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Completion of knowledge codification: an illustration through the ISO 9000 standards implementation process

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Abstract

This paper looks at the role played by the ISO 9000 registration process in contributing to the knowledge codification within the firms. The ISO 9000 standards concern the way a company should elaborate a quality system by providing guidelines and models. They are considered as a code, i.e. a common language, which leads to communication and industrial relationship. This paper focuses on how this code might be used within the firms to enhance knowledge codification. It explains the standards implementation process by studying the three steps needed to complete codification within the firm: (1) the starting point of the implementation; (2) the subject of the codification, that means the material and behavioural characteristics of the production process; (3) the impact of the ISO 9000 implementation on knowledge accumulation within the firm. This paper addresses the fact that the ISO implementation is related to knowledge codification through a learning process, which includes both individual and collective knowledge conversions.

Keywords: Codification process; ISO 9000 standards; Knowledge management; Quality; Learning process

1. Introduction

Elaborated for the first time in 1987 by the International Organisation of Standards, the ISO 9000 is a series of five related standards [1] about quality management and quality assurance. This quality assurance includes all systematic actions devoted to demonstrate to customers that the quality required will finally be obtained. The ISO 9000 series provides not only quality system models for quality assurance covering development, production and final inspection, but also guidelines for selection and use of these models. The first purpose of the ISO 9000 standards is clearly to contribute to develop and generalise quality systems in organisations. Since 1994, its implementation has been associated with a certification process, which includes both third party assessment and periodic audit to confirm that the system adheres to the standards. The certificate can be considered as evidence of a commitment to quality and it is supposed to facilitate exchanges among both different firms and different countries. Most contributions have demonstrated that the ISO 9000 series has become the most prevalent quality initiative among firms in the whole world today (e.g. Tsiotras and Gotzamani, 1996; Ismail and Hasmi, 1999; Lee and Palmer, 1999; Beattie and Sohal, 1999). This diffusion is partly due to the competitive advantage these standards are supposed to provide. Actually,

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[1] It concerns the ISO 9000:1994 standards, which were used by firms during the empirical study. In December 2000, a revised series has been published (noted ISO 9000:2000), which is based on the same principles, but has another structure (only three standards).

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most ISO 9000 studies focus on this topic (Curkovic and Pagell, 1999; Docking and Dowen, 1999; Withers and Ebrahimpour, 2000). But few of them address the fact that achieving the ISO 9000 certification supposes a learning process inside organisations. There has been little examination of the relation between these standards and knowledge accumulation and management within the firms.

This is the main topic of this paper. Its primary objective is to examine the implications of the ISO 9000 standards for the codification process within the firms. According to Winter (1995, p. 461), "Quality management ideas provide an interesting perspective on the nature of productive knowledge and the processes by which it is maintained and improved in organisations". Quality management and consequently quality assurance are based on a dynamic process of acquisition and accumulation of knowledge that can be oriented by the ISO 9000 standards. Because of its widespread international acceptance, the ISO 9000 series can be viewed as a code, a language used by firms to extend their industrial relationship and their market share. As this code establishes the documentation requirements that must be met to demonstrate a company's compliance with a quality system, it will be considered as an intermediate code. Indeed it has to be related to the characteristics of the firm to complete codification.

We assume that the ISO 9000 series is a codification tool, which has to be well used by the firm to produce an efficient accumulation of knowledge within it. In order to gain an understanding of the specific use of this tool, the paper seeks to identify different steps in the ISO 9000 implementation process. Using a case approach, it compares two SMEs on the following issues: (1) reasons for seeking implementation (why); (2) the effective implementation process (on what and how); and (3) the impacts of the ISO 9000 standards on the knowledge accumulation (results).

The paper is organised as follows. First, we argue that the ISO 9000 series is a codification tool, used as intermediate code within the firms. Second, we briefly describe the case study, which will provide opposite examples on the use of this tool. And the following sections focus on the analysis of the ISO 9000 standards implementation, dealing with the three steps of this process.

2. The ISO 9000 standards and the codification process

In order to explain the links between the standards and knowledge accumulation, it could be useful to begin this paper by an examination of the nature of knowledge.

2.1. Standards and knowledge

Knowledge can take two forms (Polanyi, 1966): implicit (tacit) or explicit (codified). The distinction and the relationship between tacit knowledge and codified knowledge are complex and constitute the topic of much analysis (e.g. Lundvall and Johnson, 1994; Cohendet and Steinmueller, 2000; Cowan et al., 2000). Following literature, implicit knowledge has to be translated into a common representation to become transmittable and useful. The codification process describes the way by which tacit knowledge is extracted from people in which it is embedded, in order to produce codified knowledge. Thus, codified and tacit knowledge are not in an opposite relationship: "While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied" (Polanyi, 1966, p. 7). These two forms of knowledge have to be associated to become useful to agents (Nelson and Winter, 1982). The codified knowledge refers to a "code", which has to be known by people who attempt to communicate. According to Cowan et al. (2000), this code can be recorded in a "codebook", which defines vocabulary, technical specifications and management procedures. It enters a firm as an information that should be properly interpreted to become efficient and refers to both explicit knowledge and tacit knowledge embedded in people.

We argue that the ISO 9000 standards constitute a "codebook", which is both a dictionary used by agents to understand written documents and the documents themselves. The standards, established by a recognised body (the ISO), are based on an inventory of what exists (in science, technology, experience, and usual practices, etc.), in relation to some observations. The second step is a selection process in order to identify relevant information. This selection process finishes in establishing and recording a limited set of solutions to solve matching problems. After-

wards, firms can use these solutions to support their technical and/or behavioural efficiency. Thus, they enhance the knowledge-base of the firm that is "the collective knowledge that the firm uses for its productive purpose" (Saviotti, 1998, p. 845).

