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Technological Centers as a Negotiated Context to Combine Technological Capabilities

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Abstract Recent perspectives on a capabilities view of the firm often recognize the need for firms to develop an external organization. From a relational view of the industry, the external organization may include economic and non-economic exchange relationships. The decision to combine both types of relationships and its relevance for the firm can be linked to their role for accessing, generating and diffusing knowledge. More often than not, these decisions are however not unilateral. This paper discusses the potential role that Technological Centers (TC's), created by the collective initiative of some local firms, can play as part of firms' external organizations and emphasizes TC's role in connecting economic and non-economic exchange relationships. It is further suggested that the diverse motives and benefits perceived by firms in relating in and across the TC's and, in general, the relevance of sharing experiences within these contexts, should be seen in the wider context of firms' specific and idiosyncratic trajectories.

Keywords Inter-organizations collaboration · Socio-economic context · Inter-organizational capability building · Industrial districts

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1 Introduction

It is commonplace to say that the amount of knowledge generated in firms has been increasing at growing rates.[1] This may translate into a substantial growth of the range of areas of knowledge that firms will have to cover (Pavitt 1998) both within their proprietary boundaries and through relationships, because those processes should be seen as involving the interplay of different actors (Håkansson 1987; Håkansson et al. 1999; Araujo et al. 2003). In particular, buyer/supplier relationships acquire strategic relevance as the increasing division of labor and knowledge may be accompanied by the need to integrate and develop knowledge within and across firms. However, as Easton and Araujo (1992, p. 63) noted "economic exchange relationships have dominated the theoretical and empirical work on industrial networks and direct relationships not of that kind have largely been ignored". This also means that knowledge creation is usually seen through the lenses of economic exchange relationships between buyers and suppliers. There seems to be no reason for this because direct and indirect relationships between firms and research institutions, universities, industry associations, or other institutions may "have a continuing impact on the operation of the network as a whole" (Easton and Araujo 1992, p. 68). This seems to be particularly true with regard to the issues of technological development.

This paper seeks to discuss how the relationships that firms deliberately establish with Technological Centers (TC's) become relevant in the forming of the frameworks that they build for analyzing their operating context, particularly when they explore ways for dealing with the issues of designing and producing complex equipments. To that purpose, lacking a better label, we resorted to what Foss (1999) has called the neo Marshalian approaches to the dynamics of industrial systems. These perspectives share with the industrial network approach the notion that "the industry/the network is more than the sum of the capabilities of firms" (Foss 1999, p. 7). This perspective, by accommodating the presence of connected relationships in the industrial system, supports the need to look at the relevance of the relationships with and through TC's in the context of other relationships, namely vertical relationships between suppliers and buyers.

The paper starts, in Sect. 2, by combining those perspectives and defining the dimensions of interest for the evaluation of the potential of firms' relationships with TC's. In Sect. 3 we present some empirical illustrations, based on the cases of two firms and a technological center. In the final section of the paper we advance some concluding remarks.

2 External Organization and Connected Relationships—The Role of Technological Centers

The evolutionist perspectives of industrial systems have stressed the role of the generation of knowledge in industries and the importance of maintaining variety in the

[1] As Hudson (1999) says, looking at firms and industries from the knowledge perspective may become nearly obsessive and also give out the wrong idea that the role of knowledge in our society is an entirely new phenomenon.

institutions involved in such processes (Loasby 1999). It has been frequently underlined that those institutions can go well beyond firms, for example, in the studies on innovation systems (e.g. Lundvall 1992) or industrial agglomerations (Kirat and Lung 1999; Maskell 2001; Romero-Martínez and Montoro-Sánchez 2008). Additionally, as knowledge is partially tacit, limited and dispersed in nature (Hayek 1945; Polanyi 1966), firms, which are often conceived as fixed entities that control and decide about given resources, can instead be seen as dynamic and idiosyncratic entities with unique capabilities that underlie the extraction of services from the resources they control (Penrose 1959/1995).

