Revue Internationale de

systémique

PATTERNS OF CHANGE
LEARNING, DIFFUSION, TRANSITION

Vol. 10, N° 3, 1996

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Revue Internationale de systémique

Revue
Internationale
de Sytémique

volume 10, numéro 3, pages 201 - 221, 1996

Organisational learning and combinative capacity during technological agreements: some empirical evidence in the robotic sector

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The issue of sustainability is therefore of particular importance under information intensity. The paper by Ehud Zuscovitch tries to tackle the issue as a problem of "Sustainable differentiation". He shows that the joint specialization in flexible organizations such as networks present one of the potential answers to the constraint of capital accumulation should the capital-specialization evolve as it does. He also shows that an institutional adjustment in the form of new rules for sharing ownership may be needed in such a perspective.

REVUE INTERNATIONALE DE SYSTÉMIQUE
Vol. 10, N° 3, 1996, pp. 201 à 221

ORGANIZATIONAL LEARNING AND COMBINATIVE CAPACITY DURING TECHNOLOGICAL AGREEMENTS : some Empirical Evidence in the Robotic Sector

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Abstract
The aim of this contribution is to discuss about learning and organization of knowledge during cooperation. We define organizational learning in a cognitive perspective as a process of knowledge mobilization without ignoring its political dimension. During alliance combinative capacity may be very fruitful for innovating but requires some specific conditions (absorptive capacity, organization of knowledge, prior knowledge...). We will illustrate this proposition by an empirical study which over a period of 10 years, shows eight cases of agreements in Germany, France and Italy in the robotic sector and observes the dynamic of learning (through rules, routines and trust). These immaterial investments create strong path-dependency leading to exploit the externalities of learning and the benefits from the relational rent. Our investigation shows the difficulty to learn from learning once shared frameworks are present because it is easier to exploit current knowledges than to explore new way of working and solving problems. Organizational inertia stabilizes cooperation and avoids uncertainty facing an agreement with a new partner but precludes another articulation of knowledge which may decrease innovative capacity.

Résumé
L'objectif de cet article est d'observer la dynamique d'apprentissage des accords interfirmes à travers l'organisation des différentes bases de savoirs. On définira ce que l'on entend par apprentissage organisationnel dans le cadre des accords en soulignant plus particulièrement la dimension cognitive de ce processus, tout en n'occultant pas sa dimension politique. Nous insisterons sur la capacité à combiner des connaissances différentes, capacité qui nécessite quelques conditions

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Rev. intern. systémique. 0980-1472 Vol. 10/96/03/ $ 4.00/© Afcet Gauthier-Villars

particulières (connaissances préalables, organisation des connaissances existantes...). Nous illustrerons nos propos par les résultats d'une étude empirique analysant huit cas d'accords pendant une période de dix ans en France, en Allemagne et en Italie entre des utilisateurs de robots et des constructeurs automobile. Nous montrerons dans quelle mesure cet apprentissage requiert de véritables investissements immatériels avec la construction d'une confiance inter-firmes et la mise en place de règles ou routines. Néanmoins, cette dynamique n'est pas une panacée car la présence de tels investissements crée de fortes externalités, des incitations à exploiter la rente relationnelle et de potentiels pièges de compétences. Les bénéfices de l'exploitation des connaissances présentes et les réticences face à l'incertitude de l'exploration, peuvent freiner le renouvellement des savoirs et l'innovation.

Cooperation is, most of the time, observed and evaluated in a technological exchange perspective with very little attention devoted to knowledge confrontation. The reasons for this lack of interest are understandable. First, many studies on agreements result from a Williamson's analysis, drawing scare attention to the cognitive evolution of the firm with its exchange of knowledge and excluding most of the time learning dynamics [1]. Secondly, research on learning in agreements puts stronger emphasis on coordination aspects or the political compromise between firms (Hamel *et al.*, 1989). Nevertheless, to understand the new division of innovative work through alliances, it is necessary to take in consideration the political aspect of cooperation and also to underline the cognitive dimension to get a deeper insight of the black box of knowledge creation. This the reason why the aim of this article is to look at organizational dynamics during cooperation, knowledge capitalization and knowledge transfer. For observing this kind of learning, I shall rely more on an evolutionary background than a behaviorist perspective.

The argumentation is backed up by an empirical investigation. I have studied eight cases of cooperation between robot users in the automobile industry and producers, in France, Germany and Italy (three interactions in France, three in Italy and two in Germany) [2]. The objective of this study, which took two years to complete, is to evaluate long term cooperation between two firms and the different technological projects they undertook during the previous ten years. I shall first define what I mean by organizational learning and try to show how it may be very important to develop the firm's absorptive capacity and to create new knowledge combinations. Secondly, I shall discuss to some organizational conditions for improving coordination between the different backgrounds of knowledge of the two firms. Rules,

routines, shared language and trust, for example, play a prominent part in the creation of these shared frameworks. Thirdly, I shall show how this shared knowledge generates learning externalities, "lock-in" and organizational inertia impeding firms from exploring new ways of combining current know-how. Finally, I shall illustrate my study more precisely by giving some detailed examples of cooperation.