The ISO 9000 series represents an intermediate step to complete the codification process within the firm. The successful adoption of the standards occurs when some adaptations, either in the technical area or in the behavioural area, are realised to meet the required specifications. This paper deals with the ISO 9000 series process of adoption and focuses on whether they contribute to a firm's codification process and knowledge accumulation.

2.2. The ISO 9000 standards

The ISO 9000 series is based on quality management principles that insist on leadership, involvement of people and process approach. It focuses on processes description and control, and defines high documentation requirements. [2] Some of these standards are requirement standards used to address customer satisfaction; some others are guidelines producing guidance for improvement of firm's quality management system.

Since 1994, the ISO 9000 standards have been related to a certification process that validates the compliance of the firm's quality system and the high documentation requirement. The certificate will be obtained at the end of the registration process, which is concluded by an external audit. This audit is an examination of the effectiveness of the quality system and attests to the compliance with the model. During the registration process, a firm must prove that its own procedures for process regulation are efficient and prevent the problems by controlling each production step.

[2] The documentary architecture of the ISO 9000 requirements is built like a "pyramid" (Lamprecht, 1992). It includes three levels (i.e. type of documents). The quality manual is at the top. It describes the quality policy planned by the top management. The second level deals with procedures, which define and describe production processes by indicating the roles of everyone involved in the process. Operational instructions (that detail tasks needed for the process to run) and registration documents (that are supposed to prove that real practices meet the previously defined rules) are at the bottom of the pyramid.

To implement the ISO 9000 standards is likely to improve the extent of documentation of products and processes within the firm (Zhu and Scheuermann, 1999; Docking and Dowen, 1999). The documentation process results in reduced variability in the production operations. It also induces managers to re-examine all their business processes. Thus, the ISO 9000 family can be viewed as a tool to gain an understanding about products and processes, even if it does not solve existing problems by itself. Meanwhile, the ISO 9000 standards suggest neither how to implement them into organisations, nor how to make the documentation system evolve. Writing a well-ordered documentation framework does not systematically produce an operational quality management system. The nature of the process which has to build-up a documentation system, the role of people involved in the project, the precision in the activities description are some of the questions that do not find ready-made answers in the standards.

Quality management deals with the firm evolution through the application of a collection of problem-solving heuristics and techniques viewed as key information obtained only with the active co-operation of those involved in organisation performance (Winter, 1995). To obtain this information, a conversion process of tacit knowledge into codified knowledge is needed, that is an externalisation process (Nonaka and Takeuchi, 1995). The following empirical analysis of the ISO 9000 standards implementation refers to this conversion mechanism, which provides knowledge accumulation within the firm.

2.3. The ISO 9000 standards and the conversion steps

As a codebook, the ISO 9000 series can generate formalisation of codified knowledge and conversion from tacit to codified knowledge. It contributes to *knowledge conversion* (Nonaka and Takeuchi, 1995). First, it leads to a *combination* process, which means the way a piece of codified knowledge is conveyed into another codified knowledge by providing registration models. Second, it is related to both the *externalisation* of tacit knowledge and the *internalisation* of codified knowledge (de-coding process). Before the formalisation stage, it supposes an extraction of tacit knowledge about real practices and

experiences. When the procedures are written, employees have to internalise them by using them in their real work. As Ancori et al. (2000, p. 258) noticed, "certification processes aim at extracting and converting tacit knowledge into a codified form; but in order to be used, the latter form mobilises again forms of tacit knowledge". The conversion process occurs when the code is used to build-up a knowledge representation within the firm. The standards can be considered as a meta-language that must be interpreted and appropriated by the firm to produce an internal communication means.

Following Nonaka and Takeuchi (1997), the "creation" of knowledge results from the activity of a special group, the *team of knowledge creation*. This team includes (1) the *officers of knowledge*, who promote the knowledge codification; (2) the *specialists of knowledge* who conduct the conversion process; (3) the *knowledge engineers* who improve the productive codified knowledge; (4) the *knowledge practitioners* who internalise codified knowledge by taking it into account in their daily work. This knowledge team can be considered as an interface between individual (partly tacit) and collective knowledge. Thus, it can be viewed as a knowledge *community*, which is at an intermediate level and plays "the role of a permanent interaction between the individual and the organisational one in the design process of the routines" (Cohendet and Llerena, 2001, p. 10). This community is created for a specific aim (here, the implementation of a quality assurance system), only for a limited time. Members are learning by interacting. They choose the items that must be codified, or they participate in writing down the procedures. So, it is a *project community* (Cohendet et al., 2000; Giard and Midler, 1993) related to a *community of practices* (Brown and Duguid, 1991; Wenger, 1998) because its members are coming mainly from the same knowledge field. But, on account of the procedural dimension of the codification process driven by quality experts, the group might be also considered as an *epistemic community* (Cowan et al., 2000).