The external circumstances of any particular firm are, at least to some extent, unique (Tsoukas 1996; Araujo 1998). In particular, firms are not "islands" of planned coordination in a sea of market transactions with anonymous entities (Håkansson and Snehota 1989, 1995). This perspective is consistent with the pioneering work of Richardson (1972), who argues that closely complementary activities (i.e. those requiring quantitative and qualitative matching) can be coordinated either within the firm or through relationships with other firms. The latter are favored when dissimilar capabilities have to be deployed in closely complementary activities. As Loasby notes (1998a), "the role of such relationships goes beyond the mere access to existing capabilities, as several other benefits (e.g. the development of new product and process) may result precisely from the connection of very dissimilar and closely complementary capabilities". However, as time matters when knowledge and learning matters, the perceived degree of similarity is closely related with the evolutionary path of each firm and the variety of its experience through time (Loasby 1998a).

This vision of firms and industry suggests not only the emergence of a dense network of relationships among firms (Richardson 1972) but also, with relation to the 'external organization' of each firm (Marshall 1920), that "such capital, of course, does not appear in the balance sheet (it would be very inadequately represented by the valuation of brand names which has recently been advocated); and it certainly is not suitable for aggregation" (Loasby 1991, p. 41).

The open (i.e. incomplete and dynamic) nature of these complex systems of connections among capabilities (Loasby 2001; Potts 2000) and the rejection of straightforward valuations of those connections and their aggregation are consistent with the notion that industrial systems can be seen as networks of partly connected and counterpart specific relationships. They are also essential for understanding stability and change in networks (Axelsson and Easton 1992; Håkansson and Snehota 1995). This means that an additional dimension for variety among firms and the generation of competitive advantage may reside in their different ways to influence and use the relationships in which they are embedded (Dyer and Singh 1998; Lorenzoni and Lipparini 1999; Moensted 2007).[2]

The development of new products and processes is often present in these inter-organizational contexts, as the forces for stability and change may acquire a greater

[2] As Loasby (1998b, p. 174) puts it, "…[a] firm may achieve distinctive advantages through the ways in which it combines external capabilities with its own". See Mota and de Castro (2004) for a discussion of how connected and partly counterpart specific relationships can help explain changes in firms' vertical boundaries and Araujo et al. (2003) for a discussion on the multiple boundaries of firms.

visibility, and extend beyond the proprietary boundaries of each firm. For example, the notion of product as a 'network entity' (Dubois and Pedersen 2002) reflects not only the emphasis given to interactive developments between suppliers and clients (Ford et al. 1998, 2002) but also the occasional need for firms to act on the networks of relationships in which they are embedded (Gadde and Håkansson 2001).

However, the usage of relationships for mobilizing resources and knowledge can go beyond supplier-customer relationships, in particular for technical developments: "Potentially there are a large number of different actors that can be involved in a technical development project together with the focal company. They can be suppliers of equipment, components, material, etc., customers or customers' customers, trade research institutes or departments of universities, consultants or producers of complementary products, and competitors" (Håkansson 1987). This suggests that other relationships, beside supplier–customer relationships can have important roles both for focal firms and for the network. Non economic-exchange relationships can vary from strong to weak and they can involve technical, knowledge or social dimensions (Easton and Araujo 1992).

The point to be made so far was that the knowledge system is not a mirror of (isomorphic to) the production system alone. Other institutions and relationships may have a role on the firm's access to new knowledge and the generation and diffusion thereof (see for example Bell and Albu 1999). We will argue that such institutions may include TC's as counterparts to a firm's strategy to pursue the improvement of its owned or accessible technical knowledge. We will further suggest next that the potential of TC's can be associated to their role in connecting and spreading tacit and/or codified knowledge among a variety of firms, including rival firms.[3]