I. ORGANIZATIONAL LEARNING AS A TRIGGER OF NEW KNOWLEDGE COMBINATIONS

Economic literature on alliances has stressed that technological learning is an important part in cooperation stabilization (Mowery, 1989; Hamel *et al.*, 1989). Acquiring new acknowledge in the technological proximity of innovative firms may reinforce actual trajectory and also provide some complementary assets. Teece (1986) has largely underlined the need for complementary assets during the innovation process [3]. This new division of labour is not an automatic process because some organizational coordination has to be implemented to help this learning. Learning has however two sides: one is given by the capacity to understand technical solutions that are distant from the actual technological trajectory and another is organizational learning required for combining ideas and for innovating. Organizational dynamics plays an important role because each firm has its own objectives and routines which need to be coordinated through specific procedures. I would like to define first what I mean by organizational learning, and then to show the potential creation of new knowledge combinations in the Schumpeterian meaning of this concept. Cooperation is not only guided by technological proximity or organizational similarity but also by some cognitive maps that I shall try to define.

Organizational learning as a cognitive process

Learning in organizations has been well described in the "behaviorist" literature (March and Simon, 1958; Cyert and March, 1963) as a progressive modification of firms objectives highly dependent on past events and past routines. Organizations have some objectives and their behaviors are dependent on results observed comparing to previous ones. Their modification is an incremental process for preserving contradictory interests in organizational truce (Levitt and March, 1988, p. 320). Compared to technological learning, this learning is more global because it includes up-

stream knowledge about the way of organizing and objectives facing this production. Technological learning which improves the way to do current tasks, opportunities to be more quickly indentified during production and technological creation, is more localized, included in organizational learning (Dosi, Teece and Winter, 1992).

For us, organizational learning is also a cognitive process, defined as the mobilisation of new knowledge through specific coordination procedures (frameworks, rules and routines) allowing to capitalize and to filter knowledge as well as facilitating its transformation and its renewal. These specific procedures can be changed by implementing new ways of coordination (for example new objectives, new rules or new routines). The notion of framework has to be explained because it limits the organizational action of each firm and makes it difficult to associate different cognitive maps which are not based on the same "world view". These frameworks are rather inert because each firm has its own action theories and its own values which are not always compatible with one another. If each innovative firm evolves according to its own technical paradigm choosing technical opportunities and identifying new solutions according to its current trajectory, more generally a firm constructs its own knowledge framework which selects events, aggregates individual know-hows, specializes core capabilities and finds adequate routines (Loasby, 1989). The notion of framework goes beyond a simple coordination mechanism because it promotes firm efficiency and gives organizational coherence through a consistent way of dividing work, solving problems and implementing routines.

These frameworks or collective cognitive maps are based on some action theories, highly specific, and potentially incompatible with other firms because they represent a lasting organizational truce and a compromise among its members. Argyris and Schön define an "action theory" as a complex system of norms, rules, beliefs and strategies embedded in the firm's know-how (Argyris and Schön, 1978). If firms detect a mismatch between their objectives and the results observed or some dysfunctions, they can modify the theory-in-use or try to do so. Organizational learning occurs in cases when there is a modification and a restructuration of a theory-in-use or when new frameworks are defined. The definition of new frameworks is rather unusual, because it is difficult to learn about learning or to engage an unlearning, to forget existing routines and to invent new ones. For this reason, Argyris and Schön suggest two main steps occur in this learning, according a terminology developed by Bateson (1977). The first level of this learning occurs when the firm engages in a "single-loop learning", *i.e.* an incremental change inside a specific framework which remains the same. The second level, called "deuroto" learning consists in learning about the process of learning itself, *i.e.*, the framework in which action theories are defined is restructured involving new cognitive maps and new rules for evaluating the impact of current practices.

Cognitive boundaries during cooperation and combinative capacity

Learning is very important because cooperation entails a confrontation between two divisions of innovative work which can also create a new knowledge combination. The restructuration of the existing knowledge can benefit from the diversity of each corporate culture and the association of such diversity can bring about new combinations which is a source of innovation as described by Schumpeter (Schumpeter, 1934). The association of two different corporate cultures is however highly dependent on experience of cooperation and the prior knowledge firms have about it. This combination, linked to the "absorptive capacity" of each firm, can also create some organizational conflicts. Prior experience facilitates the association of different frameworks because each firm has its own heuristics for solving problems which gives a background for further cooperation. This knowledge providing experience for related problems – *i.e.* a capacity of overlapping–, is not sufficient because the ability to assimilate new knowledge depends on the richness and diversity of pre-existing one (Cohen and Levinthal, 1990).