The knowledge team can produce formalised knowledge, which results from three main sources of knowledge to problem-solving (Simon, 1999; Raelin, 1997; Dooley et al., 2000): (1) *conceptual knowledge* (formal representation of the problem based on reflection and analytical knowledge); (2) *observational and experimental knowledge* (recognition of familiar patterns in problems situations, selective research along alternative problem-solving paths and instrumentation needed, experience derived from observation and involvement); and (3) *learning knowledge* (the dynamic synthesis of the other knowledge types resulting from social relationships). All these sources include both tacit and explicit aspects. This classification seems to be close to the three-dimensions of the codification process proposed by Cowan and Foray (1997): *creation of messages, creation of models and language development*. The mode knowledge can be accumulated appears as an interconnected link (with feedback loops) between these three interacting sources.

We assume that the conversion mechanisms pursue the following sequence, which is neither exhaustive nor normative, but rather a way to describe the effective codification related to the standards implementation.

The first stage deals with the primary motivation for codification, i.e. communication opportunity. It is the starting-point of the codification process (i.e. of the standards implementation) and refers to language appropriation. The officers of knowledge have to promote the language for both external (with partners) and internal (with employees) communication. It concerns the conceptualisation and the observation processes, in order to provide management practices transparency. In a second stage, we consider the subject of codification, which deals with the material and behavioural characteristics of the production process. Both *observational* and *experimental* (in the sense of experience) sources of knowledge are mobilised to identify these characteristics. The evaluation of the result of the codification process constitutes the last stage. The way the codification process acts to produce and increase transmittable knowledge is related to the *learning knowledge*.

This paper describes the standards implementation process taking into account the three steps needed to complete codification within the firm: (1) why the implementation (the starting-point of the process and people who drive it); (2) what is the subject of implementation; (3) how this codification process runs, leading to a dynamics of learning. This analysis will be illustrated by some empirical examples resulting from a case study that is to be specified below.

3. Case study: presentation

The illustration comes from a case study of two ISO 9000-certified French SMEs. These firms were chosen because of their dichotomised illustration of empirical implementation processes.[3] One case provides an example of a rapid achievement of the ISO 9000 certification process whereas the other illustrates some main problems a firm can meet during its implementation efforts.[4] This might be seen as too few firms to be a relevant study, but according to the case-study research method, "it makes sense to choose cases such as extreme situations and polar types" (Eisenhardt, 1989, p. 537).

The two companies (C1 and C2) seem to have the same profile. They belong to the woodwork industry. They are young, employ the same number of employees and their input (panelling-plain, melamine-coated or stratified) is buying on the same oligopolistic market.[5] Nevertheless, their production processes are different: C1 is mostly a production-to-order company whereas C2 is a production-to-stock company.

In company C1, small series are produced, based on customer's requirements. The wants and needs provided by the customer have to be translated into product design and production planning. The furniture components are produced on order, just as raw materials are supplied on order. During all the steps of the order processing, decisions have to be made. The operational activities involved in a production run depend on the product characteristics, which depend themselves on customer's requirements. Even if the statements of the customer are clear and detailed, operators must translate requirements in manufacturing operations and make decisions.

The production process of C2 is a make-to-stock production. It is characterised by integrated and automated production lines, which provide large series (with small product variety). These processes are standardised and all process steps are stable over time and well-defined (incoming material, machine characteristics and adjustments, tools, machine settings, etc.). The operator knows his function well and his autonomy is limited.

Both C1 and C2 started the ISO 9000 registration process in 1996. Company C2 achieved the ISO 9000 certification in the same year. On the contrary, C1 suspended the certification process in 1997 and did not complete its quality assurance system.

These two SMEs are now closely related. In the middle of 1999, during our study, C2 took over C1 by buying out 51% of its capital just after C2's introduction on the stock market in Paris. After C2's take-over, some change in company C1's top management occurred. Following this move, a deep evolution in managerial opinion on quality assurance system appears. It is the reason why we consider here a "new" case study, denoted below as C1′, which is the company C1 after the take-over. Concerning this "new" case, it should be noticed that company C2 has rapidly encouraged C1′ to pursue quality system implementation to achieve the ISO 9000 certification and company C1′ succeeded in October 2000.

4. The reason for the codification process: the ISO 9000 common language

As argued before, the ISO 9000 standards could be viewed as a code that has to be translated to become useful within the firm and to provide useful knowledge. This code is like a new language, which enhances communication means between agents. When these agents are external to the company, the ISO 9000

[3] Obviously, we do not assume that these firms are a sample or provide generalised results. We consider these cases only as an empirical illustration of possible implementation processes.

[4] The survey instrument was refined using a two stage process. First, a half-directness questionnaire was elaborated to determine both managerial beliefs and technicians perceptions of ISO 9000 registration process. It was mainly focused on the history of the implementation process and its repercussion (individual opinions and collective judgements). Second, in-depth site interviews were conducted at each firm to obtain detailed information about the experience. For each firm, interviewees were leader, members of middle and top management (in production, Sales and quality areas), secretaries, foremen and operators.

[5] Company C1, established in 1993, produces melamine-coated panelling used by furniture manufacturers (i.e. kitchen, bathroom and office furniture markets). The firm has 135 employees, with annual sales approximating € 13.5 millions. Most of its sales (85%) are made in France. Company C2, established in 1995, produces stratified flooring. Customers are "kit form home improvements" hypermarkets, specialised stores and the building industry. Company C2 employs 180 employees, with annual sales of approximately € 106 millions. Most of its production is exported (principally to UK and German-speaking countries), and only one-fourth stays in France.

certificate acts as a public signal about the firm's competencies. When these agents are internal, the standard could become a common language.