In fact, TC's may provide participant firms with valued potential benefits in terms of learning, by allowing them to directly or indirectly access the experiences of other firms, including rivals (Mas-Verdú 2007). The generation of benefits in terms of learning may be associated to the presence of indirect relationships as then direct interaction or trust between rival firms are not required (Malmberg and Maskell 2002; Maskell 2001). Such potential for learning ensues partly from cognitive proximity, i.e. the existence of a common language and some diversity, albeit residual, in the experiences of the parties, "because they do things a little differently—but in ways that are easy to understand" (Loasby 1998a, p. 155). This same view has been advanced in the literature about innovation systems and industrial agglomerations (Lawson 1999; Lundvall 1992; Maskell 2001). In fact "…variation emanates naturally when firms with somewhat similar bodies of knowledge must act on incomplete and uncertain information" (Malmberg and Maskell 2002, p. 439). This suggests that firms may consider, in their capability building decision processes, the advantages of accessing a variety of experiences beside those they confront in the context of supplier–customer relationships. In other words, the possibility will arise for firms to explore farther the existence of a common or very similar language.[4]

[3] For example, Langlois and Robertson (1995) base much of their discussion about the boundaries of firms on processes of codification and diffusion of knowledge.

[4] Also, some methodologies have been suggested to identify potentially interesting counterparts (see, for instance, Capó-Vicedo et al. 2008).

It may the asked whether these possibilities will become available only when firms are co-located in industrial agglomerations. It is certainly not clear that co-location of rivals should be a necessary condition for the materialization of the benefits from participating in TC's. Loasby argues that, whether localized or dispersed, "coordination within an industry... is easier if assumptions are shared and rivals are recognized as contributors to the growth of knowledge" (Loasby 1999, p. 83).

The same question can be considered from a different perspective. Brown and Brown and Duguid (1991, 1998, 2001) discuss the permeability of firms' boundaries in terms of what they call communities and networks of practice. They argue that firms join together different communities of practice, and such communities are inserted in networks of practice that cross the proprietary boundaries of firms. We might note that the recent surges in the development of information and communication technologies allowed the extension of networks of practice across virtual environments, the consequences for knowledge transfer and attainment being contingent on the means used (Griffith and Sawyer 2006). Firms that recognize these possibilities may find it useful to initiate actions aiming at participation in networks of practice in order to share of their partly tacit knowledge (Knight and Pye 2005). Thus they will become better able to appreciate small variations in the experiences of those involved in such networks (Tagliaventi and Mattarelli 2006). It can also be admitted that firms' relationships with TC's may take the form of weak links (Granovetter 1973; Håkansson 1987), thus creating loosely coupled networks which may operate as mechanisms to counter the potential for excessive lock-in, be it at the level of firm or at industry level (Best 1990; Grabher 1993).

A final issue is the possibility for firms to loose out to their competitors some of the secrets that they would rather retain for themselves. This can be an inevitable consequence of building a network of relationships (Foss 1999). Brown and Duguid (1998) suggest that firms may seek to counter such flows "but cutting off the outflow can also cut off the inflow of knowledge" (p. 103). Besides, even if such knowledge becomes codified, the ensuing benefits for each firm will depend on its integration in the firm's specific system of connections, or 'administrative framework'. Loasby (1998b, p. 177) expresses this idea quite nicely: "A productive opportunity may well depend on a conjunction between 'knowing how' and 'knowing that' .... Even though the knowledge may be public, the connection may not be; and the ability to make such connections may provide a distinctive capability".

In summary, the involvement of firms in technological center activities may be a means for them to directly or indirectly access the experiences of other firms and individuals in an industrial system. The potential for generation of benefits may be associated to the perceived or real similarity between the activities that may be accessed through those Centers and those carried out within the firms themselves, especially the activities that are perceived as most relevant in the context of their relationships with their clients and or suppliers. The nature of the relationships with/through TC's may vary in terms of commitment and or investment. They may either operate as weak links, i.e. mostly as information channels, or they may have a stronger nature, involving the commitment of other resources, in particular human resources since these are critical when issues of access to and generation of knowledge are paramount.

A relational view of the industrial system would suggest that the benefits from the involvement of firms in the activities of TC's might, at least in part, arise from their being embedded on connected relationships. An important dimension for the analysis of such potential would be the possibility to directly or indirectly access the capabilities of other firms and actors in specific areas of activity perceived as relevant for the focal firm. However, as mentioned before, what is relevant for each firm may be contingent on its previous experiences over time, especially those in the context of its relationships with other actors.