Let us illustrate this point very briefly with two short examples. Renault Automation, a French robot producer, was used to cooperating with few partners at beginning of the 1980s. In fact, this firm was cooperating with only two French users and was developing specific solutions according to their needs. Most of the technical solutions were experienced with hydraulics, very far-away from the electrical way of conceiving robots that all foreign producers had adopted. This firm had progressively reduced its capacity to absorb different backgrounds of knowledge and was unable to cooperate with German or Italian users during the mid-1980s, first because its technical culture based on hydraulics was very different from the electrical one, but secondly because the habit of cooperating with two French firms had also reduced its capacity to understand different ways of solving problems and different ways of welding. On the opposite side, Comau used to exploit the diversity of knowledge through cooperating with Italian, German, French and English users. Its considerable absorptive capacity was reflected in its great innovative capacity over time and in its increasing market share on the European market during the 1980s [4].

The combinative capability during cooperation is the capacity to efficiently exploit current knowledge and to create new combinations by integrating new ideas and by articulating existing know-how in another way [5]. The combination of ideas can be very creative but also quite destructive because the confrontation of two different corporate cultures may not be able to be associated in a harmonious way. Combining ideas is not, simply a question of additional knowledge between two firms but the ability to associate two cognitive frameworks and create a new one. If prior knowledge can facilitate the assimilation and the exploitation of new knowledge, a trade-off between assimilation in the neighbourghood of existing one and assimilation distant from the existing one, has to be defined. This dilemma between exploitation of current knowledge and the need to explore new cognitive dimensions is a recurrent problem in learning (March, 1991; Arthur, 1991).

Indeed combinative capacity plays a prominent part for restructuring current knowledge and for generating a more general one. This the reason why combinative capacity may facilitate the implementation of a deutoro learning far-away from prior experimentation. Nevertheless, as I shall describe below in my empirical study, this process is more complex in industrial relations. Moreover learning, incremental or radical, is not an automatic process. In order to be built, learning needs specific investments. These investments in communication, in technological field and organizational coordination try to unify differences in corporate cultures, as shown in the next section.

II. KNOWLEDGE DIVERSITY AND SHARED FRAMEWORKS DURING COOPERATION

The potential confrontation of two different corporate cultures may be overcome by the creation of shared knowledge facilitating the coordination of the new organizational structure, decreasing uncertainty about cooperation and deliberations. As Crémer (1993) has underlined, such knowledge is very useful for improving communication within an organization and increasing efficiency. The creation of a commonality of knowledge is a long learning process, essential for creating an organizational identity specific to the agreement. If shared knowledge helps cooperation through a better coordination, this process is not the only aim of cooperation: too much commonality can reduce knowledge diversity and shorten the innovative capacity. A trade-off must be observed between commonality of knowledge and diversity promoting creativity and innovation (Marengo, 1995). In my

empirical investigation, I have observed different ways to reduce this diversity with rules and routines on one side, shared language and trust on the other.

Rules and routines

Rules play an important part for coordinating the cognitive background of two different firms and facilitate cooperation by implementing time-saving mechanisms which are very useful in the case of repeated interactions. Rules are collective knowledge that save individual knowledge (*i.e.* they substitute complexity of individual knowledge, such as why a robot has a particular kind of problem, for the simplicity of collective knowledge such as, how to repair it quickly), (see Favereau, 1989, 1995). More precisely, a rule is a prescription one may conform to it and which indicates what behavior is allowed or prohibited in a particular context (Shimanoff, 1980). Following a terminology borrowed from Holland, we can observe different types of rules according to their capacity to integrate interpretative principles (Holland *et al.*, 1989). Empirical rules for example prescribe actions to be taken on the environment with a low modification in the state of knowledge inducing a single loop learning, whereas inferential rules tend to modify empirical rules and to produce better ones. These latter may be interpreted as "meta rules" leading to some basic changes in current knowledge, *i.e.* double loop or deutoro learning in existing frameworks. Routines in these conditions are defined as empirical rules because there are composed most usually of sequences of action that proceed with little conscious deliberation [6].

In my investigation I have noticed different empirical rules. The first one, that I noticed among the firms, is about the after sales services. These services, which are essential in the user/producer cooperation and crucial for the renewal cooperation with the same producer in the next cooperation, play a prominent part in building trust. The rule quoted in France and Germany is that services provided by the producer during the beginning of the process are including in the robot price (help for implanting the robot and general maintenance after the process of exploitation). Specific services for bringing a change in the process must not exceed 30% of the robot price. A second empirical rule among users and producers dealt with the financing of the specific development during a technological agreement (the cost of this development which exceeds the normal development of a standard solution, has to be shared among the two firms). But this specific development gives a signal or an informal guarantee to the producer that, for the next robot

purchased, he would be able to profit from his specific investment by a substantive order from the user.