The ISO 9000 series is a communication tool, which facilitates the development of industrial relationship. That is the "signalling" effect of the certificate. According to the literature, seeking the ISO 9000 certification is primarily motivated by the need for a market share, competitive pressures, or customers requirements (Terziovski et al., 1997; Beattie and Sohal, 1999; Lee and Palmer, 1999). The certificate is considered as a reliable signal of effective quality management practices for customers and other partners (such as stakeholders, banks, etc.) (Anderson et al., 1999). Actually, this document is "only" a proof that the company's quality system complies with the ISO 9000 requirements (Curkovic and Pagell, 1999). But, whatever the certificate indicates, it can be viewed as a code, a common language which contributes to a firm's transparency and provides opportunities to develop industrial relationship.

To relate to our study, it should be noticed that in company C1, which failed in its first ISO 9000-certification attempt, the Sales Department took the initiative of the registration process. Salesmen wanted to use the certificate as an argument to lead to a real competitive advantage. No customer explicitly asked for it. Company C1 make-to-order production is bought by industrial customers. In this kind of relationship, past experience (reputation and confidence) is prevalent. However, the salesmen did not realise that such a project implied a transparency in all parts of the organisation, Sales Department included. The attempt to formalise their working methods rapidly led to resistance, which could partly explain the failed ISO 9000 certification.

In company C2, the decision to start the ISO 9000 registration came from the Financial and Accounting Department, who regarded it as a useful tool to resolve organisational problems produced by the fast development of the company. Moreover, certification appeared as a requirement to enter large distribution networks where customers faced the final consumers and could use the supplier certificate as a commercial argument of their own.

In case C1′, after C2 take-over, the motivation to complete the certification process came from company C2's top management. It can be partly viewed as a result of C2 introduction on the Stock exchange. C2's top management planned to develop the "kit" manufacturing activities of company C1 in order to make production series larger and more standardised. In such perspective, the certificate might be used for its "signalling" effect of good practices.

The ISO 9000 certification is not only a signal given to partners. The documentation requirements entail both codified knowledge and written knowledge about products, processes and management. By providing knowledge codification and formalisation, the ISO 9000 standards contribute to a firm activity transparency. The firm has to be able to understand its own functioning and to make it understandable to others (especially through the quality manual, a document that can be consulted by employees or customers). In such a perspective, the ISO 9000 documentation provides a window by which the organisational structure and practices can be easily observed and evaluated. This description of what is inside the "black box" (in the sense of Rosenberg, 1982) is based on the standards, which have to be translated to become a common language within the firm. This translation is carried out by quality experts, which follow the top management involvement to meet the ISO 9000 principles. Leaders should create and maintain the internal environment that generates people's full involvement in continuous improvement.

This can explain the achieved ISO 9000 certification in company C2. In this company, the ISO 9000 principles represent an organisational tool for producing different levels of quality forbearance just as generating organisational dynamics. By communicating continuously with the employees, the quality experts succeeded in making them assimilate the step. They found a way to interpret the ISO 9000 standards and to translate this language into operational documentation. The implementation process began with an articulation between the knowledge-base of the firm and the codebook.

On the contrary, in company C1, the certification project was not a priority for the leader. There was a lack of management commitment. Following the literature (e.g. Ragothaman and Korte, 1999; Withers and Ebrahimpour, 2000), problems encountered by SMEs seeking the ISO 9000 certification are mainly

the lack of management staff,[6] the overall costs of obtaining and maintaining the certification, and the difficulty of interpreting the standards. These problems increase when the company is forced to use an outside management-consulting firm for the certification process (cost increase, difficulty of translation). It was the case in C1.

Only two experts were working together (a consultant and an internal quality assistant) without other workers involvement. And because the top management was not committed to the ISO 9000 principles implementation, actually there was no means for the translation. The first uncompleted documentary system is a close duplication of the ISO 9000 model without either interpretation or taking into account the organisational specificity. The documentation was meant only for external auditors and written in a quality expert language. As a result of this uncompleted process, the code was not used: the employees did not apply most documents resulting from the registration process. There was no translation of the ISO 9000 series and experts did not extract tacit knowledge from operators.

In case C1′, the quality engineer was this time employed by the company C1 and knew the C2 quality approach well. So the C1′ codification process followed the same principles as C2. Furthermore, company C1′ had to integrate C2's "technical culture". The final goal was that operators could equally work in one or the other company. This mechanism is supposed to begin with the sharing of a common language that means the same quality documents.

The ISO 9000 series constitutes a common language that enters a firm as a new communication means, without the disappearance of former codes. Following an appropriate translation process within the firm, it generates new opportunities to communication between agents. Learning appears when people are able to connect this new knowledge with their well-known practical activities. The reengineering management approach insists on the dimension of human factors, the past-dependency and the phenomenon of capitalisation of knowledge in the continuity of practices (Champy, 1995). The codification based on the ISO 9000 standards provides this knowledge conversion and accumulation. Thus, it can be viewed as a common and used language.

5. The subject of the codification process: the ISO 9000 implementation base

The registration process and required documentation enhance the codification of knowledge about production processes. Production processes should first be identified and laid down to gain an understanding of the subject of the codification. The quality system implementation is based on observational and experimental knowledge. The subject is stated by experts, who translate the ISO 9000 language at the first step of the implementation process. This step consists in close examination of what is really done during operational activities. Observations deal both with the description of human actions and the collection of empirical data (process input, processing parameters, output characteristics) from the process during its normal run. In a make-to-stock production where processes are standardised, it could be easier to obtain this observational knowledge than in a make-to-order production. Nevertheless, some make-to-order production processes can also become stable over time and induce an easy observation of which manufacturing operations are required to produce the output. The ability to obtain these data arises from the time-stability of the production process. The characteristics of the production processes influence the nature of the operational knowledge that might be codified and formalised. The acquisition of the observational knowledge leads to the identification of the subject of the codification.