3 Research Method

The data that we present next were obtained in the context of an ongoing study first started in 1996 with the objective of analyzing the stability and change of firms' boundaries in a Portuguese high technology industrial district that produces molds for the injection of plastics. The research design reflected our interest in business relationships and the role of territorially-based institutional actors. An intensive research strategy has been adopted, which emphasizes the substantial connective relations between agents, as opposed to formal relations of similarity Sayer (1992). One of the empirical findings of that research was the presence of relationships with varied strength and proximity between the firms in the industrial district and the local Technological Center (TC).

The field work included 12 in-depth semi-structured interviews with senior managers of the four firms and the TC. The format adopted was that of semi-structured interviews which are deemed particularly useful when "…highly sensitive and subtle matters need to be covered, and where long and detailed responses are required to understand the matter the respondent is reporting on" (Ackroyd and Hughes 1992, p. 104). Two interviews were conducted with the director of the local TC and its chairman. Three to four interviews were conducted with the Managing Directors (MD) and key staff in each firm. The interviews were recorded and subsequently transcribed and analyzed. Primary and secondary data were also obtained from other six firms and two institutional actors connected to the industry, namely the trade association (CEFAMOL) and ICEP.[5] The research team also attended a number of industry events and collected proceedings of industry conferences. Firms' internal documents and interviews with suppliers (e.g. steel and machinery suppliers, software providers) were particularly useful in confronting different perspectives on historical events and developments related to the industry. Further information kept on being obtained in the following years, through our regular participation in the events of the molds industry and within other activities involving CENTIMFE[6], the local TC, and the research team. Thus, our inquiry has been based on multiple sources of verbal and written information, following the case study method (Eisenhardt 1989; Yin 2003).

[5] ICEP is the Portuguese government agency for the promotion abroad of the Portuguese industry, trade and tourism.

[6] CENTIMFE stands for "Technological Center for the Industry of Molds, Special Tools and Plastics".

4 The Empirical Context

The industry of molds for the injection of plastics, also referred simply as the molds industry, is an interesting empirical context for this study. A mold to inject plastics is in general a unique product built especially for a specific customer. The director of the largest Portuguese molds marketing and engineering firm considers that, despite only about five percent of molds presenting truly innovative solutions:

> Each mold is a particular case inasmuch as the plastic material and the equipment change. We cannot say that what we did for a piece is exactly the same as what we had done for another piece because, for example, the material and its behavior will be different.

The uniqueness and complexity of molds has important consequences for their design and production but these are further complicated by other sources of uncertainty and variability, which affect the molds and/or the plastic pieces or components that they will produce. The conception, design and engineering of a mold require the combination of contributions from several areas of expertise about materials (e.g. plastics and steel). A mold is a unique combination of both standard and specific components, which are made up or assembled in a sequence of closely complementary activities, from the conception of the plastic piece that will be produced by the mold to the conception and design of the mold itself and its fabrication, assembly and testing, see Fig. 1. Incomplete knowledge about the behaviors of materials can result in changes or corrections on the molds and/or plastic pieces that they will produce. Such changes or corrections will usually require one or more activities to be repeated and/or performed anew. The need for corrections is generally due to lack of sufficient or timely knowledge by the supplier about the behavior of the mold, while changes are a consequence of uncertainty on the part of the customer about operating or aesthetical aspects of the plastic piece that the mold will produce. In the latter case, in order to test the mold, it will be used to inject small batches of pieces, which will in turn be experimented in real operating conditions. A supplier may incur serious consequences due to excessive or untimely changes and/or corrections. These may hinder its relationships both with its customer and its other counterparts (customers and suppliers), namely in terms of time to delivery, not to mention the substantial direct costs from the activities involved in the conception, production, assembly and testing of molds.

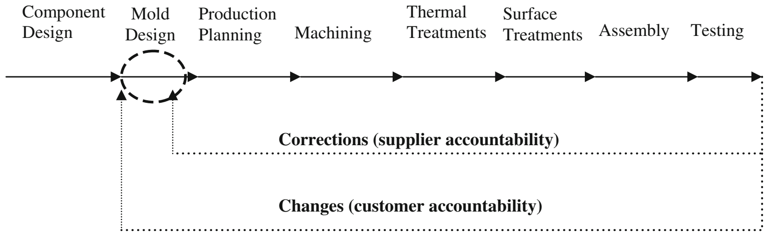

Fig. 1 Mold industry—closely complementary activities

Our interviewee from IB, one of the largest independent mold producers, was quite emphatic about changes in molds.

