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Innovation networks: From technological development to business model reconfiguration

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Abstract

This case study presents an example of how a technological innovation network provides the necessary resources to change the business model, in order to achieve global competitiveness. It describes the R&D investments of a family-operated business that supplies the aluminum industry with metals and non-ferrous metal alloys. Seven years ago, when the company was facing a severe financial crisis, it ignited a "re-birth" process through research activities, which developed a product known as "aluminum tablets". The company established changes and brought product innovations by introducing tablets from steel scraps with aluminum alloys through "water atomization" technology. The impact of this innovation was not limited to the new product's technological aspect, but it also changed the company's operational and commercial activities, which ultimately resulted in a more comprehensive customer base focused in foreign trade. The present work appraises the evolution and development of this product, supported by a theoretical reference focused on innovation networks and business models.

Keywords: Innovation networks; R&D; Business model

1. Introduction

The importance of innovation on competitiveness is well recognized. However, there is less consensus about what enables an organization to innovate.

In the last 25 years, by means of research the sources of competitive innovation in inter-companies cooperation networks have been analyzed. For Dosi, international competitiveness and macroeconomic performance are functions of an innovation-based commerce and long-term innovation abilities (Dosi, 1982). And Chesnais concludes that a country's long-term competitiveness depends on virtuous and cumulative interactions among different industries in the form of cooperative agreements and inter-companies technological alliances, in order to improve technological diffusion (Chesnais, 1991).

Empirical findings support such statements. Based on studies concerning the economic performance of the region of Emilia-Romagna, in Italy, Best states that new models of global competition rely on the innovative performance of inter-firms networks (Best, 1990).

Innovation networks are a logical effect from the increasing complexity of innovative products and services. New products are complex, because they have many features and components, and also because they must satisfy multiple requirements in the complex business environment. This increased product complexity demands the integration of a broad number of different specialized skills. In this sense, innovation networks represent an organizational solution for product and service innovation, since they integrate different organizational skills favorable for a common goal (Pyka and Küppers, 2002).

1.1. Innovation

The term "innovation" is precisely defined in the academic literature. Freeman (1982) differentiates innovation from

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invention since invention is the idea or the model with which to improve a product, equipment, process or a system. On the other hand, innovation, in the economic sense, only occurs after the first commercial transaction resulting from this new product, equipment, process or system.

Different innovations may require quite different organizational efforts and may result in a multitude of competitive impacts. Thus, innovations may be categorized in an organized typology. For the purpose of this paper, two innovation types are analyzed: incremental and disruptive innovations.

Incremental innovations utilize current technology in the current market to strengthen current competencies. This type of innovation generates value by accumulative effect and by creating versatility (Abernathy and Clark, 1985).

On the other hand, disruptive innovations frequently begin in limited markets, but, after technological improvements, they substitute current technologies and simplify the product and the value proposition (Christensen et al., 2004).

1.2. Innovation networks

In the 80s, Industrial Economy theories influenced innovation research, which theorized the structural factors determinative of the innovative activities in a company (Porter, 1983). Those studies found that the ability to establish relationships in a network of organizations was a key issue, in order to develop a company's organizational innovative capacity.

Another argument for innovation networks came from the successful performance of Japanese companies. In the 80s, Nissan, Toyota and Mitsubishi built many strategic alliances with other organizations. Those alliances improved significantly the learning abilities of these Japanese companies from the interactions with their network members (Rycroft and Kash, 2004). The authors define "networks" as the linkages between organizations (other companies, universities and regulatory agencies), in order to create, capture and integrate the many different skills and knowledge needed to develop complex technologies and bring them into the market.

The Confederation of British Industry, conducted a research on the innovation best practices in British companies and found that the innovative enterprise seeks collaboration with other companies and universities, in order to maximize its knowledge and minimize its risk along the innovation process (CBI (Confederation of British Industry)/ DTI, 1993).

In Zimbabwe, the performance of innovation networks for four light engineering small and medium enterprises depended on the organizational capacity to learn and on the entrepreneur's education level and previous employment experience in big corporations. Moreover, in order to improve products and to design new products, the networks with Enterprise Support Organizations were as important as networks with customers (Chipika and Wilson, 2005).

In France, the development of environment-friendly viticulture utilized two different types of innovation networks: networks to construct common knowledge and social identity and networks to gather fast solutions for specific problems (Chiffoleau, 2005).

In Europe, small and medium size companies in the electronics hardware-based sector use almost twice as much of their R&D expenditures in partnerships than large firms do. However, these small and medium size companies are more cautious when choosing partners, because half of the partnerships fail and those companies do not have abundant resources to overcome unsuccessful projects (Narula, 2004).

In Taiwan, the high technology industry resulted from the development of an innovation network integrating a research institute, the government, universities, industrial companies and international organizations (Hsu, 2005).