The two companies under study belong to different categories. The C1 make-to-order production process can be considered as a *half-structured process* (Lerch, 1998), where the target of the production process is defined ex ante, but the sequence of activities is partly undetermined. Outputs are partially or fully customised products. The production object is identified, but the way to obtain it cannot be described before the process run. The operator has to choose the relevant action taking into account the particularity of the output and the production context. In this production process, decision-making activities are more important than in the other SME. The subject of the

[6] As mentioned by Sironopolis (1994), over 90 percent of the SMEs failures in achieving the ISO 9000 certification are due to lack of professional managerial expertise.

codification process is more complex and less stabilised in company C1 than in company C2 where the implementation process should be easier to start because of the *structured* aspect. Company C2 produces a limited set of outputs with well-identified process steps. The target of the process is invariable and products are standardised. The operator's actions are fixed along the process steps and well-defined. Operators have limited autonomy in their work and just carry out orders. The standardised production process of the company C2 is typically a *structured* one.

In the first case, the quality expert did not consider the production process characteristics (undetermined production parameters). He wrote long and detailed documents that finally were not applied by workers. The knowledge formalisation took place without a real understanding about the subject of codification that would have resulted from observation. On the contrary, in the C2 documentary system, the quality documents are streamlined. Formalised procedures and checklists are presented as tools that can help employees in their daily work (not control them).

Knowledge accumulation within a firm depends on a selection process to identify the relevant knowledge that should be formalised to become useful information. The ISO 9000 implementation starts from an identification of the subject of the codification, which refers to some characteristics (material components and human actions) of the production process. It should be noticed that, even if the structures of the production process are different, the structure of the quality systems could be the same to deal with the ISO 9000 requirements. In the two certified companies, quality systems are close in many aspects: [7] few procedures (more or less prescriptive, depending on the operators' autonomy that should be taken into account); many instructions; registers computing, etc. Observational knowledge refers more to the application of the ISO 9000 principles (i.e. the process run) than to the result of the implementation process (i.e. the structure of quality system).

We can conclude that the ISO 9000 principles were translated in the same way in the two certified cases. Even if the subject of the codification process differs, the implementation induces the same structure for the quality systems. The documents result from the translation of the codebook and its articulation with the knowledge-base of the firm that includes the production process characteristics. To be efficient, the documents have not only to formalise the relevant codified knowledge, but also to integrate the tacit knowledge, which can be extracted by quality experts.

6. The method of codification: the learning of the ISO 9000 standards

The ISO 9000 standards relate to the codification process in two ways. First, they are used as a codification tool, which allows a firm to (1) formalise the codified knowledge within the firm (*combination*); (2) codify tacit knowledge embedded in people (*externalisation*); (3) and sometimes to share experiences through discussion about the process functioning (*socialisation*). In a second step, the result of the standardisation (i.e. the documentation) has to be re-appropriated by people within the firm to be useful and to contribute to organisational learning (*socialisation*).

To relate to our study, it should be mentioned that two codification methods could be identified. In case C1, workers were not really involved in the codification process by the experts. They were asked to depict their effective work, but they were not supposed to participate in the formalisation process itself. Mistrust to knowledge transmission could be observed anywhere. Both in offices and workshops, employees felt dispossessed of their knowledge by the method of implementation. They saw the documentation as a bureaucratic phenomenon enhancing inertia and time loss. On the contrary, in the cases C2 and C1′, middlemen (such as quality controllers, foremen, etc.) were largely involved in the codification process, beside final adjusters. Middle managers played their role of interface between the top management and the real daily work. Moreover, top managers told employees that implementing a quality system was an opportunity to clarify their roles and to recognise their competencies. The purpose was to obtain a shared representation of the implementation goal. The implementation can be successful when the process is

[7] The role of experience is pointed out: this result can be explained by the close links (as mentioned before) between the quality expert involved in the second attempt of company C1 and the C2 experience of the ISO 9000 implementation.

driven by an expert who socialises the objective. This process requires the main efforts at the first stage, which deals with both the socialisation of the goal and the externalisation of tacit knowledge. The role of the quality expert is to listen to people, to help them to express correctly what they do and what they know. The second stage of the implementation concerns the choice of the best practices, which needs to be discussed and arbitrated between operators and superiors.

These conversion processes are related to the relevant *knowledge team* (Nonaka and Takeuchi, 1997). As cases C2 and C1′ show it, each member of the team has to be effectively involved in the conversion. The top management (including the leader's purpose) can be considered as the *officers of knowledge*. They impulse the codification in a way that facilitates people involvement. The quality experts (internal and consultants) are the *specialists of knowledge*. They have to produce formalised knowledge on the basis of the codebook and to translate it into a shared language within the firm. They are also engaged in the externalisation process because they have to take into account people in whom tacit knowledge is embedded. The middle management can be viewed as the *knowledge engineers* because they have to extract the relevant tacit knowledge from the operators. Moreover, they take a part in the socialisation process in being the middlemen between the officers and the operators (this time, translation of the top management purpose). Finally, the operators are the *knowledge practitioners* who internalise the codified knowledge in including it in their daily work.