A third empirical rule for limiting a strong dependency among the two firms in Germany, is that the number of robots from a specific producer must not exceed 80% of the amount of robots held by the user. In Italy, this rule is not so explicit despite the strong position of Comau (around 70% of the applications). In France, the situation is more contrasted and path-dependent on the story of each producer. For Renault, the rule is to buy robots from Renault Automation even if the prices are higher, but for Peugeot, the rule is to diversify the purchase of robots in order not to be too dependent on one producer, that is the reason why in this latter firm the total amount of robots from one producer must not exceed 50%.

Inferential rules, more generally, are observed for fixing "meta- rules" about technological appropriability and for regulating opportunistic temptations. Their aim is to stabilize technological development, to allow certain clarifications in the transferability of technical solutions, and to provide a compromise between collective interests (*i.e.* the rapid dissemination of innovative solutions) and the individual interests of the user (*i.e.* to preserve the exclusivity of his solution). When specific developments are implemented, a compromise must exist about the solution transferability among other users. For example, in the case of the creation of specific off-line software for monitoring the robot, the technical solution and its methodology is transferred, but the data of this specific software remain confidential. If these rules are contextual and specific to each particular cooperation, the general tendency is to maximize the dissemination of innovative solutions after maintaining exclusivity for a short time.

Shared language and trust

Shared language is an important lubricant in cooperation because, as Brown and Duguit (1990) have underlined through the notion of "communities-of-practice" learning occurs in a specific context with the building of its specific professional culture and its own specific language. Learners do not construct abstract knowledge but this knowledge is included in a community which allows firms to acquire a subjective view point and to learn the main objectives of this small entity. In some cases, regional proximity may help the construction of this specific language (as we observed in Germany) but most of the time professional language between the two firms overcomes cultural distance and creates shared frameworks. This language plays an

important role for sharing and exchanging tacit knowledge between the two firms and translating different "bodies of knowledge" across organizations. As Brown and Duguit recognize "Abstractions detached from practice distort or obscure intricacies of that practice. Without a clear understanding of those intricacies and the role they play, the practice itself cannot be well understood, engendered (through training), or enhanced (through innovation)" (Brown and Duguit, 1991, p. 40). The transmission of collective knowledge and its interpretation helps to understand, through narration, the way the other firm solves problem *in situ* and to build a shared understanding when facing technical problems. This effort of translation explicits non canonical practice and tries to incorporate some know-how in a more formal way, allowing a better transfer from one organization to another.

This "learning by working", based on trust, creates a new knowledge which is specific to the cooperation and thus new technological, relational and/or organizational assets. These specific assets are more stable if they are not limited to occasional ties between two teams and reduced to human relations between two organizations and personal trust. That is the reason why organizational trust between two firms may emerge to stabilize technological cooperation (Dodgson, 1993). In my empirical study, I mentioned that shared language and personal trust were, most of the time, a first step towards the construction of an organizational trust based more on the duration of inter-firms relations than on geographical proximity.

This process however takes time because one does not have trust ex-ante, therefore trust may be interpreted as a learning dynamics [7]. During cooperation trust turns into a highly specific and idiosyncratic asset which is difficult to transfer to another instance of cooperation. Indeed, contrary to reputation, which is collective knowledge, trust cannot be transferred from one relation to another (Ouchi, 1980). Assets specificity stabilizes cooperation and generates mutual interdependency and even lock-in, as I shall show below. This cumulative investment, which facilitates further cooperation, is a transactional type of capital based on a system of reciprocity (Palay, 1984). Schrader (1991) has underlined this point in an empirical test showing that firms in agreements exchange know-how and are expecting important benefits in the long-run. This creates expectations about the next benefits from cooperation and some specific rent to exploit in the long run [8].

If there is a strong imbrication between shared language and trust, in my case studies, this one may not be automatic and path-dependent on the story of industrial relations and the institutional context. What is important for cooperation, is that the combination of all these shared frameworks stabilizes

agreements and creates externalities which are two-sided: on the one side, this implies following a specific pattern without looking for new procedures; and one the other side, this learning can bring some strong path-dependency that may impede future innovation. This point will be more precisely described in the next section.

