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Exploring the microfoundations of External Technology Commercialization: a dynamic capabilities perspective

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ABSTRACT

External technology commercialization, or ETC, refers to the organization's deliberate transfer of technological assets to another independent organization involving a contractual obligation for compensation in monetary or non monetary forms. This approach to the commercial exploitation of technological assets has been increasingly adopted by the most innovative and successful companies in the last decade and, as a result, it has raised the interest of scholars in management and economics as well. Nevertheless, several issues have remained under researched so far. In particular, the management and organization of ETC activities represents a promising area for further inquiry.

Adopting the Dynamic Capabilities perspective as a theoretical lens for examining ETC management at the organization level, this paper represents a first attempt to address the issue from a comprehensive standpoint. Specifically, it develops a framework which identifies the managerial and organizational aspects underlying the firm level capability to effectively undertake ETC. The model is then illustrated through a case study of an Italian electrochemical company, which has been active in ETC for many years. Combining evidence from the case study and findings from prior studies, research propositions are developed regarding organizational antecedents of the dynamic capability in externally leveraging technology assets.

1) INTRODUCTION

As intangible assets now account for 50% to 70% of the market value of companies (Kline, 2003), effectively managing technological assets has become a competitive priority for top managers (Chesbrough, 2003; Teece, 1986). Not only are companies exploiting their technologies internally by applying them in final products and services, but they are also considering external technology commercialization as a way to take full commercial advantage of their technology portfolio (Rivette & Kline, 2000). External technology commercialization (ETC) (Lichtenthaler, 2004) refers to the organization's deliberate transfer of technological assets to another independent organization involving a contractual obligation for compensation in monetary or non-monetary rent. In such transactions, the economic good that is exchanged is knowledge disembodied from products (Grandstrand, 2000), in the form of technologies, patents, know-how. ETC transactions can take various contractual forms, e.g. out-licensing agreements, joint ventures, spin-offs, IPRs sales, exploitative alliances and divestment of firm's units (Granstrand, 2000).

Several authors report the growing importance of ETC, that is increasingly regarded as a strategic activity (Arora *et al.*, 2001; Lichtenthaler & Ernst, 2007). Many firms have realized that a large part of their technologies are not used for internal exploitation (Kline, 2003). This underutilization of technology assets has brought more and more firms to actively pursue ETC: a well know case is IBM, whose licensing revenues amounted to about $2 billion in 2001 (Chesbrough, 2003). On the other hand, there is a higher demand for external technologies: in a context of widely distributed knowledge and rising inter-organizational relations, companies make greater use of external innovations in their own business, as advocated by the Open Innovation paradigm (Chesbrough, 2003).

The topic of ETC has raised the interest of scholars in management and economics only recently (Bidault & Fischer, 1994; Teece, 2000), and several issues have remained under-researched so far (Gassmann, 2006; West *et al.*, 2006). In particular, the management and organization of ETC activities represents a promising area for further inquiry (Lichtenthaler & Ernst, 2007a). ETC posits in fact several challenges: due to technology market imperfections and high transaction costs, technology deals are much more complex than transactions on product markets (Bidault & Fischer, 1994) and the identification of potential technology customers and the pricing of intangibles are seen by firms as problem ridden areas (Escher, 2004).

Adopting the Dynamic Capabilities perspective (Teece *et al.*, 1997; Eisenhardt & Martin, 2000) as a theoretical lens for examining ETC management at the organization level, this paper represents a first attempt to address the issue from a comprehensive standpoint. Specifically, it develops a

framework which aims to identify the organizational antecedents and managerial aspects underlying the development of a firm-level capability in undertaking ETC. The model is then illustrated through a case study of an Italian electrochemical company, which has been active in ETC for many years. Combining evidence from the case study and results of prior studies on technology management, research propositions are developed regarding key managerial levers that foster a dynamic capability in externally leveraging technology assets.

The paper is structured as follows. Section 2 reviews existing literature on ETC. Section 3 develops the theoretical framework and section 4 describes the rationale and the methodology employed for the case study. Section 5 and 6 report and discuss the case study. Finally conclusions are drawn and some avenues for future research outlined.

2) LITERATURE REVIEW

The concept of external commercialization of technological assets was first introduced in the 1970s, when a number of scholars started analyzing the peculiarities of selling technologies and know-how and argued that the full exploitation of a company's technology should include not only product applications but also technology sales (Anderson, 1979; Ford & Ryan, 1977). Ford (1985) introduced the term "technology marketing" to describe a holistic approach to external knowledge exploitation. Lichtenthaler (2004) introduced the term External Technology Commercialization (ETC) to focus attention to the supply-side turnover-oriented activities necessary to commercialize a technology disembodied from products (Koruna, 2004). In the context of Open Innovation, ETC may refer to the outbound dimension of open innovation, i.e. the search for external organizations with the purpose to commercial exploit technological knowledge (Chesbrough & Crowther, 2006), or similarly, to the inside-out process of Open Innovation, defined by Gassmann & Enkel (2004, p.1) as 'the external exploitation of ideas in different markets, selling Intellectual Property and multiplying technology by channelling ideas to the external environment'.

A first stream of research has addressed external technology commercialization from a strategic perspective, basically addressing the question of whether external exploitation should be pursued in the case of a given technology or innovation (Teece, 1986; Gans & Stern, 2003). A number of determinants that influence the decision to commercialize a given technology or to compete directly in the product market are found at specific innovation level, i.e. radical or incremental (Gans & Stern, 2003), broad impact (GPT) or narrow impact (Hicks & Hedge, 2005); at the firm level, i.e. positioning with regard to complementary assets (Teece, 1986; Gans & Stern, 2003); and at the

industry level, i.e. appropriability regime (Teece, 1986) and product market fragmentation (Gambardella & Giarratana, 2007). Applying the Transaction Cost Economy (TCE) paradigm to the issue of appropriating returns from innovation, Teece (1986) and Gans & Stern (2003) argue that the exploitation of innovation (through internal production or via contractual relations with an external entity) essentially depends on the appropriation environment. When transaction costs are high, due to expropriation threats during inter-organizational bargaining, firms are more likely to commercialize via internal production instead of pursuing ETC.

A second stream of research has studied the dynamics underlying technology markets (Arora *et al.*, 2001). Lamoreaux and Sokoloff (1998) document the existence of an organized market for technological knowledge in the USA in the early 20th century. During the 1990s an increased division of innovative labor has determined the growth of technology markets (Arora & Gambardella, 1994) and has favoured the birth of small serial innovating firms, whose main business is to generate and sell technologies (Hick & Buchanan, 2003). However, technology markets are still characterized by significant inefficiencies which affect the tradability of technologies (Guilhon, 2001).

Another established field of research is about the management of intellectual capital, which provides also insights into the coordination of different means of exploitation. A number of scholars have described generic strategies for IP exploitation (Grandstrand, 2000) and discussed different mechanisms to convert innovation into profit (Sullivan, 1998). In the context of open innovation, firms not only need to know how to create, protect but also how to market and sell IP to other companies (Chesbrough, 2006). Other authors have focused on a given contractual form: licensing and cross-licensing agreements (Grindley & Teece, 1997; Anand & Khanna, 2000; Fosfuri, 2006); spin-off strategies (Chesbrough & Rosenbloom, 2002); exploitative commercial alliances, through which innovative firms combine their technological resources with downstream complementary assets (Colombo *et al.*, 2006; Rothaermel & Deeds, 2004).