> We are confronted with some dramatic situations of molds that have been lingering in here for two years. They produce one piece every now and then, every now and then they introduce changes, and every now and then they make an awful amount of 'noise' in our organization. We have a normal planning but we have to change our plans because the client asked us to inject 50 odd sample pieces for a change [he requests we do to the mold]. And we have to go in haste change his mold to make him the samples. And then that stops all over again [concerning that mold].

Several actions can be used to reduce the need for changes or corrections and producers do resort to some pre emptying strategies in this respect: accessing the knowledge of some firm which is known to have produced a similar mold; excluding from their portfolio those customers who favor the development of plastic pieces and molds by successive approximations (and changes); increasing their specialization in molds of similar sizes, geometrical complexity and tolerances in order to substantially reduce errors and subsequent corrections, etc.

Some firms, however, try to manage a mix of situations or even seek to develop their relationships with customers known for their frequent requests for changes (e.g. automotive industry). In the latter case, it may be fundamental for the development and sustainability of the relationships that the producer develops capabilities to support the customer during the initial phases of the development of the plastic pieces that the mold will produce. In general, the need for corrections and/or changes requires the development of capabilities in several areas, like materials behavior, machining and prototyping. In this context, some of these firms resort to CENTIMFE, for example to search for technologies, like prototyping, that will help them avoid some problems with the conception, design and production of the plastic pieces and the molds to inject them, well before their production stages.

CENTIMFE, henceforth called TC for short, was founded in 1991. The number of its associates, including firms and other institutions, grew steadily to nearly 200 now. The firms associated with the TC include engineering and commercialization firms, suppliers of steel, firms specialized in one or several transformation activities (molds design, tooling, machining, polishing, etc.), component suppliers (injectors, heaters, electronic parts, etc.), suppliers of software like CAD, and suppliers of industry related machines and other equipment. It is worth noting that two of the firms with the largest local turnovers are predominant members in the Board of the TC.

4.1 The SOM Case

SOM is a SME, counting about 80 staff. By mid 1990s SOM had to face growing turbulence in its portfolio of customers, including increased variability in the number and value of the orders taken and loss of some customers to its competition. The firm started efforts to stabilize or increase both the size and homogeneity of its customer portfolio, according to some, deemed desirable, cumulative criteria: the customers' prospective volume of orders, their openness to consider the suppliers' advice (the customers being possibly problematic in specifying their desired final pieces), and the standards of size and complexity of the molds sought, including shapes and tolerances.

By then, the firm submitted a project to the TC, which involved other producers and institutions. The project was initially defined as aiming at improvements in the processes of mold projecting and machining, e.g. high speed milling command.[7] One of the relevant dimensions was the need to reduce the deliberate over sizing of some components, a practice commonly used to allow a margin for further cutting on them later on if corrections became necessary. As size is closely related to the pressures needed for injecting the molten plastic materials into the mold, the project also involved the Department of Polymers of the University of Minho. The benefits were expressed as follows, following the first few meetings:

> … all the situations where you discuss about certain aspects are important teachings, and also it is the relationship that is important because, at any time, we can talk because we are nearer [to each other], and in the things that are discussed we all learn with one another.

Even if the benefits in this area are not obvious, access to the TC can have positive consequences, for example at the level of portfolio of relationships, because the firm can develop its relationships based on its capabilities to more actively participate in the co-design of the pieces to be molded.[8] It is expected that this allows a better anticipation of problems with molding the final pieces and with producing molds, namely by conceiving and suggesting alternatives that the customers find acceptable, both in terms of the pieces and in accrued efficiency benefits for production activities. Besides, it is also expected that advances in the knowledge about the behavior of plastic materials can help reduce the need for corrections in the molds themselves.