The way people are involved in the implementation process has an effect upon the codification process. In the case C1, the knowledge team was not really efficient because it provided a limited learning of the standard (a limited codification). This team can be considered as an *epistemic community*: the two requirements — the group shares a common purpose and it has a procedural authority — are met in this case. Actually, the procedural role assigned to the quality expert leads to consider that the knowledge team focused on quality implementation can always be assimilated to this kind of community. But, in both cases C2 and C1′, this team integrated some *project community* aspects because members were learning by interacting. Moreover, in the three cases, the purpose of the team was the construction of codified knowledge and the circulation of best practices.

The ISO 9000 implementation leads to knowledge codification that means to know how an organisation *learns* the standard. It is also relevant to assess the effectiveness of *learning by* the standard, which is related to the impact of the ISO 9000 implementation on the individual and collective beliefs. If the dynamics of learning occurs, the standardisation of operations will turn into new opportunities of improvement: "Quality management methods provide some novel ways of converting a portion of these latent opportunities into recognised opportunities, and recognised opportunities into actual improvements" (Winter, 1995, p. 474).

The team of knowledge creation produces codified knowledge by translating the codebook. It can be related to the concept of *single loop learning* (Argyris and Schön, 1978) viewed as the action of learning the standards. Organisation members modify their habits without asking about the deep reasons for this change. But, to look inside the organisation leads to identify another kind of learning, the *double loop learning*. This time, organisational changes occur because some basic principles must move on. According to March and Simon (1958), members of an organisation have often different points of views, leading to equivocal situations corresponding more to various ideas than to a unique and shared representation. This is the reason why collective action requires co-ordination of individual actions, communication between agents and incentive mechanisms. When a large proportion of members of an organisation are not able to adjust mutually to this representation, procedures can compensate (at least partially) this lack for coherence. The process pursues generally the following sequence:

In the first step, the target is *to write what we do*. The creation of knowledge results from partial exteriorisation of tacit knowledge embodied in the behaviour of actors. At this stage, the procedure represents an explicit and common representation "*public map*" playing the role of co-ordination mechanism (Argyris and Schön, 1978). In the second step, the purpose is *to rationalise what we do*. The creation of knowledge comes from the combination of explicit knowledge included in the representation itself. The procedure constitutes a go-between, a communication support for actors implied in the improvement. In the last step, the goal is *to do what we write*. Finally, actors

generate a new type of learning when they internalise the procedure in their own behaviour. When the internalisation of the procedure occurs, explicit knowledge is integrated in the tacit representations of actors as for the cultural management. Procedures play this time the role of a self-controlled process driving the execution of activities. This further internalisation supposes a high degree of employee commitment to quality. [8]

From an evolutionary viewpoint, organisational learning is history-dependent, routine-based, and target-oriented. Organisational knowledge capabilities are fragmented, distributed and embedded in organisational "routines", which refer to regularity and predictability (Nelson and Winter, 1982). These routines have to combine disruption and incremental change. It is like a slow process of fermentation, which produces organisational learning. In both cases C1′ and C2, seeking the ISO 9000 certification and the codification process associated contributed to create, formalise and record routines and continuity in rules of actions. "Quality management is the quest for improvement in organisational routines through the application of a particular collection of problem-solving heuristics and techniques" (Winter, 1995, p. 464). Quality management promotes an evolutionary rather than a revolutionary approach to change.

Nevertheless, the routines must change when the context is changed or the conversion of knowledge occurs. The process of adaptation, and here the learning effects can turn out to be self-destructive (March, 1994). The ISO 9000 registration can lead to the same result. The codification of practices through quality approach could provide "traps of exploitation" by enhancing inertia. Such a phenomenon is not specific to step by step improvements due to quality management, but can be generalised when the exploitation of current solutions is made without the exploration of new solutions. There is a strong temptation for the ISO 9000-certified companies to react within the framework of the quality system and to refuse actions situated out of the ISO 9000 standards border. In that case, the firm limits the scope of learning. The flexible interpretation of the ISO 9000 family can be illustrated by the way C2 solves problems with non-conforming materials. A procedure derived from the ISO framework is to return the doubtful lot to the supplier. The staff of C2 considers that such behaviour prevents the capitalisation of competencies because it supposes to refuse the input without an attempt to identify the reason of the non-conformity. Even if a problem appears in a supplier, it could be useful and efficient for an industrial customer to clear up the incident or to help the supplier to do it, in order to prevent its repetition. Most of the time the company C2 tries to find a solution by itself [9] or contacts the supplier in order to find a solution together. In this case, the ISO 9000 model is not considered as a constraint without any possibility of adaptation, but as a convenient framework that maintains decision-making autonomy.

A strict interpretation of the ISO 9000 series could rigidify the knowledge accumulation and codification, which are still important for the development of an SME. The prescriptive dimension or the detailed descriptions of some procedures may reduce the autonomy of actors in limiting their responsibility area. For example, preventive maintenance activities have to be formalised in procedures to meet the ISO 9000 documentation requirements. The rules of action are stabilised and standardised. They can be precisely described by documents that provide a structured toolbox to keep the process on target. These activities were detailed in maintenance procedures in the two companies. But other types of activities are more difficult to codify. The repair activities could be used as an illustration of the possible inefficiency of detailed prescriptions. The way to find the cause of a failure is extremely difficult to express. This kind of knowledge can be partly viewed as *unarticulable* knowledge. Operators have to face complex situations in which they need access to relevant knowledge mainly based on past experience (experimental knowledge). Detailed procedures would constitute here a restriction to an efficient decision-making process by enhancing inertia. If the process of codification is efficient,

[8] This commitment can be enhanced by some specific Human Resource Management policies. For example, we notice a close coherence between the values of the quality management and the HRM system in the firm C2 (profit sharing, salary bonus related to an evaluation of individual performance, etc.). In contrary, the first failure in the company C1 seems to be partly linked to some contradiction between the HRM policy and the quality project (high turn over of adjusters, Salesmen salary is based on the cash flow, etc.).