This brief review indicates that a systematic analysis of the managerial and organizational approaches firms use to implement an ETC strategy is lacking. Scattered research has been carried out on the topic only recently. Some scholars have explored different aspects related to the management and organization of ETC: Lichtenthaler (2004) and Escher (2004) have used a process perspective to highlight the activities that firms carry out to externally leverage technologies. Their findings point to the importance of preliminary process stages such as planning and intelligence in order to enhance the effectiveness of actual technology transfer, the final stage of the commercialization process. The organization of ETC advances interesting issues as the heterogeneity of the tasks involved (technical, marketing, legal) requires a great deal of

coordination between different departments and management levels (Escher, 2004). Tschirky *et al.* (2000) advance that appropriate organizational structures are required to effectively carry out technology marketing. A dedicated ETC function with corporate wide responsibilities for IP exploitation is a solution put forward by a number of authors (Kline, 2003; Chesbrough, 2003). However, only few works, to our best knowledge, have attempted to link organizational and management decision to firm's performance in trading technologies. Using survey data from 152 industrial firms in Germany, Austria and Switzerland, Lichtenthaler & Ernst (2007b) find that firms increase their performance in licensing out technologies by developing the reputation of being a valuable technology provider. Firms develop such reputation by embracing a centralized approach to ETC, dedicating full-time resources to the task, actively supporting technology transfer with services and initiating learning effects. Another study on the same survey data (Lichtenthaler, 2007) argues that high levels of proficiency in managing ETC process stages and the existence of a systematic routine enhance performance in ETC as measured by ETC revenues and relative performance over competitors. Among all the phases, quality of executing negotiation and monitoring & control tasks have the strongest positive impact on performance.

A qualitative study on 14 case studies of both successfully and unsuccessfully licensed university technologies carried out by Hsu and Bernstein (1997) shows that the value of technologies is a not sufficient driver of licensing success, as many worthy IP remain unlicensed. Managerial effort from the entrepreneur and appropriate design of remuneration structure of licenses are equally critical component to the successful outcome of a technology transaction. Finally, Aggarwal and Hsu (2008) when studying the determinants of heterogeneous firm-level cooperative R&D commercialization strategies in the biotech industry, find that investments in the development of capabilities in governing licensing and equity-based alliances positively influence firm valuation. However, the authors simply proxy licensing and equity-based alliances capabilities with prior experience in such technology deals and do not address whether certain managerial mechanisms drive heterogeneous distribution of such capability..

The reasons underlying very different levels of performance in ETC, that are documented in the literature (Lichtenthaler & Ernst, 2007a), remain therefore largely unexplored. The paper represents a first step to overcome this limitation of extant research. In particular, it adopts a dynamic capabilities perspective to unearth the managerial and organizational levers that support the development of superior capabilities in undertaking ETC and thus might explain different levels of performance in ETC.

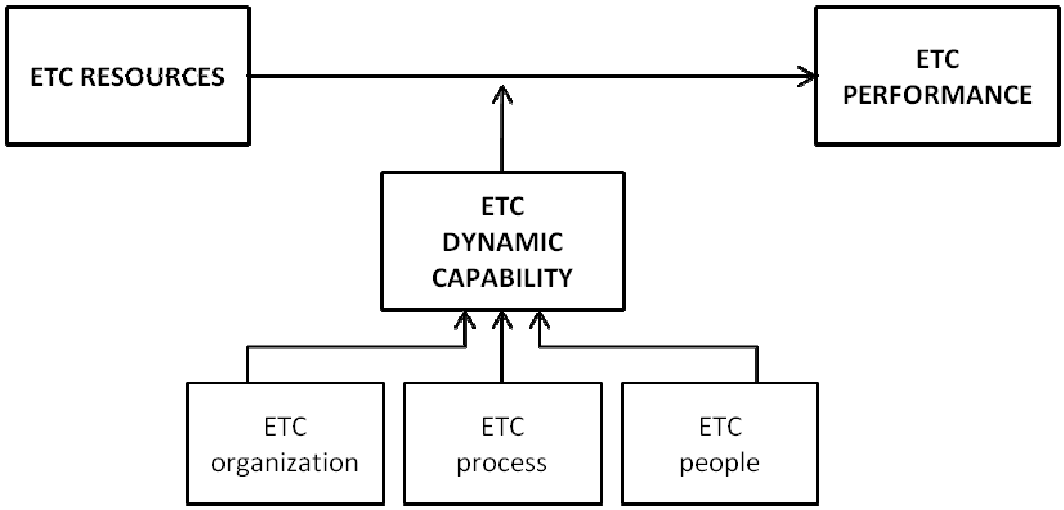
3) THEORETICAL FRAMEWORK

The ability to structure and manage external technology commercialization can be regarded as a firm-level dynamic capability (Lichtenthaler, 2007). Such capability resembles a "patterning of activities" as suggested by Winter (2003), where he defines an organizational capability as "a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type" (p. 991). Drawing from Aggarwal and Hsu (2008), we argue that this capability to trade technology assets is a firm's aggregate collection of knowledge, routines and organizational structures associated with this particular exploitation mode. Also, we argue that such capability is dynamic in nature as it is geared toward effecting organizational change and it allows a firm "to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece *et al.*, 1997, p. 516). The Dynamic Capabilities (DC) framework proposed by Teece et al. (1997) argues that competitive advantage not necessarily stems from scarce difficult-to-imitate firm-specific assets, but from how they are configured by managers (Cavusgil *et al.*, 2007). is defined by as Indeed, Eisenhardt and Martin (2000) conceptualize dynamic capabilities as a set of specific and identifiable strategic and organizational processes "that create value for firms within dynamic markets by manipulating resources into value-creating strategies". Consistently with this definition, we advance that the dynamic capabilities perspective may be an effective approach to look into a specific type of strategic and organizational process, external technology commercialization, through which technological resources can be converted into value.

A dynamic capability approach has been adopted in the literature for looking into a number of phenomena similar to ETC, e.g., new product development (Marsh & Stock, 2003; Deeds *et al.*, 2000), alliance formation (Kale *et al.*, 2002; Rotharmel & Deeds, 2006), external knowledge acquisition (Zahra & George, 2002), innovation management (Rothaermel & Hess, 2006; Lee & Kelley, 2008). The application of dynamic capabilities to ETC is likely to improve our understanding of how established companies can successfully leverage their technology assets.

For the purpose of the paper, a theoretical framework (fig. 1) is developed which combines a number of managerial and organizational variables that are relevant to ETC.

Figure 1. Theoretical framework



The framework encompasses four major building blocks. The first one comprises the ETC dynamic capability that enables an enterprise to exploit the resources from which long-run performance in external technology commercialization might originate. In order to define the concept of dynamic capability in ETC, we refer to Teece's work (2006), who advances that dynamic capabilities help the firm accomplish two critical tasks: (1) to sense and shape opportunities and threats, (2) to seize opportunities by successfully reallocating, adjusting or developing resources. The second building block relates to the microfoundations of an ETC dynamic capability. Teece (2007, pp. 1319) defines microfoundations as "the distinct skills, processes, procedures, organizational structures, decision rules and disciplines" that underlie dynamic capabilities. Accordingly, the microfoundations block in our framework includes the organizational antecedents and managerial levers from which an ETC dynamic capability originate (i.e. ETC process, organization and people). The model advances that a firm's performance in ETC (that represent the third block of the framework) is influenced by the extent to which it possesses the above mentioned dynamic capability. The fourth constitutive element of the framework corresponds to the ETC resources. In the wake of the resource-based theory of the firm (Wernelfelt, 1984), they represent the stock of intangible assets owned by the firm that serve as inputs, "raw materials", to the pursuit of external technology commercialization.