In Japan, Mitsubishi and DoCoMo developed a new mobile multimedia market for a mobile videoconferencing platform. For this development, innovation networks allowed these companies to obtain both fast access to relevant knowledge and the synthesis of knowledge domains, which were created in long time periods by the departments of each company involved. For this purpose, it was necessary first to integrate each corporate capability internally and then, to reciprocally integrate the capabilities of both network partners externally (Kodama, 2005).

Other researchers have studied how innovation networks operate in reality. For this purpose two perspectives are of special interest for empirical studies: analysis of the relationship structures inside an innovation network and analysis of the dynamic and systemic behavior of a network along the innovation process.

Ahuja studied how relationship structures in cooperative networks impact innovation measured by patent number in the chemical industry. He found that direct relationships play a very different role in the innovation process than indirect relationships do (Ahuja, 2000).

A direct relationship is the access one organization has into another organization without the intermediation of a third part. On the other hand, indirect relationships occur when an organization obtains access to many other organizations through the intermediation of a third organization. Ahuja demonstrates that direct relationships are suitable for resource and knowledge interchange, while indirect relationships are suitable for quick access to specific information.

Pyka and Küppers developed a dynamic and systemic model to analyze the behavior of innovation networks throughout the innovation phases. Based on four case studies in the biotechnology, telecommunication, energy and e-commerce industries, they developed a computational model with which to simulate innovation networks. The dynamic model analyses the interdependencies of the

following factors compounding an innovation network (Pyka and Küppers, 2002):

(a) The firm's own R&D efforts.
(b) The innovation partnerships and alliances.
(c) The resulting knowledge base.
(d) The resulting innovation.
(e) The market acceptance for the innovation.

1.3. Business model

The term "business model" is frequently utilized ambiguously. Nevertheless, some definitions are more accepted owing to their conceptual soundness or because of their empirical foundation.

Business model is "a statement of how a firm will make money and sustain its profit stream over time" (Stewart and Zhao, 2000). For Morris "a business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets" (Morris et al., 2005).

Some researchers observed successful companies like Intel (Eisenhardt and Sull, 2001), Yahoo (Girotto and Rivkin, 2000; Rindova and Kotha, 2001) and Dell (Yao and Liu, 2003), in order to find an empirically based concept of business models.

With this in mind, Chesbrogh and Rosenbaum analyzed 35 case studies and found that a business model is composed of the value proposition, target markets, internal value chain structure, cost structure and profit model, value network and competitive strategy (Chesbrough and Rosenbaum, 2002). Linder and Cantrell interviewed 70 CEOs and analysts and concluded that a business model derives from variables such as pricing and revenue model, channel and commerce process models, internet-enabled commerce relationship, organizational form and value proposition (Linder and Cantrell, 2000).

Based on a broad analysis of theoretical and empirical researches, Morris developed a framework that systemically describes the basic components, the unique combinations and the guiding principles to analyze a business model (Morris et al., 2005).

To identify the basic components, Morris proposes the following questions:

(a) How will the firm create value?
(b) For whom will the firm create value?
(c) What is the firm's internal source of advantage?
(d) How will the firm position itself in the marketplace?
(e) How will the firm make money?
(f) What are the entrepreneur's time, scope and size ambitions?

In the next step, the framework identifies how the firm creates unique combinations of the basic components in a specific manner. Finally, the framework describes the guiding principles defined by a set of operating rules to ensure that this unique combination will be implemented.

2. Research methodology

According to the constructs identified in the bibliographic revision, the empirical research will follow the analytical framework illustrated in Fig. 1.

The present work will analyze how a mid-sized company in a developing country succeeded to grow and internationalize its business (dependent variables) as a function of innovations in the organizational business model shaped by resources provided from a technological innovation network. More specifically, the research studies three factors of the innovation network (independent variables):

(a) The relationship structures.
(b) The innovation typology.
(c) And the innovation network dynamic.

To conduct this analytical framework, the case study research methodology was chosen. The case study is suitable for researchers to answer questions as "how" and "why", whenever the empirical analysis focuses on a real-life context (Yin, 2005).

Since the present work aims at identifying how an innovation network enabled the change in a business model for internationalization, it will be necessary to conduct an explanatory study to understand how and why the innovation network structure and dynamic created the access for the key resources that shaped this new business model.

2.1. Case study protocol

For Yin, research protocols define standardized procedures, in order to ensure the reproducibility of the case study conclusions, even when different researchers follow those same procedures (Yin, 2005).

The case study procedures should define the main research question, the information sources and the specific question that should be answered by the research.

Unity of analysis: The theoretical focus of the research is the theory of innovation network and the theory of business model, while the unity of analysis is the innovation network of a medium-size Brazilian Metallurgy Company.