4.2 The IB Case

IB employs about 600 people, which means that, in this sector of activity, it is considered a large firm worldwide. The IB group is made out of 15 firms and a training center. Within the group, SET is the unit responsible for product development, project management and commercialization. Its origin can be traced to the 1980s but it was formally created as a firm only in 1990. In 1983, the firm pioneered in Portugal the acquisition of CAD/CAM stations, involving a substantial financial effort. Its customers induced this:

> [Our customers] pressed [us] to its use [of CAD/CAM] before they themselves knew how to work with [those] equipments or had [qualified] people [to do that]. Initially they set deadlines to firms: 'you must have CAD before date X, so that we can work with you' [they said]. All of them underestimated the time that

[7] High Speed Milling: The usage of this technology may allow better finishing of surfaces and greater dimensional precision, thereby reducing the time required for finishing activities.

[8] Those efforts can be seen as aiming to change the interfaces between SOM and some of its customers (see also Araujo et al. 1999).

they themselves would take to use that technology and we, that initially believed them, ended up [a few years later] teaching those customers how to use that CAD that they told us we should have… we got hold of CAD and became aware that we knew better than them how to work with it. This was an incentive for us to do the job instead of them. SET took hold of simultaneous engineering and offered it to its clients as a cost of entry to the engineering capabilities that we did not have [beforehand]. We had to learn before we did have a market.

Then IB became more involved in the design and development of the pieces to be injected. The knowledge that it has acquired since, about plastics and the joint development of products, became especially useful vis-à-vis some customers who ignored the potential and the limits of plastics as a basic material.[9] The creation of SET was due in part to IB's interest in promoting the exploration and development of rapid prototyping and in continuing to explore the potential of concurrent engineering.

In 1995 IB became actively involved in the administration of the TC, together with one of its major competitors. In 1998 it promoted a project directed at monitoring, exploring and developing technological advances in rapid prototyping by using SLS (Selective Laser Sintering) technology.[10] This project involved the creation of a network of firms and other institutions for this purpose. The TC is responsible in the network for the exploration of the Selective Laser Sintering (SLS) technology. IB became aware of this new technology in 1986. Basically, SLS uses laser beams to cut functional tri-dimensional physical models from a CAD drawing. The laser beam cuts or melts, layer by layer, the material used to shape the desired piece. During the developmental phase engineers faced several problems that need to be solved, e.g. in finishing, resistance to fatigue, and stability of materials in time, etc. In any case, to the extent that it will become possible to produce functional prototypes by SLS, it will be possible to test in real operating conditions the pieces obtained by SLS. This will avoid the need to design and produce molds to inject the prototypes of the plastic pieces, and then to have to subject those molds to a series of changes following the succession of tests and improvements made on the pieces. Also, ongoing projects are researching ways to combine SLS with other prototyping technologies. It is expected that, as technology matures and spreads, some pieces may start being directly out of in their intended component material, thus foregoing milling activities. This can have a dramatic impact in the industry. According to one of the TC's technicians:

We constantly monitor the development of new materials and the evolution of technology and seek to adapt the acquired knowledge to the needs of industry.

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[9] "… products [were] that could be defensible if viewed in [made out of] metal, but, viewed in [made out of] plastics, some pieces could not even be reasonably [well] molded. And we were aware of that, that we were having increasing difficulties in talking with our customers. Many times we had to train our customers' technicians [so] that they could understand what we were discussing about".

[10] "[This technology] will revolutionize many areas of activity. In the beginning it had not been discovered that the pieces needed to be "baked". Also there were not strong enough materials. Nowadays pieces are already made in polycarbonate. [The use of this technology] is not yet disseminated because it is very expensive. The equipment bought by the TC did cost over €0.5 million. It is a bit like CAD. I could have waited that technology to mature, but then I would have missed any advantages".