The rationale behind our theoretical framework is that a firm may have resources potentially able to drive superior ETC performance, yet lack dynamic capabilities to fully realize their ETC potential (Ray et al., 2004). Resources do not explain by themselves performance, because capabilities are needed to deploy resources so as to achieve superior performance (Eisenhardt & Martin, 2000). Therefore, we posit that ETC resources influence ETC performance and that this relationship is mediated by the firm's dynamic capability to convert technologies into economic

value. The development of this capability depends on managerial choices regarding ETC organization, process and people. On the following, each block of the framework is commented on in greater details.

ETC resources

The resource-based theory of the firm (Wernerfelt, 1984; Barney, 1991) advances that business enterprises consist of portfolios of idiosyncratic and difficult-to-trade assets. Such assets may determine a firm's competitive advantage at any point in time. Teece et al. (1997) define a firm's asset position as its current specific endowments of technology, IP, complementary assets, customer base and its external relations with suppliers and competitors. In the context of ETC, key resources from which a firm might derive long-term superior performance are the stock of technology assets owned by a firm. The volume of IP and technological knowledge that can be externally commercialized represent firm's ETC commercialization potential (Lichtenthaler, 2007) and has been found to strongly influence performance in ETC (Fu & Perkins, 1995; Ford, 1985). Also important may be the financial assets available to implement ETC activities; its reputation as technology provider; the social capital, i.e. firm's network of ties with the scientific and business environment. Hsu & Bernstein (1997), for instance, find that contacts in the VC community can give a university's TTO a competitive advantage in licensing

Moreover, the allocation of financial, human and technological resources to ETC business, its effort and commitment are driven by the strategic relevance of ETC in the specific firm. Firms regarding ETC as a strategic activity are likely to invest more resources in ETC and thus expect higher returns from ETC. In this respect, Escher (2004) divides firms in three groups to which different ETC strategies correspond: ETC as main business, ETC as additional continuous business and ETC as additional occasional business.

ETC performance

ETC performance conceptualizes the extent to which a firm is capable of appropriating economic returns from its own investments in innovation through ETC, i.e. the share of profits that accrues to the innovator from the external exploitation of technologies (Teece, 1986). Monetary performance measurements depend on the contractual forms chosen for ETC. Lichtenthaler & Ernst (2007a) limit their assessment to revenues from licensing out (up front payments and royalties) and sales of technology assets. However, it might be important to include in the ETC performance concept also the revenues or profits earned by joint ventures and spin-offs created out of the firm's technologies, proportionally to the equity owned. Finally, some authors have used subjective measures of

performance as top management's perception of success relative to competitors (Lichtenthaler, 2007).

ETC dynamic capability

ETC dynamic capability refer to the organizational capability to externally leverage technology assets. In the context of outbound open innovation, the existence of such dynamic capability is documented by Gassmann and Enkel (2004), according to whom companies need to develop a multiplicative capability, i.e. the capability to multiply and transfer innovation to outside environment by external exploitation. Similarly, Amesse and Cohendet (2001) argue that success in managing outward technology transfer depends on firm's emitting capacity, i.e. the capability of emission of knowledge outside its frontier. For the sake of clarity, we bring back these notions up to the concept of ETC dynamic capability.

We claim that the development and exercise of a dynamic capability in ETC lies at the core of enterprise success in ETC. Following Teece's (2006) framework, we argue that firms achieve higher performance in ETC by leveraging two fundamental capabilities: *a) sensing and shaping new opportunities for ETC*, i.e. the superior identification of promising opportunities through scanning and exploring external technology and market environment, establishing links between technologies and applications, filtering and interpreting information to select the ETC opportunities most likely to achieve marketplace success (Teece, 2006); *b) seizing ETC opportunities*, i.e. the ability to take action promptly and make appropriate investments in the development and commercialization activities, to select business models and partners for ETC (Teece, 2007).

ETC microfoundations

This block include the specific organizational mechanisms and managerial levers on which a company can intervene to develop a dynamic capability in ETC. As argued by Teece (1998), the proper structures, incentives and management allow firms not only generate but also deploy and use their innovations and knowledge assets (Teece, 1998). We distinguish these microfoundations in three categories:

a) ETC process

The concept of ETC process accounts for the characteristics of the flow of activities that a firm carry out when performing ETC. This aspect is critical because, as pointed out by Teece (2006), core elements that support dynamic capabilities are organizational and managerial processes. Koruna (2004) has defined the external commercialization of technology as the process of

transferring technological knowledge from a sender to a receiver: Three aspects can be analyzed with respect to ETC process:

a) the critical tasks and activities needed to accomplish a technology deal. Lichtenthaler (2007) proposes a model consisting of five stages: planning, intelligence, negotiation, realization and control, while Escher (2004) identifies seven technology commercialization steps: evaluation of ETC potential, definition and valuation of ETC projects, keep-or-sell decision, ETC project planning & controlling, ETC business development, ETC business realization and customer care.
b) the structure of the process, which include the degree of systematization and formalization of ETC process, its parallel or sequential design, the factors that trigger the initiation of such process.
c) the practices and tools employed by a firm to execute ETC tasks. Such techniques may include IP pricing methodologies (Bidault, 1989; Chiesa et al., 2003), use of communication channels, by which they signal the intention to externally leverage technology (Tschirky *et al.*, 2000), negotiation checklists and use of intermediaries (Bidault & Fischer, 1994).

b) ETC organization

The concept of ETC organization refers to the organizational dimensions that facilitate the development of an ETC dynamic capability. These comprise the explicit structures, metrics and rewards required to direct, control and motivate individuals to perform critical tasks (Harreld *et al.*, 2007). With regard to organizational structure, some authors argue that strategic ETC requires an independent business unit empowered to make corporate-wide decisions about technology exploitation (Kline, 2003; Tschrky et al., 2000; Kale *et al.*, 2002), while some firms employ task forces and dedicated cross functional teams (Escher, 2004). Other aspects that are considered at this level are: the level of formalization and hierarchy (Escher, 2004), the establishment of decision making responsibility in ETC (Ford, 1985), the introduction of incentive programs that reward ETC (Teece, 2007). At the single ETC transaction, the critical organizational decisions refer to team composition, weight of leadership and degree of autonomy (Escher, 2004).

d) ETC people

The concept of ETC people accounts for the human resource characteristics and skills of the people performing ETC. Therefore, at this level we consider the single individuals' educational background, expertise, attitudinal traits and other qualities. Antecedents of dynamic capabilities can

indeed be found at the individual level. Rothaermel & Hess (2007) show that human intellectual capital, defined as the presence of highly skilled and talented employees like research scientists, has a key role in a firm's ability to build new capabilities in innovation. Given the complexity of ETC business and its multidisciplinary nature, a broad range of skills is needed to cope with both technical and market uncertainty (Chesbrough, 2003). Hsu, Bernstein (1997) argue that individuals who took the initiative to organize a business around a technology were overwhelmingly the single most important factor for technologies successfully licensed to start-up firms.

4) METHODOLOGY

In the second part of the paper we report and discuss the experience with ETC of a firm we have been investigating in the scope of our research. Our aim is to employ the case study in order to illustrate the constructs and the logical relationships encompassed by the theoretical framework developed in the last section. As suggested by Siggelkow (2007. pg. 22), this illustrative use of a case study is particularly powerful because "by seeing a concrete example of every construct that is employed in a conceptual argument, the reader has a much easier time imagining how the conceptual argument might actually be applied to one or more empirical settings".