III. PATH-DEPENDENCY AND ORGANIZATIONAL INERTIA

In my empirical investigation, I have noticed a rather high intensity of organizational inertia, once cooperation is launched. More precisely, in eight cases of cooperation between users and robot producers in France, Germany and Italy, which lasted around ten years (with a renewal of the technological project), I observed four cases of organizational inertia: the technological cooperation never stopped, and new projects were always engaged; two cases of high stability: cooperation was always going on between the two firms but there was a capacity to cooperate with other robot producers if complementary assets [9] were needed for the user. This generated a faithfulness in the cooperation which did not prevent the user from having other technological projects; and two cases of organizational flexibility [10]. In this latter case cooperation had been rather occasional and could perhaps be reactivated, but at the time of evaluation, because of the low coordination between the two firms, one could not predict whether the agreement would be renewed in the future.

I observed that the probability of inertia increased with the lenth of cooperation because the more shared frameworks were implemented, the more organizational memory was an important impedement to changing the way of cooperating [11]. In some case studies, organizational inertia was present with a low level of learning, a continuous decrease of innovative capacity and a low combinative ability. This high stability was implemented as a way to stabilize learning and to exploit current knowledge instead of initiating innovation (a rather risky and costly process for the two firms). In a word, the situation was paradoxical: the more successful the cooperation and the more important shared knowledge the more alliance was routinized and the more scattered was the exploration. This process can be better understood through three points, discussed below: 1 – the efficiency of learning and the reluctance to explore new ways of cooperation, 2 – "lock-in" and shared frameworks, 3 – profits from learning externalities.

The Efficiency of learning and the reluctance to explore new ways of cooperating

Learning is confronted with an important dilemma as pointed out by March (1991) of exploiting current knowledge without trying to renew it, *i.e.* without explorating new uncertain heuristics not profitable from a short-sighted point of view. Even if this exploration is not profitable, an innovative firm has to continue this exploration in order not to exhaust its initial background of knowledge. At the same time, an organization has to benefit from the exploitation of current knowledge and cannot always exploring new heuristics without exploiting them. This situation implies a trade-off between these two dimensions which is difficult because of the self-reinforcing nature of learning. Strong externalities and strong benefits from actual specialization tend to delay the need for exploration. Moreover, exploration generates a process of unlearning current routines, increasing this difficulty (Hedberg, 1981).

This difficult dilemma can lead to a competency trap occuring when new organizational procedures are not accepted even if the current organizational procedure is inferior (Herriott, Levinthal and March, 1985). This competency trap, due to over-specialization, may generate a myopia in the learning process, because short-run aspects are overestimated and the long-term perspective of learning underestimated (Levinthal and March, 1993). In the perspective of cooperation, this means that short-run efficiency tends to develop knowledge in the close neigbourhood of the current capabilities rather than to innovate. This process is self- reinforcing by the ability of an organization to build its own "models of the world" and its own cognitive map (a way to solve problems).

Exploiting technological opportunities within an existing paradigm may lead to single- loop learning whereas double-loop learning may be required for finding new combinations of knowledge. Insufficient informational feed-back may accelerate this process, by reducing the diversity of the different backgrounds of knowledge. For example, if a producer has only a few privileged users, he may be "locked-in" in specific options connected with users' need thus decreasing its explorative capacity.

Lock-in and specific investments

The reluctance to explore new backgrounds of knowledge can be better understood by the immaterial investments engaged in cooperation for creating

routines, rules, trust and financial investments which lock the firms together and impede organizational change. These material commitments and the immaterial ones tend to create a strong interdependency leading to new investments linked to prior ones. In the case of cooperation breaking down, important sunk costs are lost thus diminishing the attraction of new agreement. Facing uncertainty in the cooperation with a new robot producer, the user tends to overestimate these costs and to exploit the externalities of the current learning.

These investments – either material or immaterial– create specific assets: i.e. investments made in a specific context with greater value in the existing coordination and which cannot be transferred to another cooperation without loosing part of their value. In the case of cooperation breaking down, the capacity to switch these investments towards a new user is low. Williamson has described these assets very well (Williamson, 1985). If one cannot be in agreement with him about the opportunistic way he considers cooperation, one has to recognize the crucial aspect of these assets which may be seen as a "credible commitment" of one firm towards its partner. Specific assets engaged by the robot producer may improve the cooperation because they give a *signal* to the user that he is able to invest in the cooperation and this may encourage the user to do so. More generally, these specific investments create incrementally strong interdependencies which reduce uncertainty, strengthen trust, but on the other hand constrain organizational flexibility of the two firms which become gradually prisoners of earlier commitments.