The placement of the SLS project in the TC, beside allowing a close monitoring the exploration of that technology without the involvement of large human and financial resources from one firm only, lets the development of the technology be fostered by the variety of requests placed by others firms or institutions.[11] For example, to produce a model for the lid of an engine's 'intercooler', which had to fulfill some demanding requirements of temperature and pressure, various coatings had to be analyzed and tested. Finally, and inasmuch as SLS may become a real alternative to other prototyping technologies or even to the mold based production of plastic pieces, it is believed that the current commitment with the existing, more traditional technologies, will have to be re-equated. The industry already shows some interest in directly applying the SLS technology to produce small series of piece, especially small pieces without critical surfaces finishing and with relatively small production cycles (Soares and Novo 2000). The TC is presently a member of the national network of quick prototyping that has been created in the mean time, and this allows it to supply the industry with a range of varied rapid prototyping technologies beside the SLS technology.

4.3 The TC as a Link Joining Networks of Practice

Another dimension in the activities of the TC, which goes beyond the projects referred above, is the carrying out of training programs. Both SOM and IB participate in these training activities and IB also provides training staff. These training courses are mostly organized by request and/or according to the needs of groups of firms.[12] They involve, as training staff, both external technicians and personnel from a variety of firms in the industry (e.g. molds or materials producers).

The TC also provides services in designing and testing molds. Some associated firms regularly place orders, sometimes for a whole line of products. This way, the TC works not only as a provider of spare capacity but also as a supplier of complementary services to those firms which do not hold some specific capabilities or resources (e.g. rapid prototyping). By delivering services, the TC's technicians acquire a high proximity to the problems and capabilities of the firms and end up developing capabilities in very similar areas. In fact, the management of the TC has been facing serious problems due to personnel turnover, as local firms hired many of its technicians, because training takes times and not everything can be codified. Those technicians become attractive to their prospective employers, at least in part, because they are deemed to learn from being exposed to a wider variety of the problems that firms face and consequently become more capable to recognize and appreciate patterns of similarity between problems and solutions that have proved adequate.

[11] "A person, who is in a University, or elsewhere, sends us the necessary information and we send him [back] the piece [he needs]."

[12] A local entrepreneur phrased as follows this aspect of a common language in the local context: "If a certain Mr. X comes to speak about the chemical composition of stainless steel he will certainly not drive much attention. However, if the technician Y comes to speak about his problems with the thermal treatment of surfaces, or about the lack of radiation in some critical zones, or the difficulties faced in milling, then you can be sure that not a sound will be heard in the seminar room all through the presentation and there will be plenty of questions".

4.4 Comments About the Cases

It should first be noted that the firms themselves submitted to the TC the projects in question. The SOM and IB cases illustrate how the decisions to start several projects like high speed milling, rapid prototyping, and the analysis of the behavior of plastics acquired relevance in face of the firms' relationships with their customers and their intentions in that respect. Their relevance stems from the specific problems that firms face (or expect to face) and from their being placed to an entity close enough to the industry to share a common language and similar concerns. As illustrated in the cases other similar and complementary activities may favor or reinforce this cognitive proximity (e.g. mold design and testing), see Fig. 2.

The cases also show that, due to the institutional nature of the TC and especially the involvement of several firms in its activities, the results of 'internal' activities can, to some extent, propagate throughout the industry. In a strong sense, the TC is a relevant actor in the spiral of knowledge referred by Lundvall (1996) and Nonaka (1994), involved in the ongoing process of codification and partial diffusion of previously tacit knowledge and the generation of new tacit knowledge. Inasmuch as the TC participates in a variety of similar and complementary activities intimately associated to the industry's needs, the knowledge generated in those contexts can be transferred to other actors, directly or indirectly connected with the focal firms.

It should be noted that the fact that it operates as a link in the wider 'network of practice' (Brown and Duguid 1998) does not imply identical impacts on each firm and on the industry. Firms can differ in their interests and in their capability to interpret and capture such knowledge (Cohen and Levinthal 1990; Loasby 1998b), which, in part, is a consequence of the connectivity of the partly counterpart specific relationships at the level of each firm. IB and SOM decisions regarding their involvement in the TC' activities and the eventual results from those involvements seem to gain meaning in the context of their histories and their economic exchanges with other firms.