In order to pursue this illustrative objective, the selected firm needs to be "very special in the sense of allowing one to gain certain insights that other organizations would not be able to provide" (Siggelkow, 2007, pg. 20). This is why we choose to discuss the case of a firm that has been engaged in External Technology Commercialization for a long time. ECIF (the real name of the firm has been blinded for confidentiality reasons) is an Italian company operating in the electrochemical industry, which employs 680 people and has an annual turnover of 250 million Euros in 2007 (5% of which invested in R&D activities). Its core business activity consists in the supply of components and technologies for the production of chlorine, caustic soda and other industrial electrochemical applications. ECIF privileges, as an ETC form, the establishment of Joint Ventures (with third parties), to which proprietary technologies are transferred for commercial exploitation. Other forms of ETC such as out-licensing agreements are not widely employed. ECIF represents an interesting case to study since the evolution of its ETC performance reflects not only a clear strategic shift but also deep changes in the way ETC is managed and organized within the firm. Two stages can be identified: a first one from the early '80s to the late '90s, when ETC was considered as an additional occasional business by ECIF and low performance levels derived from poor managerial decisions and organizational inability to cope with the complexity inherent in this

activity; a second stage, that started from the beginning of the 2000's, has seen ECIF proactively and continuously searching for external exploitation opportunities for the technologies it internally develops. In order to achieve significant economic rents from ETC, an ad-hoc organization and specific management systems have been designed and implemented to better cope with this activity. According to the managers, such internal systemic changes have played a role in the achievement of high levels of performance.

In this second stage, ECIF has established 3 JVs out of its own technologies. About 100 proprietary patents have been transferred to the JVs. In 2007 revenues from these 3 JVS, with which we measure ETC performance, amounts to 60 million Euros (at one time more than 20% of its annual revenues). The overall ETC revenues have grown in the last 10 years of more than 5 times, and top management acknowledges the increasingly importance of external exploitation activity for the overall strategy of the firm:

"To remain innovative leaders in our core business, we have to develop new businesses by participating our technologies with leading partners in their own markets"

– R&D Director of ECIF

Information about ECIF and its ETC business have been gathered mainly through direct semi-structured interviews with key informants. In particular, we have interviewed:

- The Chief Executive Officer of ECIF;
- The Head of the R&D unit of ECIF;
- The head of Marketing & Business Development Group at ECIF;
- A University professor who has consulted ECIF on the organization of its R&D activities and the methods for technology evaluation.

Interviews lasted on average 2 hours, were type-recorded and transcribed. They were based on an interview protocol that was developed starting from the theoretical framework (see Annex 1). The rationale for employing multiple respondents, some working for ECIF but with different roles and responsibilities and one coming from outside it, was to reduce the risk of retrospective and personal interpretation biases, that might undermine the construct validity of case study research (Yin, 2003). Furthermore, information gathered through direct interviews were triangulated with data drawn from company documentation, e.g., organization charts, innovation project reports, due diligence for technology evaluations.

The next section of the paper describes the organization and management of ETC in ECIF, with the aim to illustrate the constructs and the relationships encompassed by the theoretical model.

5) CASE STUDY

ECIF, founded in 1923 and headquartered in Milan, is one of the world's oldest and most well-respected electrochemical companies. Within this broad sector, ECIF is a leading supplier of technologies for the production of chlorine, caustic soda and derivatives, and of noble metal-coated electrodes for chlor-alkali applications. The industry is highly concentrated, with few incumbents holding large shares of the market and serving process technologies and equipment to chemical producers. Technological change is slow: mature and highly reliable technologies are widespread in the industry and the mortality rate of new R&D projects at prototyping stage is around 70%. The appropriability regime is tight and patents are an effective means to capture rents from innovation and a pre-requisite for technologies to be externally commercialized (Arora, 1997).

Led by a family of Italian entrepreneurs, ECIF operates in 60 different countries with consolidated revenues of 250 € million, and it is acknowledged as one of the most innovative firms in the electrochemical industry. As a proof of a long tradition of breakthroughs discoveries, in 1968 ECIF invented, patented and commercialized DSA® electrodes, which still ensure the company high operating margins and control of 70% of the chlor-alkali market.

ECIF's technology strategy until 2000

Traditionally ECIF focused on the internal exploitation of its strong electrochemical know-how. As a vertically integrated firm, ECIF performed in-house all the value chain activities, from R&D to the production of entire industrial plants (chemical reactors), which were sold directly to chemical producers. ECIF carried out the design and manufacturing of electrochemical components (anodes) and the incorporation of such components into machines, equipment and the engineering of full plants for chemical companies. The external exploitation of technologies was carried out as an additional occasional business: three Joint Ventures involving the transfer of proprietary IP were established with different downstream partners: the first with General Electric from 1975 to 1981, the second with Dow Chemical from 1985 to 1990 and the third with Lurgi until 1994. Sub-optimal selection of partners and difficulties in the management of partnerships determined poor economic returns from these forms of ETC, which turned out to be highly unsatisfactory for the firm and were interrupted. However, at the end of the 90s, a number of changes in the competitive scenario caused a major shift in ECIF's strategy with important implications on the strategic relevance of ETC and significant improvements in ETC performance.

ETC as a strategic priority for ECIF

High level of competition and reduced margins in the business of engineering & construction for chemical plants pushed ECIF to divest these activities and focus on the upstream development and supply of high-tech components. Such components became the "bottleneck" assets in the value chain (Teece, 2006), representing the most valuable and differentiating element in the industry. This specialization on core components determined a change in the firm's strategy related to technology exploitation:

> "an exclusively internal appropriation of core technology's value; a collaborative exploitation approach through partnerships with external partners for non-core IP" – *CEO of ECIF*

Accordingly, core IP on components and related production processes started to be strictly protected, enforced and exploited in internal facilities. Conversely, for the patents related to machinery, equipment and production processes for chemical companies, ECIF explicitly started to plan external modes of exploitation, systematically searching for ETC opportunities and potential partners. Although novel and valuable, this IP fell outside ECIF's new core business and therefore had to be transferred to other firms or new JVs.

Since 2000, ECIF has increasingly been engaged in ETC transactions. About 100 patents were transferred outside the firm to capitalize 3 newly created joint ventures. These technologies today constitute key intangible assets in the new ventures established with leading partners. Altogether these IP families were valued around 9 € million and ECIF got in return equity stakes in the JVs, from 50% to 20%. Table 1 reports some preliminary information about the JVs that have been established (and are still active) for the external exploitation of ECIF's technologies. These JVs are intended to achieve an integration of distinctive technology and downstream assets to deliver a superior value proposition to customers. The choice of Joint Venturing as a contractual form for ETC, instead of IP sale, reflects ECIF's willingness to maintain a stake in the future economic rents generated from its technologies, whereas joint venturing was preferred to licensing, due to the necessity to better integrate complementary assets provided by the partners into a fully dedicated firm to successfully exploit ECIF's IP with a long term horizon.

Figure 3 provides an overview of ECIF's current business model. The internal exploitation modes of ECIF's technologies (ITC) represent its core business, i.e. the supply of electrochemical components, both to engineering companies in the case of the new plant's construction and to end producers directly in the case of refurbishment of existing plants. These activities generate about 190 € million in sales, about 76% of the total consolidated revenues.