Moreover the interaction of material and immaterial investments tends to obscure the effort to evaluate cooperation and to lead to the renewal of the same learning over time, which may decrease creativity. With few objective criteria for judging the present benefits of cooperation, firms tend to exploit current knowledge coming from actual cooperation, rather than exploring new one [12]. This is due to the fact that learning dynamics, based on bounded rationality and direct experience, is an imperfect process based on an incomplete panorama of the world (Simon, 1976; Arthur, 1991). Consequently continuity is not always relevant for evaluating success or failure in learning (Hamel, Doz, Prahalad, 1989). In some cases, continuity in cooperation is going on despite an increasing dependency of one partner, and sometimes cooperation stop means that learning objectives have been reached. I shall describe, in the case of Renault Automation, how organizational inertia has brought some competency trap. As this relative failure was not acceptable, the best way to justify it was to continue cooperation and to deny the importance of this "lock-in".

Benefiting from learning externalities

The low proportion of firms which stop cooperation may also be explained by their willingness to benefit from externalities. Learning is a self-reinforcing process and positive feed-backs produce increasing returns which tend to lead cooperation down specific paths, even if other options would have been better (Arthur, 1988). This path-dependency is not only technological but also organizational (Levinthal and March, 1981).

These externalities in inter-firm coordination have been very well described as an organized market (Marshall, 1919, 1920). The aim of this organized market is to minimize transaction costs through informal agreements. Each firm therefore creates its external arrangement which requires time and specific resources because it includes the building up of a reputation and an adequate understanding of the different partners. The building of this capacity generates supplementary costs for the manufacturer and generally increases the costs that the customer is willing to pay. These additional costs tend to stabilize the relation and to create network externalities. The relational rent will be lost in the case of high instability during inter-firm coordination (Aoki, 1988). Aoki has defined it as specific returns that contribute to increasing informationnal efficiency. If this relational rent plays a crucial role for stabilizing cooperation, this latter is not only relational but also organizational. The dilemma for the firm engaged in cooperation is to benefit from these rents without avoiding to explore new options. An organizational balance has to be found for creating specific resources in cooperation which can also conciliate technological reversibility: "Organizational balance depends on the formation of quasi-rent, that is to say, the creation of specific resources at the scale of the collective, global organization. Satisfying this condition organizational balance requires a fidelity to linkages and a conception of inter-firm organizational architecture appropriate to the effective interaction of resources from different organisations" (Foray, 1991, p. 401). As we will see below, this balance between exploration and exploitation in empirical cases, is not easy to obtain!

IV. SOME EMPIRICAL EVIDENCE IN THE ROBOTIC SECTOR

I shall now examine in more details three examples of cooperation giving an illustration of the prior discussion. I shall show how a French robot producer has not benefited by cooperation and has decreased his own combinative capacity through an over-specialisation in one technological option. On

the opposite, an Italian producer has continuously improved his knowledge background through cooperation, and has benefited by double loop-learning. Finally, an international producer is considered who has provided some new perspectives in learning to a French user and has tried to change its current routines.

Lock in and competency trap: the case of Renault Automation and Renault

Renault Automation and Renault have a long story of cooperation which began in the early 1980s with the conception of pincers for a welding robot. The servo-mechanism which regulates the speed was neither pneumatic nor electric but hydraulic. The cooperation was for the conception of this servo-motor. This technical solution had many advantages and allowed a higher productivity on the welding robot (*i.e.* a higher number of welding points compared to the electric enslavement). As productivity was good, the number of welding robots decreased in the process. Renault had a great devotion to this technological project because it had suggested the idea and also because the short-run technological performances were better. From another point of view, there were many inconveniences in the use of this technological solution due to high exploitation costs. Hydraulic servo-mechanisms were very sensitive to pollution and cleanliness. Moreover this solution required the working of a small hydraulic power-station in which learning was important. All servo-mechanisms were hydraulic or hydro-electric and the main motor was conceived on a hydraulic system involving a specific path for solving problems and the use of a particular trajectory for welding. This technical solution was so specific that it was impossible to transfer it into a German or an Italian process.

During the 1980s, the electric trajectory showed progressively increasing returns and positive feed-backs that implied for many robot producers to transform their specific know-how through the electrical solution (Lazaric, 1992). Renault Automation continued the development of technical solutions around hydraulic trajectory, whereas all producers gave up this solution in order to benefit from economies of scale in electric components. Renault did not accept this change because in its particular context, performances were better with hydraulics. Moreover there were no objective reasons for the producer not to continue in the same direction of improving its own current installed technical bases. Accepting the electric solution implied an important unlearning process, a change in corporate culture and some technological

incompatibilities. For the producer, the hydraulic solution was an important competency trap that was closing out foreign markets and prevented it from benefiting from the diversity of knowledge of others users [13]. When Renault Automation realized this "lock-in" at the beginning of 1985', it had already lost foreign market shares and had to invest for learning quickly in another background of knowledge. Renault, however, was reluctant to adopt this new solution and continued to buy hydraulic robots [14]. This implied in fact such organizational reconfigurations and unlearning in current routines for the user that the firm was unable to consider some changes even if its producer was gradually evicted from the robotic sector.