[9] The problem might come from the logistic Department, the way the materials are kept in stock, etc.

it produces knowledge accumulation that allows for better way to react in front of a specific problem and to correct disturbances in the production process. Consequently, for this kind of activities, it could be useful to limit the detail of the procedures. In both cases C2 and C1′, quality experts decided to limit the detail of the documentation for repair activities.

One of the results of standards implementation should be that routines are recorded and under control that enhance organisational learning possibility. But, as mentioned by Nelson and Winter (1982, p. 112), "attempts to change routines often provoke a conflict which is destructive to the participants and to the organisation as a whole". Thus, it could be useful to precisely define the way the documents are revised to take into account the evolution of daily work or the identification of problems dealing with the chosen procedures. In that sense, the implementation process can be considered as a link that results in knowledge codification. Nevertheless, following Ancori et al. (2000), the formation of knowledge cannot be described as a linear process. It is an interactive system including wisdom (beliefs; judgements; values), messages and representation, which provides collective learning and common language. Thus, the implementation can be considered as an interconnected link with feed-back loops (in the sense of Kline and Rosenberg, 1986). The registration is the process by which the documents are conceived and diffused within the firm, with reference to the different steps of the effective implementation (composed by conceptual, observational and learning knowledge). This process should include feed-backs between quality experts and knowledge practitioners to be able to produce a relevant documentation that might be in continuous evolution.

Quality management principles include the idea of continuous improvements. For this topic, the ISO 9000 series is supposed to provide a help to a firm building such an efficient quality system, which supports learning within the organisation. But the series is sometimes misunderstood by the firm and considered as a constrained model. By recording formalised knowledge, the implementation could encourage people passivity. Documentation can also registrate old ways instead of new ideas because it mainly records stabilised manners. All these consequences may lead to partly curtailing the ability of the company to explore new opportunities. According to Dean and Bowen (1994), this point produces a dilemma for agents by asking them, on the one hand, to develop abilities for making improvements in their activities and, on the other hand, to require them to conform to top-down procedures that can produce inertia.

Such a perspective deals with policy implications. A key issue for government policy is to develop an infrastructure promoting a good understanding of the ISO 9000 principles and, thus, the appropriation mechanism, especially for SMEs. The standard making process is a continuous negotiation process driven by international standardisation bodies in which a large number of parties (and interests) are involved. But usually, the SMEs are not playing an important role in the standard making settings. Consequently, some of them are used to consider published standards mainly as models, and sometimes as constraints, that must be directly applied in their organisation. A specific public programme focused on the management standards principles could be a relevant policy to enhance the efficient implementation of such standards. This policy issue has to run preferably at the European level to confirm co-operation and to avoid resource dispersion.

7. Conclusion

Over the last decade, the ISO 9000 standards have increased their impact on organisations by proposing a way to create a competitive advantage and to manage the quality systems. As they include documentation requirements, these standards are also related to the accumulation of knowledge within the firm. They promote knowledge codification and formalisation.

The ISO 9000 series represents a guideline to build an efficient quality system and to provide learning effects. As a codebook, it provides a common language to firms and its implementation implies a process of knowledge codification within them. This language must be appropriated by people and articulated with the former codification of the firm. In that sense, it is an intermediate step to complete knowledge codification within the firm.

The completion of the codification depends on the most active interpretation of the standard within the firm. To consider it only as a signal for partners may

leads to an organisational rejection of the quality procedures because of the lack of translation. To consider it only as a constraint, imposed by the institutional environment (like the International Standards Organisation itself) or the industrial partners, induces the duplication of the model without any appropriation attempt. The commitment of top management is important at the starting-point of the implementation process. It should promote the sharing of the purpose between all the members of the firm and consequently their involvement in the codification process.

The completion of codification depends also on the nature of the firm. The characteristics of the production process affect the nature of the knowledge to codify and, therefore, the difficulty of completing the codification, but not the result of the codification process. The latter is associated with two kind of learning processes: learning the standard and learning by the standard. These two types of learning (i.e. single loop and double loop) are linked in the sense that a continuous process of learning may create conditions for strategic reorientation. Learning the standard is not neutral for an organisation, and may generate capacities of adaptation due to learning by the standard itself. The impact of a descriptive codification such as the ISO 9000 model is not only a guarantee of stabilised process, but it is also a means for creating new potentialities for further improvements. This ability depends partly on the nature of the process and the managerial attitude toward continuous learning.

Obviously, the knowledge management supported by the ISO 9000 implementation is a subject that has not been exhausted in this paper. For example, it could be useful to specify the role of team knowledge and its impact on the evolution of routines. These standards can also be considered as an organisational innovation that is widely diffused. Such a perspective should address the fact that the standards adoption might be interpreted with the technological diffusion literature.

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References

Ancori, B., Bureth, A., Cohendet, P., 2000. The economics of knowledge: the debate about codification and tacit knowledge. Industrial and Corporate Change 9 (2), 255–287.

Anderson, S.W., Daly, J.D., Johnson, M.F., 1999. Why firms seek ISO 9000 certification: regulatory compliance or competitive advantage? Production and Operations Management 8 (1), 28–43.