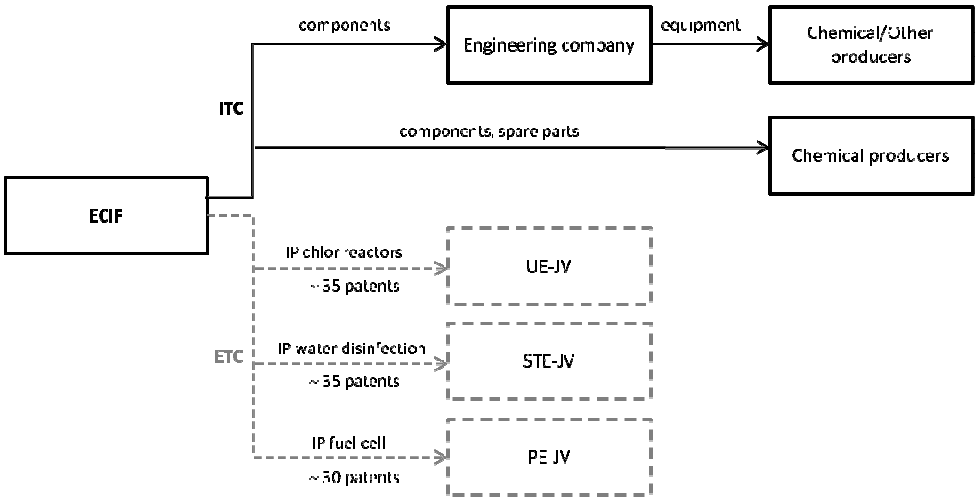
Complementary to ITC, external technology commercialization is realized by ECIF through the establishment of 3 JVs described above. ETC performance can be thus evaluated considering the share of the annual revenues earned by the JVs, accruing to ECIF proportionally to the equity owned. In 2007 ETC revenues amounted to 60 € million, which constitute almost 22% of total sales. Thanks to the success of these JVs, which are now leaders in the respective market niches and have developed their own clear identity, ETC performances have increased fivefold since 2000. Managers at ECIF claim the superiority of ECIF performance in ETC when compared to competitors:

> "our approach is unique: competitors in the industry play alone, they barely have any collaborations " – *R&D Director of ECIF*

Table 1 – Main characteristics of the currently active ECIF's Joint Ventures

JV's name	Year	Equity share	Reasons	ECIF contribution	Partner contribution	Main business
NU-JV	2001	20	Risk and cost sharing	Technological	Technological	Fuel cell technology
UE-JV	2000	50	Strategic shift Search for larger scale	Technological + Marketing	Technological + Marketing	Engineering company: design and construction of chemical plants
STE-JV	2002	50	Access to complementary assets	Technological	Downstream assets: marketing and brand	Supply of industrial plants for seawater treatment

Figure 3 – ECIF's business model



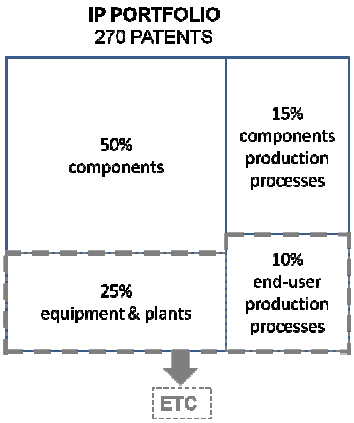
In terms of ETC resources, ECIF is recognized as a leading technology provider. With 10 € million annual worth investment in R&D and 62 professionals carrying out R&D activities (10% of total workforce), ECIF has gained a strong reputation of having leading technological competencies:

"With the exception of Moplen technology, invented by Nobel Prize Giulio Natta, we are the only case of an Italian firm developing something technically unique and monopolistic in the electrochemical industry worldwide" – *R&D Director of ECIF*

As a proof of strong technological know how, ECIF receive 7 patents and launch a radical new product every year, which, considered the low innovation rate of the industry, put ECIF in the first tier of technology developers. The share of revenues from products less than five years old is around 12%. Figure 4 shows ECIF's current IP portfolio, made up by about 270 patents. In terms of exploitation, it can be distinguished between: IP on components and related production processes (65% of total) for which an exclusively internal deployment is planned; and IP on machinery and production processes for chemical companies (remaining 35%) for which ECIF is actively looking for buyers or partners. Therefore, these latter patents, currently dormant, closely represent ECIF's ETC potential.

Finally the increasing strategic relevance of ETC (from additional occasional to continuous business) has determined a larger allocation of resources to external modes of exploitation: 15% of the total R&D budget is explicitly allocated to develop new technological projects in unexplored fields not related to core activities. This strategic choice is closely linked to ETC activities as results from these R&D projects are likely to be exploited externally, as a consequence of ECIF's strong specialization strategy on core components.

Figure 4 – ECIF's IP portfolio (2007)



Managing and organizing for effective ETC

Because of the higher strategic relevance that ETC has assumed for ECIF over time, an ad-hoc organization and specific management systems have been designed and implemented to better perform this activity. According to the managers, these choices appear to have allowed ECIF to improve its capability to successfully establish and carry out ETC transactions, radically improving the firm's performance in this activity in comparison with its early attempts before the 2000s. (POSSIAMO ANCORA DIRLO?).

"We have been a technological leader for long time. However, it is only recently that we have managed to effectively capitalize our technological know-how externally."- *CEO of ECIF*

"We are surprised to see how similar levels of technological know-how over time, but organized and managed differently, can determine such dissimilar levels of performance"
- *R&D director of ECIF*

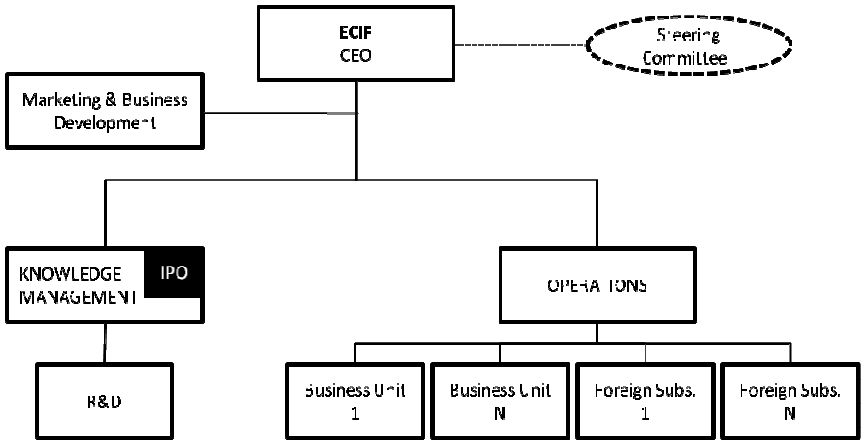
As far as the organizational dimension is concerned, three corporate level centralized functions are deeply involved in ETC activities (fig. 4):

- Marketing & Business Development Group (MBDG), a permanent structural element responsible for searching and seizing ETC opportunities. This task executing function, composed by 6 people and staff to CEO, carry out marketing activities exclusively unrelated to existing businesses. MBDG involves R&D division and IP office on a part-time basis in the implementation of ETC projects.
- R&D division where most of the R&D activities are centralized. Its mission is to strengthen the standing of ECIF in the different fields of electrochemistry where ECIF is active. In the context of ETC, opportunities sensed by MBDG must be supported with research effort, when technology is not readily available or must be adapted to fit with customer needs.
- IP office (IPO), once part of the R&D division and now internal to the Knowledge Management function, is responsible for managing ECIF's IPRs. Beyond fulfilling traditional filing tasks, a team of 3 technology experts is active in IP intelligence and valuation.

"ECIF manages patents as alive and liquid intangible assets. Patents are like money: when capitalizing a new joint venture, IPRs are our main "bargaining chips" – MBDG Director of ECIF

A temporary organizational entity is an ad-hoc multifunctional steering committee (SC), composed of CEO, CFO, COO and directors from R&D, MBDG and other business units. The steering committee has decision making and supervision roles. Two key decisions in ETC initiatives are made: the decision to invest in seizing the specific ETC opportunity and the final decision to enter into the contractual agreement.