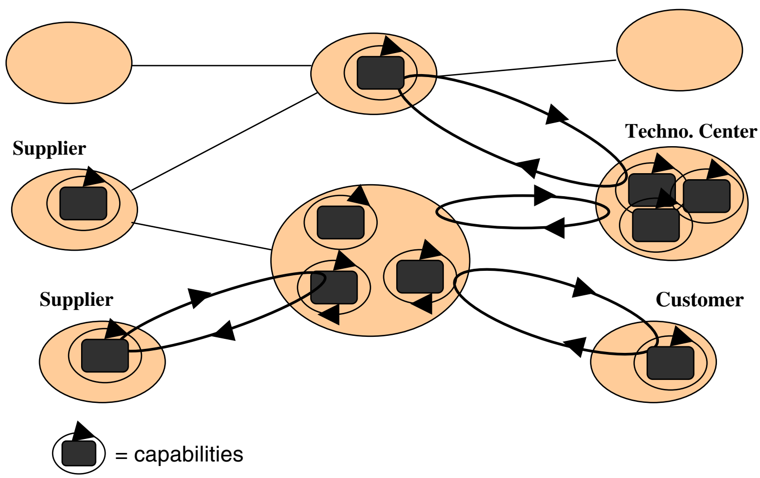

Fig. 2 Generation of and access to intra and inter-firm capabilities variety

The study also suggests that the connectivity of relationships is equally relevant in terms of the benefits that the TC can generate. On the one hand, the transfer of some benefits to competitors cannot easily be avoided, given the very nature of the institution even if they can be perceived and used differently by each firm. On the other hand, the generation of potential benefits seems to be intimately associated to the participation of rival firms presenting a rich diversity of experiences and interests. The question here is to be able to access similar yet sufficiently varied capabilities so that learning may occur. Our informers seem to agree that the benefits from the exchange of experiences handsomely compensate the potential costs due to copying and loss of exclusivity. This may be particularly relevant in an industry in which the complexity of the products and/or the frontiers of knowledge seem to require maintain the possibility to access and mobilize other people's capabilities in future occasions that, recognizably, cannot be anticipated.

5 Concluding Remarks

It was said that supplier–customer relationships have been central to the industrial networks approach. They have also been central to the issues of technological development, although it is recognized that other relationships may play some role. Recent approaches to the dynamics of industrial systems have emphasized not only vertical relationships, i.e. access to dissimilar capabilities, but also the possibility of accessing, albeit indirectly, the experience or capabilities, somehow similar, of rival firms. We suggest that connections with the TC's have a potential role at this level but that potential only gains relevance in the context of economic exchange relationships involving customers and/or suppliers.

Our research suggests that the TC's can have an important role in providing indirect access to knowledge generated in other contexts, in particular those of firms with similar capabilities. Our study also suggests that the potential of TC's for learning can be associated to their role as providers of services, in some cases partly duplicating those provided by or in some firms. In other words, the similarity of capabilities in specific areas can help to maintain cognitive proximity to and relevance for the context in which firms operate, and thus facilitate the processes of dissemination of knowledge in the industry.

Finally, our study suggests that the motivations and benefits perceived by firms and, in general, the relevance of sharing experiences in this context should be seen in the context of firm's specific and idiosyncratic trajectories. This means that some firms, contrary to others, may consider that their participation in a TC would incur more costs than it would provide benefits, despite both being difficult to estimate in advance. For example, some firms in the industry acquired their own SSL technology equipments and use them for their operations with their own customers. Others maintain weak links to the activities of the TC (e.g. training activities) and mostly emphasize the access and development of technical knowledge in the context of their own relationships with their customers and suppliers. Finally other firms look with mistrust at the activities of the TC and abstain from influencing them. In fact all these varied postures and decisions, which reflect differentiated framing of problems and contexts, should be recognized as valuable because they bring further variety into the industrial system. We do agree with Loasby (1998a, b, pp. 157–158) when he says (sic):

> The organisation of capabilities is the organisation of systems for generating and testing new and improved skills. The systems are the institutions of economic evolution, which requires specialisation, but not uniformity, within each specialism. There may at any time be 'one best way' of achieving a particular kind of result, but to train everyone within a specialism in that 'best way' would be a recipe for disaster. (Fortunately, there are always a few who escape or resist such training). Diversity is necessarily a system property, and it requires the absence of control; for control frustrates the development of capabilities to which one might later whish to have access.

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