Exploring knowledge diversity: the case of Comau and Mercedes

Comau has a rather similar story to Renault Automation because its technological development has been led by a specific user which created many innovative solutions. The first one, resulting from a close cooperation between Comau and Fiat, was the "Robogate", a very famous welding system integrating robot and engineering processes into the same conception. This solution allowed a good synchronization of product and process and created a new knowledge combination, based on a specific methodology for welding. The cooperation between the two firms was constant between 1976 and 1982 and was less regular after. Nevertheless, Comau has continued to innovate in this system by integrating new users' constraints. Whereas Fiat was not willing to invest in new technological cooperation and wanted to exploit a technical solution for stabilizing the process, Comau began to explore new technical opportunities with foreign users.

The agreement with Jaguar in 1985 was illustrative of this new way of working and the cooperation with Citroën and Mercedes had the same function. This exploration was crucial for Comau which had an important know-how in the machine tool business and needed to transform it by integrating new backgrounds of knowledge coming from its users. For example, the corporate culture of Comau was that the equipment had to last a long time, even if short-run performance characteristics were low. But for users the short-run performances were more important than the mechanical structure implying some modifications in the conception for integrating these new requirements.

This combinative capacity may be given by the cooperation between Comau and Mercedes in 1991 for a welding system which took as dominant design, the "Robogate" [15]. In the case of Robogate, user and producer were adapting

the welding system to the plant configuration, but the particular configuration of the Sindelfingen plant transformed the routinized way of working. These new constraints of the configuration were integrated, transforming the welding system and bringing new innovative solutions in car accosting (*i.e.* in the way the robot approached the car). Instead of exploiting the same methodology and routines, which limited organizational learning to a single loop, Comau succeeded with its different partners to recombine existing technical solutions and organizational procedures for improving and renewing its own learning. Contrary to the case of Renault Automation, the confrontation of different ways of working and solving problems increased the firm's own combinative ability.

This example is also illustrative of a different way of producing knowledge. In this case, the producer was able to create a specific solution and to use this local knowledge for creating new experiments. Comau has the capacity to extract from practice abstract knowledge and to transfer it in another context. This ability to generalise a specific know-how and to articulate it in universal categories for bringing new combinations is, as recognized by Arora and Gambardella, a crucial point for innovation (Arora and Gambardella, 1994).

Learning to learn: the cooperation between Renault and ABB

ABB is an international firm resulting from the association of two robot producers (Asea, a Sweedish company and Brown Boveri, a Swiss company). This firm has few technological agreements with French, Italian or German users because its research capacity is localized in Sweeden. Of course technological agreements do not always need geographic proximity, but in the case of the robotic sector a laboratory located not very far from the user is required most of the time because cooperation is created after a period of mutual experimentation providing for the two partners an idea of the way of working.

These repeated interactions create the beginning of the technological agreement renewed in many cases, because of the presence of potential externalities to exploit in a future cooperation. This path-dependency generates one way of cooperating, most of the time a single loop-learning, rather satisfacing because a firm needs not always to explore new procedures, but to capitalize knowledge. As showed with the example of cooperation between Renault/Renault Automation, the myopia in learning process can bring some competency trap. This the reason why, in some cases, cooperation with a new partner without shared frameworks and past may be very

innovative and may bring new rules in learning. I shall illustrate this process by the cooperation of ABB and Renault –an occasional agreement– which had been very innovative.

At the beginning of 1991, ABB was cooperating with Renault for an off-line monitoring process and trying a new methodology for working. In the usual way of monitoring robot, experimentations and tests are made after robot installation. This process is rather long because it needs many tests and technical validations for connecting problems before launching a new car. ABB convinced Renault that a cooperation before launching was necessary and might provide some significant improvements during this period, reducing delay time. In fact, this off-line monitoring software was not radically new and had been experienced by many users as a way of improving process/product synchronization. For Renault this new technological project was changing radically the way that the firm was usually working and created new routines. ABB and Renault had, for example, conceived together a plant configuration for the new car and this work brought many questions about the traditional way that the user was making automatization. Renault learnt a lot: the experimentation time during the launching car period was divided by two, compared to the traditional methodology. In this case, corporate culture between the two firms brought some confrontations in ideas and an important learning different from the prior learning experimented with Renault Automation. This double-loop learning was facilitated by a low organizational memory which had not closed the way of explorating new options. If this kind of learning has required the creation of meta-rules, *i.e.* new inferential rules according to Holland's terminology, this rather unexpected experiment because of the ties' yough and the low organizational trust between the two firms, remained only local. Indeed Renault was for example unable to spread its new methodology through other plants for using it in another context. This low absorptive capacity of the user shows also the limits of this kind of learning if prior knowledge is not present.