Figure 4 – ECIF's organizational structure



The process through which each ETC initiative at ECIF is carried out consists of a structured though flexible sequence of activities involving the above mentioned organizational units (figure 5). Constant coordination and repeated information flows between the units allow to transform an early opportunity into a finished ETC transaction. Notwithstanding the recently increased strategic significance of ETC, external exploitation activity cannot be considered as a routinized procedure. Planning effort is limited and not formally carried out by ECIF's management.

"We do not believe that rigorous planning and detailed procedures would be beneficial to our ETC performance" – *MBDG Director of ECIF*

The initiation of the process can be triggered by the following events, occurring alone or in concert :

a. Business opportunity sensed by the MBDG when fulfilling its scouting activity.
b. Technological discovery or existing IP that may be externally commercialized.
c. External sourcing requests from third parties.

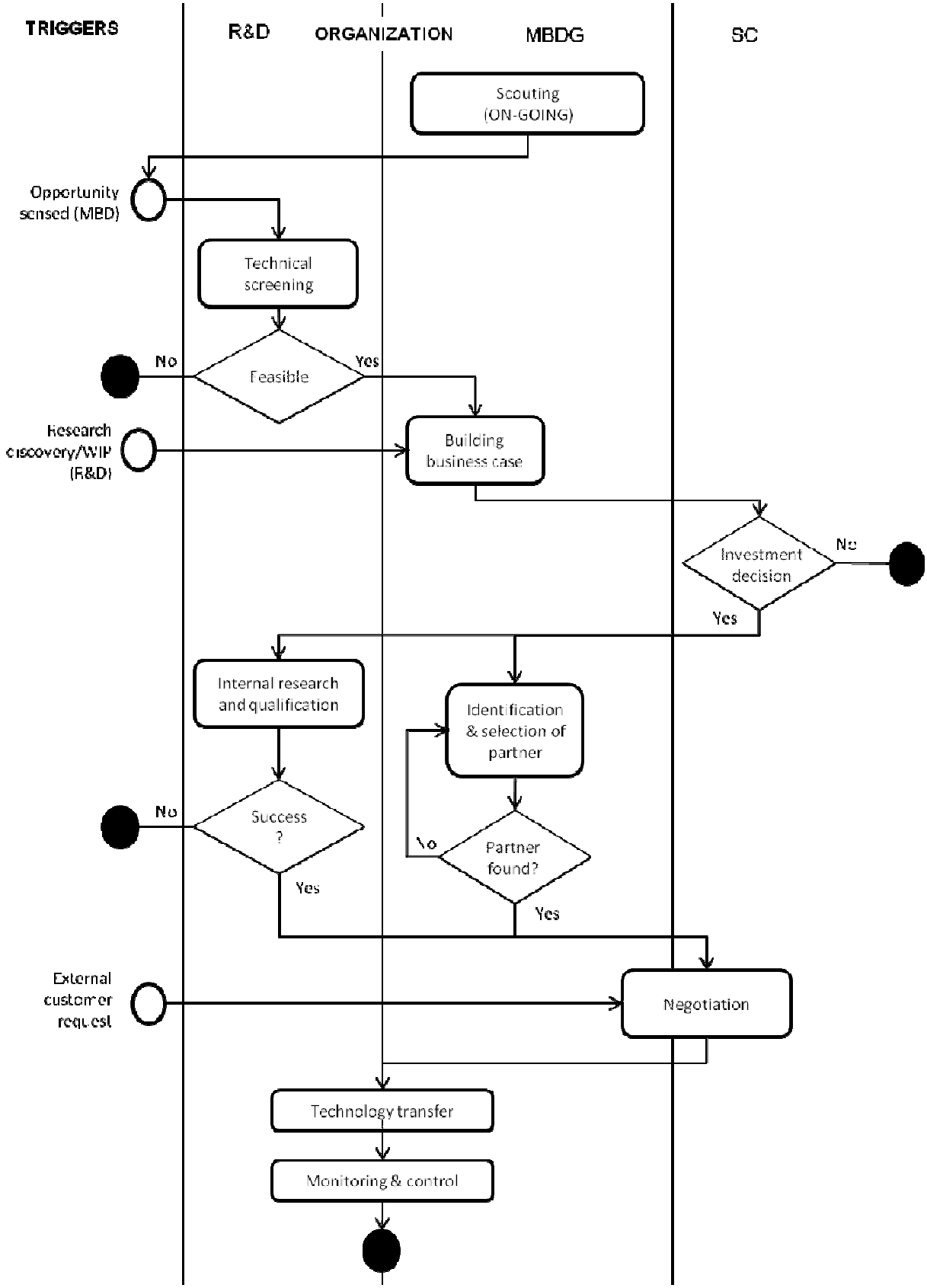
The way through which ETC process has been structured allows ECIF to deal with multiple events triggering the process. While in the case of NU-JV ETC opportunity derived from a technical discovery made by R&D, for ST-JV ECIF was first contacted by its future partner requesting the rights to use ECIF's water treatment technologies.

The ETC process flows through the accomplishment of the 8 steps. Scanning external technology and market environment in search for ETC opportunities is done by MBDG on a continuous basis. Once a new business opportunity is sensed, MBDG commissions a preliminary technical screening to R&D, which explore its technical feasibility. In case of positive response from R&D or in presence of a technical discovery, the MBDG builds the business case for the opportunity at issue. On the basis of the case, the steering committee gives the go-ahead (or not). In the subsequent internal research and qualification phase, R&D invest in the technical development within the 15% budget to address the opportunity sensed. In parallel, MBDG starts identifying potential partners first broadly, then focusedly. The search rely on social networks and market information. Once the partner is selected and IP, negotiation begins, conducted by senior managers from the steering committee. The actual transfer of technology and the monitoring and control phase of ETC initiative conclude the ETC initiative.

In order to execute tasks related to ETC, ECIF makes use of some management tools: business planning techniques, participation to fairs and conferences, resort to external IP experts for patent valuation and legal advisors for contracts. However ECIF's attitude is to combine these practices with much practical wisdom and common sense typical of a medium sized Italian firm.

"If we used only advanced quantitative techniques designed for multinational companies, our Chief Financial Officer would never allow us to pursue ETC strategies. Highly uncertain ETC businesses tend to be penalized by codified managerial tools" – *R&D Director of ECIF*

Figure 5 – ETC Process



As far as ETC people are concerned, 6 full-time employees in MBDG are involved in ETC business (1 head, 1 chemist and 1 engineer for technical assessment, 2 marketing specialists, 1 back office for market surveys). Professionals in the MBDG have long experience in ECIF, high level of seniority and deep knowledge of technology at issue. They usually have a technical background but worked in the sales department for many years.

"A key characteristic of ETC people is creativity but even more important are political skills. In fact, not only they have to be good in approaching and attracting external potential buyers, but they also have to sell ETC importance internally, involving and gaining support from other units"

– R&D Director of ECIF

6) DISCUSSION

The analysis of ECIF's experience with ETC allows to discuss the theoretical framework presented in Section 3. The framework posits that ETC resources influence performance, a key tenet of the resource-based view of the firm. This relationship conceptually follows that the higher is firm's commercialization potential, the greater the expected revenues from ETC, as found by Lichtenthaler (2007) and Fu and Perkins (1995).

In the case of EICF, the five fold increase of ETC revenues in the last ten years (from 12 to 60 million €) can be partly explained by larger allocation of technological and financial resources to the practice of external technology commercialization. ECIF's strategic shift toward specialization on high-tech components have determined the fact that many valuable technology assets, no more critical for firm's business, were available for external exploitation. Due to the transfer of about 100 patents, ECIF holds consistent shares of equity in the JVs, whose annual revenues in 2007 account for 24% of its total sales. Moreover, the availability of financial assets, up to 15% R&D budget, allows MBDG to promptly invest in the execution of ETC. Larger funds allocated as a consequence of higher strategic relevance of ETC have positively influenced the performance of ECIF in this activity, thanks to increased R&D and marketing effort.

