.
- Lorenz, Edward. and Lazarcic Nathalie. (2001) : Replication of Business Practices in Two Institutional Contexts: Lessons from Japanese Firms in Britain and France, mimeo.
- Lorenz, Edward (2001): Models of Cognition, the Contextualisation of Knowledge and Organisational Theory, *Journal of Management and Governance*, 5 (4), 307-330.
- Metcalfe, J. Stanley (1986): Technological variety and the process of competition, *Economie appliquée*, n° 3, 493-520.
- Metcalfe, J. Stanley (1993): Some Lamarckian themes in the theory of growth and economic selection: a provisional analysis, *Revue Internationale de Systémique*, Vol. 7, n° 5, 487-504.
- Metcalfe, J. Stanley (1998): *Evolutionary Economics and Creative Destruction*. London: Routledge.
- Nelson, Richard R. (1994): Routines, in *The Elgar Companion to Institutional and Evolutionary Economics*, vol. 2, edited by G. Hodgson, W. Samuels, and M. Tool. Aldershot: Edward Elgar, 249-253.
- Nelson, Richard R. and Sidney G. Winter (1982): *An Evolutionary Theory of Economic Change*. Cambridge/MA: Belknap Press/Harvard University Press.
- Nelson, Richard R. (1995): Recent Evolutionary Theorizing About Economic Change, *Journal of Economic Literature*, 33,. 48-90.
- Nonaka, Ikujiro and David J. Teece (2001): Research Directions for Knowledge Management, Nonaka, Ikujiro and David J. Teece (eds.) *Managing Industrial Knowledge*, Sage, Thousand Oaks, CA, 330-335.

- Pentland, Brian T., Malu Roldan, Ahmed A. Shabana, Louise Soe, L., and Sidne G. Ward (1996) 'Lexical and Sequential Variety in Organizational Processes: Some Preliminary Findings and Propositions', <http://ccs.mit.edu/papers/CCSWP195/CCSWP195.html>
- Pentland, Brian T. and Henry Rueter (1994): Organizational Routines as Grammars of Action, *Administrative Sciences Quarterly*, 39, 484-510.
- Peteraf, Margaret A. (1993): The Cornerstone of Competitive Advantage: A Resource-Based View. *Strategic Management Journal*, Vol. 14, 179-88.
- Reed, Richard and Robert J. DeFillippi (1990): Causal Ambiguity, Barriers to Imitation, and Sustainable Competitive Advantage. *Academy of Management Review*, Vol. 15, No. 1, 88-102.
- Rivkin, Jan W. (2001): Reproducing Knowledge: Replication Without Imitation at Moderate Complexity. *Organization Science*, Vol. 12, No. 3, 274-293
- Schechner, Richard (1985): *Between theater and anthropology*. Philadelphia/PA: University of Pennsylvania Press.
- Schumpeter, Joseph (1934): *The Theory of Economic Development*. Harvard University Press.
- Spender, J.-C. (1989): *Industry Recipes - An Enquiry into the Nature and Sources of Managerial Judgement*. Basil Blackwell, Oxford
- Szulanski, Gabriel and Sidney Winter (2002): Getting It Right the Second Time. *Harvard Business Review*, January 2002, 62-71.
- Winter, Sidney G. (1971): Satisficing, selection, and the innovating remnant. *Quarterly Journal of Economics*, Vol. 85, No. 2, 1971, 237-261
- Winter, Sidney G. (1975): Optimization and Evolution in the Theory of the Firm. Day, Richard H./Groves, Theodore (eds.): *Adaptive Economic Models*, Academic Press, New York, 73-118
- Winter, Sidney G. (1982): An essay on the theory of production, in Hysmans Saul H. (eds) *Economics and the world around it*, University of Michigan Press, Ann Arbor.
- Winter, Sidney (1987): Knowledge and competence as strategic assets. Teece, David (ed.): *The competitive challenge - strategies for industrial innovation and renewal*. Ballinger, Cambridge/MA, 159-184
- Winter, Sidney G. (1990): Survival, Selection, and Inheritance in Evolutionary Theories of Organization, in *Organizational Evolution - New Directions*, edited by J. V. Singh. Newbury Park/CA: Sage, 269-297.
- Winter, Sidney (1995) :Four Rs of Profitability: Rents Resources, Routines and Replication, in C.A. Montgomery (ed.), *Resource-based and Evolutionary Theories of the Firm: Toward a Synthesis*, Boston: Kluwer Academic Publishers, 147-178.
- Winter, Sidney and Szulanski G. (2000) : Replication of organizational routines : conceptualising the exploitation of knowledge assets, in *The strategic management of intellectual Capital and*

organizational Knowledge : a collection of readings, Bontis, Nick and Choo Wei Chun (eds), Oxford University Press New York.

Winter, Sidney G. (1991): 'On Coase, Competence and the Corporation' in *The Nature of the Firm - Origins, Evolution and Development*, edited by O. E. Williamson and S. G. Winter. Oxford: Oxford University Press, 179-195.

Winter, Sidney and Gabriel Szulanski (2001): Replication as Strategy. *Organization Science*, Vol. 12, No. 6, 730-743

Zollo, Maurizio and Sidney G. Winter (2002): Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science*, Vol. 13, No. 3, 339-351