CONCLUSION

Organizational dynamics during technological agreement plays an important role. More precisely, my empirical investigation shows the capacity of innovative firms to learn and to take advantage by associating backgrounds of knowledge. This association can bring new combinations and a creative process if some conditions are met. Indeed, combinative capacity is highly dependent on absorptive capacity of the two firms and prior knowledge, but

also on the organizational capacity for creating a specific identity to the cooperation and a new corporate culture.

Shared frameworks try to unify knowledge diversity through routines, rules, shared language and trust and provide also some convergent anticipations about the future of cooperation. At the same time, these immaterial investments stabilizing agreements create specific assets difficult to transfer to another cooperation. Immaterial and material investments create strong incentives for continuing cooperation and the same type of learning. As I noticed in my empirical study, the more cooperation has an important memory, the more difficult it is to learn about learning because it is easier to exploit the benefits of an actual cooperation than try to invent new rules. This path-dependency provides exploitation of current learning externalities and avoids exploration of new ways of learning because short-run efficiency crystallizes learning and decreases the innovative capacity. Even if an organizational balance has to be found for preserving investment reversibility, my empirical study shows that this process is difficult and contingent from the story of industrial relations and from national systems of innovation.

Notes and references

1. For some exceptions, see Schrader (1991), Dodgson (1993) and Ingham (1994).

2. The nationality is according that of the producer. This study has been funded by the French Ministry of research with the HTT program. We would like to thank Mr. C. Henry for his support. For the complete results of this study, see Lazaric N. (1993). The evaluation concerned the technological aspect of learning (nature of the trajectory, transferability of technical solution, appropriability regimes, etc.) and the organizational dynamics of learning (single-loop learning, double-loop learning, organizational memory, organizational inertia, routines, rules, etc.). In this contribution I shall focus on the organizational dimension of this cooperation. I define cooperation agreements as subunits quasi-independent from the owner firm, constituting a specific organization.

3. For an illustration of this point in information technologies, see Hagerdoorn and Schakenraad (1991). 33% of agreements in this sector follow this motivation.

4. For more details, see below our section IV.

5. For a similar discussion, see also B. Kogut and U. Zander (1992).

6. According to Nelson and Winter's conception, a routine is "in a highly specific way, much as a 'program' is used in discussion of computer programming. It may refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance" (Nelson and Winter, 1982, p. 97). Routines are composed of sequences of action that proceed with little conscious deliberation because some behaviors become automatic after repetitions. This automaticity gives organizations efficiency and a structured way, rather satisfying, for dealing with a problem and giving quick responses. I am referring here to static routines and I am not discussing dynamic routines very closed in their principles to inferential rules. For a discussion on static and dynamic routines, see Dosi, Teece and Winter, 1992.

7. For a longer discussion on this point, see Lazaric and Lorenz, 1995.

8. In this perspective, trust may be defined as a set of beliefs on the future behavior of one agent and more precisely "the decision of an agent to place trust in another depends on her believing that he will act in a way that makes her better off rather worse off. In general when we say that an agent trusts another we are referring to this background of *belief*" (Lazaric and Lorenz, 1995, p. 2).

9. For a precise definition of complementary assets, see Teece (1986).

10. Organizational flexibility means for us a high instability in cooperation and the capacity to learn from different organizations without exploiting the benefits from learning externalities.

11. We observed cooperation between the two firms over the last 10 years but some time this agreement was older than the evaluation period (more precisely in the case of Renault/Renault Automation, Renault/PSA, BMW/Kuka, Mercedes/Kuka, Fiat/Comau, Comau/Mercedes).

12. In the case of uncertainty with regards to future options, it is rational to wait for additional informations and to preserve existing routines for avoiding rapid decisions without pertinent informations (Heiner, 1988). In the case of new learning opportunities, firms will compare actual performance which benefits from important externalities with uncertainty with the new partner.

13. Renault Automation could not sell in foreign country and moreover gradually decreased its market share in France. Its market share in the French market was more than 60% at the beginning of the 80 and was only 27% in 1992.

14. The only French producer who accepted to experiment electric robots was at that time PSA, which supported this new option by substantial purchase. In fact this purchase was risky because the electric system had many problems and was just at the beginning of the first trial and error procedure!

15. This cooperation between Mercedes and Comau which created the Rotogate has benefited from important learning externalities with other users. Indeed Comau had in 1986 a cooperation agreement for improving the Robogate on the E 30 model. Comau had tried to improve this system in 1988 with BMW when the E 34 was launched but this very ambitious project, failed because of time delay and it too important material investment for the two firms. The failure was relative because gave to Comau a good experience for the cooperation with Mercedes three years later.

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