In addition, because of the imperfections in the markets for technologies, social capital and reputational assets have played a key role in the successful completion of ETC deals. Its reputation as leading technology developer has eased the initiation of transactions as in the case of STE-JV, in which the future partner proactively contacted ECIF requesting the right to use ECIF's water treatment IP. Also, the current JV partners were informally approached leveraging a rich network of

contacts. Past good relations with these companies have facilitated the closing of a beneficial bargain. Findings from ECIF's case are consistent with Hsu and Bernstein (1997) and Bidault and Fischer (1994) according to whom social contacts in the business community and reputation can give a firm a competitive advantage in ETC. Therefore, we posit the following proposition:

Proposition 1: Higher amount of resources in terms of technological, financial, reputational and social capital assets, help firms achieve higher performance in external technology commercialization

The theoretical framework also posits that the influence of ETC resources on performance is mediated by the development of an ETC dynamic capability. The rationale is that, while the underlying source of value to the firm is the specific technology asset commercialized externally, it is the effective use of the dynamic capability that enables to extract higher share of returns from the exploitation of technology (Eisenhardt & Martin, 2000). The analysis of ECIF's experience with ETC may suggest that the firm has developed over time a dynamic capability to successfully carry out technology transactions, in comparison with the firm early moves into ETC. First, the dynamic character of such capability has allowed ECIF to adapt and reconfigure resources and management systems to match the requirements of a changing environment. At the end of 90s, changes in the competitive scenario called ECIF for a significant shift in its innovation strategy. Not only did ECIF answer with a different IP portfolio exploitation approach, but also with corporate renewal in terms of organizational solution. Consistently with its strategic shift, ECIF has established a dedicated function for marketing & business development and has moved IP office from R&D to Knowledge Management division in order to improve external exploitation potential.

Furthermore, consistent with Teece's work (2006), this capability allowed ECIF to accomplish two fundamental functions: (i) to sense ETC opportunities when they are still in an early phase and select the most promising; (ii) to seize the most promising ETC opportunities. Our case study suggests that sensing by gathering valuable technological and market information from both inside and outside the enterprise and making sense of it is crucial to timely identify and calibrate opportunities for external exploitation of technologies.

"A key point is to unearth the "buds" of a new opportunity and to pick the opportunity when it is more convenient and easier to handle" – *R&D Director of ECIF*

Equally important is the effective selection of best opportunities that will create the highest value. Early disposal of poor opportunities at ECIF is achieved on the basis of repeated practice and organizational learning: by feeding management systems with a constant deal flow. Managers at ECIF also acknowledge the importance of seizing, i.e. the ability to promptly address opportunities by committing investments and resources without delay.

"In comparison with the past, we are now able to rapidly and efficiently examine many more ETC opportunities. Accurately selecting opportunities and promptly taking action is absolutely fundamental to raise the rate of success. Rush headlong through the first illusion of a huge market with a vague and incomplete product definition is a sure viaticum to failure."

– MBDG Director of ECIF

In the light of this, we posit the following proposition:

Proposition 2: A dynamic capability in external technology commercialization mediates the relationship between resources and performance: firms with superior sensing and seizing of opportunities will extract an higher share of value from the exploitation of their technologies.

The theoretical framework finally puts forward that specific organizational and managerial mechanisms (microfoundations) underlie the development and the strengthening of a dynamic capability in ETC. From the case study it emerges that superior sensing and seizing of ETC opportunities may be achieved by managerial solutions adopted and implemented by ECIF in the last years. Key aspects will be discussed in more details hereinafter.

Microfoundations - Organization

ETC organization at ECIF is characterized by a separate dedicated organizational unit, MBDG, that is charged with the responsibility of pursuing new business opportunities and making ETC happen. Following its strategic shift, ECIF opted for structural separation to avoid that ETC effort was overwhelmed by the forces of "business as usual". The interviews with ECIF's managers allow to understand that a dedicated function with full time professionals constantly scanning external environment acts as an effective antenna for sensing new ETC opportunities and as a collector of knowledge, allowing for learning effects and experience accumulation in opportunity recognition (Zollo & Winter, 2002). Being a visible point of contact, a dedicated unit enhances external

visibility and credibility, maximizing the yield from ECIF's reputation on the marketplace and thus facilitating the identification of partners.

With regard to the seizing dimension, ETC organizational solution at ECIF allows to make effective decisions and promptly catch up ETC opportunities. MBDG's legitimacy to request part-time resources across divisions and high decisional autonomy to employ resources within its own budget guarantee rapid seizing of opportunities. The integration and coordination of ETC with ECIF's corporate strategy is achieved with the steering committee at the senior executive level. The steering committee ensures top management commitment and avoids decision making biases against ETC. Consistently with Kale, Dyer and Singh (2002), which find that in the context of alliance-making firms with a dedicated alliance function show higher level of alliance capability, we posit the following proposition:

Proposition 3.a: A dedicated business unit responsible for ETC, tightly integrated at the senior management level, help firms accomplish superior sensing and seizing of ETC opportunities.

Microfoundations - Process

High quality in executing the tasks along the ETC process help the firm identify new opportunities and organize effectively and efficiently to embrace them (Teece et al.,1997). From the analysis of ECIF's case, two phases have emerged to be key in accomplishing successful ETC deals: scouting and identification & selection of partner.

ECIF's managers point out that the firm is particularly proficient in scouting activity because of a strong market orientation and professional network management. Market orientation (Narver & Slater, 1990), achieved through continuous scanning of firm's competitive arena and monitoring of customers' changing needs, guarantees quick responsiveness to new opportunities. Also, ECIF consider its professional network of contacts as the most valuable source of information. In order to initiate and develop business relationships with other companies, MBDG director and R&D director steadily visit workshops, conferences and fairs. Also 40% of MBDG director's and 15% of R&D director's time is dedicated to maintain business contacts alive through mails, phone calls and social dinners. Good relations with current partners has enabled ECIF to form and sustain JVs. This is consistent with contribution from Bidault and Fischer (1994) who argue that companies need to develop and sustain networks of technology partners through professional relationship management if they want to operate successfully on technology markets. ECIF's network management practices thus maximize the yield from social capital assets on ETC performance by determining superior sensing of opportunities. We posit the following proposition:

Proposition 4.a: Market oriented scouting activity relying on network building and maintenance, help firms accomplish superior sensing of opportunities

ECIF's case also highlights that importance of the accurate identification and selection of partners when seizing ETC opportunities. Compared with the JVs established in the 80s, in which suboptimal choice of partner was a main driver of failure, ECIF has demonstrated a more proficient screening mechanism. Two clear criteria are taken into account in the selection of the most suitable ally: the contribution (in terms of assets) needed in each JV and the existence of mutual advantage. First, the partner has to be leader in the assets which lacks to ECIF to be successful in the specific market. While in the UE-JV ECIF has partnered with an established leader providing best-in-class downstream assets, such as market presence, brand and intangible customer list, in the case of NU-JV ECIF has allied with small highly entrepreneurial player, which developed breakthrough fuel cell technologies needed to complement and commercialize those of ECIF. Secondly, the interviewees stated that negotiations can only be successful when there is a win-win situation. In the case of UE-JV, ECIF partnered with its closest competitor because both saw a great advantage in joining forces to establish the to-be leader in the construction of chemical plants for electrolysis. In the case of NU-JV, the ally was chosen because both had a strong incentive to disrupt established market equilibria.