Argyris, C., Schön, A., 1978. Organizational Learning: A Theory of Action Perspective. Addison-Wesley, Reading.

Beattie, K.R., Sohal, A.S., 1999. Implementing ISO 9000: a study of its benefits among Australian organizations. Total Quality Management 10 (1), 95–106.

Brown, J.S., Duguid, P., 1991. Organizational learning and communities of practice, toward a unified view of making, learning and innovation. Organisation Science 2 (1), 40–57.

Champy, J., 1995. Reengineering Management: The Mandate for New Leadership. Harpercollins, New York.

Cohendet, P., Steinmueller, W.E., 2000. The codification of knowledge: a conceptual and empirical exploration. Industrial Corporate Change 9 (2), 195–209.

Cohendet, P., Llerena, P., 2001. In: Proceedings of the Nelson and Winter Conference on Routines and the theory of the firm: the role of communities and communication. DRUID, Aalborg.

Cohendet, P., Creplet, F., Dupouët, O., 2000. Organisational Innovation, Communities of Practice and Epistemic Communities: The Case of Linux. Mimeo, BETA, Strasbourg.

Cowan, R., Foray, D., 1997. The economics of codification and the diffusion of knowledge. Industrial and Corporate Change 6 (3), 595–622.

Cowan, R., David, P., Foray, D., 2000. The explicit economics of knowledge codification and tacitness. Industrial and Corporate Change 9 (2), 211–253.

Curkovic, S., Pagell, M., 1999. A critical examination of the ability of ISO 9000 certification to lead a competitive advantage. Journal of Quality Management 4 (1), 51–67.

Dean, J.W., Bowen, D.E., 1994. Management theory and total quality: improving research and practice through theory development. Academy and Management Review 19 (3), 392–419.

Docking, D.S., Dowen, R.J., 1999. Market interpretation of ISO 9000 registration. The Journal of Financial Research 22 (2), 147–160.

Dooley, K., Anderson, J., Liu, X., 2000. Process quality knowledge bases. Journal of Quality Management 4 (2), 207–224.

Eisenhardt, K.M., 1989. Building theories from case study research. Academy of Management Review 14 (4), 532–550.

Giard, V., Midler, C. (Eds.), 1993. Pilotages de Projet et Entreprises: Diversités et Convergences. Economica, Paris.

Ismail, M.Y., Hasmi, M.S., 1999. The state of quality management in the Irish manufacturing industry. Total Quality Management 10 (6), 853–862.

Kline, S., Rosenberg, N., 1986. An overview of innovation. In: Landau, R., Rosenberg, N. (Eds.), The Positive Sum Strategy. National Academic press, Washington, DC.

Lamprecht, J., 1992. ISO 9000, Preparing for Registration. Marcel Dekker, New York.

Lee, K.S., Palmer, E., 1999. An empirical examination of ISO 9000-registered companies in New Zealand. Total Quality Management 10 (6), 887–899.

Lerch, C., 1998. Une Nouvelle Représentation du Contrôle Organisationnel: le Pilotage des Processus, Thèse de Doctorat de Sciences de Gestion. Université Louis Pasteur, Strasbourg.

Lundvall, B.A., Johnson, B., 1994. The learning economy, Journal of Industry Studies 1(2).

March, J.G., 1994. A Primer on Decision Making. Free Press, New York.

March, J.G., Simon, H., 1958. Orgnizations. Wileys, New York.

Nelson, R., Winter, S., 1982. An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge.

Nonaka, I., Takeuchi, H., 1995. The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press, Oxford.

Nonaka, I., Takeuchi, H., 1997. La Connaissance Créatrice, la Dynamique de l'Entreprise Apprenante. De Boeck Université, Bruxelles.

Polanyi, M., 1966. The Tacit Dimension. Anchor Day, New York.

Raelin, J., 1997. A model of work-based learning. Organization Science 8 (6), 563–578.

Ragothaman, S., Korte, L., 1999. The ISO 9000 international quality registration: an empirical analysis of implications for business firms. International Journal of Applied Quality Management 2 (1), 59–73.

Rosenberg, N., 1982. Inside the Black-Box. Technology and Economics. Cambridge University Press, Cambridge.

Saviotti, P., 1998. On the dynamics of appropriability, of tacit and of codified knowledge. Research Policy 26, 843–856.

Simon, H., 1999. The many shapes of knowledge. Revue d'Economie Industrielle 88, 23–39.

Sironopolis, N., 1994. Small Business Management: A Guide to Entrepreneurship. Houghton Mifflin Company, Boston.

Terziovski, M., Samson, D., Dow, D., 1997. The business value of quality management systems certification evidence from Australia and New Zealand. Journal of Operations Management 15, 1–18.

Tsiotras, G., Gotzamani, K., 1996. ISO 9000 as an entry key to TQM: the case of Greek industry. International Journal of Quality and Reliability management 13 (4), 64–76.

Wenger, E., 1998. Communities of Practice Learning as a Social System, Systems Thinker.

Winter, S.G., 1995. Organizing for continuous improvement. Evolutionary theory meets the quality revolution. In: Cohen, M., Sproull, L. (Eds.), Organizational Learning. Sage, London, pp. 460–483.

Withers, B., Ebrahimpour, M., 2000. Does ISO 9000 certification affect the dimensions of quality used for competitive advantage? European Management Journal 18 (4), 431–443.

Zhu, S., Scheuermann, L., 1999. A comparison of quality programmes: total quality management and ISO 9000. Total Quality Management 10 (2), 291–297.