"In UE-JV the partner is very different from ECIF: pragmatic and routinized. In NU-JV it is very similar: entrepreneurial and risk taking. However, in both cases, we look for the best. The choice of the partner makes 90% of ETC success." – *MBDG Director of ECIF*

"The value of the single patent, the setup of the new JV, etc. are only technicalities. To have success they need to have shared objectives and mutual advantage *" – MBDG Director of ECIF*

In the light of ECIF's experience, we posit the following proposition:

Proposition 4.b: Accurate selection of partners based on the quality of complementary assets and on the existence of mutual advantage help firms accomplish superior seizing of opportunities

Microfoundations - People

Successful technology transactions are accomplished though the work of people. The choice of people performing ETC at ECIF reflects different criteria. In the senior positions, ECIF relies on

individuals with high personal standing in the business community who can leverage their broad network of contacts and informal relationships with key players. The reputation of ECIF as high-tech leader is thus conveyed and enhanced by its executives. Other key traits of ETC managers are risk tolerance to tackle high degree of uncertainty often characterizing ETC initiatives; political skills to manage relationships both internally and externally; entrepreneurial attitude, i.e. the propensity to assemble and integrate resources to drive change; high seniority to leverage experience. Specialists in the MBDG have at least 10 years of work experience at ECIF.

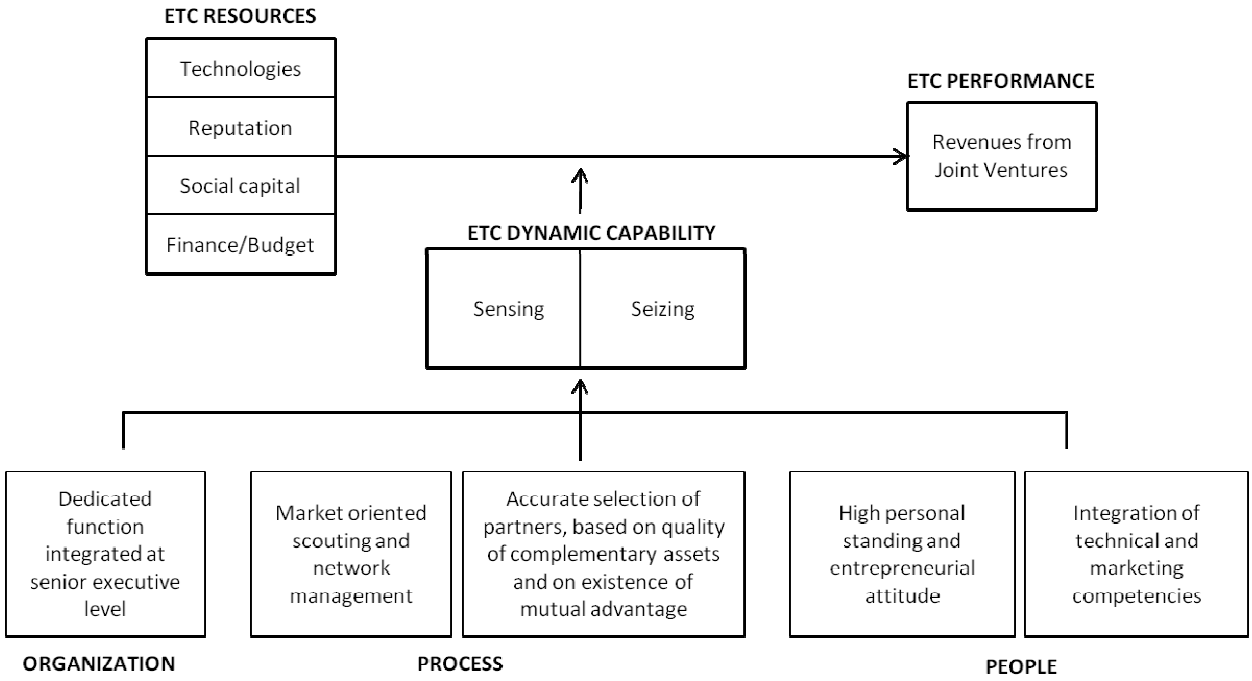
Proposition 5.a: ETC managers with high personal standing, entrepreneurial attitude and experience help firms accomplish superior sensing and seizing of opportunities

Finally, the interviews with managers point out that ECIF's capability in managing ETC relates strongly with employing highly skilled workers that tend to integrate competencies from at least two educational fields. Professionals at the MBDG group have a technical background but also long past experience in sales departments. Deep knowledge of both products and customers produces an effective blend of marketing and technological competences. The integration of different sources of expertise, often cited as a critical success factor in new product development (Brown & Eisenhardt, 1995; Marsh & Stock, 2003), is beneficial also in the context of ETC and in the case of ECIF is also achieved at the individual level, in addition to cross-functional teams. Since integrated skills and multifunctional understanding appear to be distinguishing characteristics of ETC people, we posit the following proposition:

Proposition 5.b: ETC professionals combining technical and marketing competencies help firms accomplish superior sensing and seizing of opportunities

Figure 6 reports the contribution of ECIF's case and the hypothesized relationships among the constructs of the theoretical presented in Section 3.

Figure 6 – Theoretical framework reinterpreted



7) CONCLUSION

This paper focuses on External Technology Commercialization (ETC), an approach to the commercial exploitation of technological knowledge that has assumed a prominent role in the innovation strategies of the most successful companies in the last years (Chesbrough, 2006; Lichtenthaler, 2005). In particular, it investigates how the management and organization of ETC might influence the performance with which an innovating firm carries out this activity.

The paper addresses this research question adopting a dynamic capabilities perspective (Eisenhardt & Martin, 2000; Teece, 2007), which has been successfully applied to interpret phenomena similar to ETC (Rothaermel & Deeds, 2006; Rothaermel & Hess, 2006; Marsh & Stock, 2003). In the first part of the paper, using research into dynamic capabilities and literature about ETC, a theoretical framework is developed that: (i) show how a number of assets may affect ETC performance; (ii) identifies the dimensions of an ETC dynamic capability that are likely to underlie superior ETC performance; (iii) illustrates the microfoundations of this dynamic capability, i.e. the managerial and organizational variables from which the capability originates. In the second part of the paper, the case of an Italian firm that has been involved in ETC for years is reported with illustrative purposes (Siggelkow, 2007). Specifically, the case study shows in a real context how a dynamic capability in establishing joint ventures is able to improve the performance of an

innovative firm in ETC. Moreover, it develops a number of research propositions drawing from the fact that specific organizational and managerial approaches seem to lie at the heart of an ETC dynamic capability.

The paper is believed to be useful first of all to researchers in strategic innovation management and especially ETC. It provides in fact an interpretative conceptual framework which might be able to explain different levels of ETC performance and hence represents a promising starting point for future confirmatory empirical research. Moreover, it shows that the dynamic capability perspective can be applied to investigate External Technology Commercialization, as Lichtenthaler (2005) has recently claimed. The paper holds anyhow a number of interesting managerial implications. It suggests in fact to R&D, IP or senior managers working in firms for which ETC has a prominent role in their innovation strategies, the reasons for which the decisions they take to organize and manage this activity are able to affect performance. Interpreting the experience of ECIF with ETC through the theoretical framework developed in the first part of the paper, a number of suggestions for organizing and managing ETC that are likely to improve the innovating firm's ETC performance are unearthed. These should be better conceived by managers as a starting point for identifying the solutions that are more appropriate to the needs of their companies, rather than best practices or blueprints for success.

The paper obviously represents the first exploratory step of a larger research project which is aimed at identifying the determinants of a firm's ETC performance. Future research will be aimed at enriching the interpretative framework that is put forward here through the analysis of other representative cases, and at validating the relationships it encompasses through large-scale empirical analyses.

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