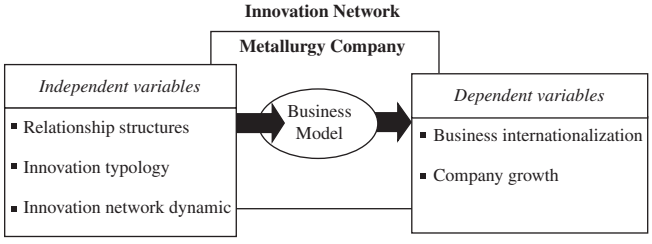

Fig. 1. Analytical structure.

The research will focus on the period from 1997 to 2005, but will also briefly summarize the company's development since its foundation in 1978.

Research question: In which manner did the technological innovation network enable the Metallurgy Company with the business resources and relationships required to innovate the company's business model?

Objective: The study aims at identifying the relationship structures that enabled the Metallurgy Company to create a technological product innovation and a new business model to increase the company's competitiveness in the global market.

Constructs validity: To increase the conclusions validity, the research utilizes multiple sources of information: journals, newspaper, government agency website, entrepreneurs club website and an interview with the Metallurgy Company's entrepreneur.

And the quality of the causality relations derives from the adherence to:

- Morris business model framework (Morris et al., 2005).
- Pyka and Küppers model for innovation network dynamic (Pyka and Küppers, 2002).
- And Ahujas framework for network structures (Ahuja, 2000).

Specific questions: The case study at the Metallurgy Company aims to answer the following questions:

- Which is the relationship structure of the Metallurgy Company's technological innovation network?
- Which was the sequence of innovation types?
- How was the dynamic of the innovation network?
- In which way did the technological innovation network provide the resources for changing the Metallurgy Company's business model?

3. Case study

A Ph.D. engineer founded the Metallurgy Company in 1978 to produce metallic chrome powder by means of a new technology for the Brazilian market, a process called aluminothermy. The Metallurgy Company sold chrome for the niche market of electrodes welds. This market was growing mainly as a result of the expansion of the maritime platforms of the Brazilian oil company. At this time, barriers and obstacles to imported products characterized the Brazilian economy, as a result, the Metallurgy Company operated in the domestic market with little international competition. This business model was successful for the company owner up to 1986, at which time the firm had 80 employees and earned US$ 200 thousand per month.

However, after 1986, the Metallurgy Company declined in the new economic scenario of open Brazilian domestic borders for the global economy. Customers now could choose the cheaper chrome from China, consequently, the Metallurgy Company lost clients and revenues decreased.

In 1997, the company operated under financial deficits and was technologically stagnated. At this moment, the Metallurgy Company faced a strategic choice with two different business visions:

(a) The vision of a very small company focused on products for niches in the domestic market.
(b) Or the vision of a global company.

The founder of the company passed on the administration to the family's second generation, to his son, a metallurgic engineer, and to his daughter, a business administrator. Before leaving the Metallurgy Company however, the founder advised the new directors to consider a new business idea: alloying tablets composed of metallic powders for the aluminum producers to improve its resistance and plastic properties.

The new directors decided for the business vision of a global company. But how would a small Brazilian organization make way into the global market?

It took two years to launch the new product, the metals tablets. In the first year, the Metallurgy Company developed the product and only after the second year, it succeeded in obtaining the first customer in the aluminum industry, which is a concentrated oligopoly. The aluminum producers are large-sized companies, which deliver aluminum for extrusion and stamping plants to produce cans and sheets.

The first step to internationalize the business was to consolidate the Metallurgy Company's market-share in the domestic market. By 2000, the Metallurgy Company counted on 30% of the Brazilian market. In order to gain access to the international market, the Metallurgy Company planed to attract customers with low prices and reliable commodity. For this purpose, the company looked for new technological means to utilize recycled scrap iron and aluminum alloys as raw materials.

However, this strategy required a systemized Research and Development activity in the technology of water atomization. For a small company, water atomization is a complex technology. Therefore, the entrepreneur searched for alliance and found that, in Brazil, the IPT—Instituto de Pesquisas Tecnológicas (Institute for Technological Research) masters the water atomization technology.

The Metallurgy Company joined the Institute for Technological Research in a cooperative R&D project to develop tablets of alloy metal by water atomization. This idea is in the process of obtaining a patent in the US and in Brazil.

The project funding relied on governmental agencies for financial resources, since this project satisfied the criteria pertaining to generating innovative products for actual market and generating new jobs.

In 2003, the Metallurgy Company hired a researcher from the Institute for Technological Research network to

start the internal R&D department and establish the plant to manufacture the product with the new atomization technology.

The water atomization technology enables the Metallurgy Company to increase competitiveness by reducing prices, increasing margins and also by customizing microscopically the shape of the metallic powder surface, in order to increase product performance in the client operations.

By absorbing the water atomization technology, the Metallurgy Company also gains access to potential new business opportunities: iron powder for the food market and smelted iron powder to produce complex parts for the automobile market.

From 1997 to 2005, the Metallurgy Company increased the number of employees from 15 to 135, they increased manufacturing six times and increased exportations from one to over 20 countries.

3.1. The Metallurgy Company's innovation network

The Metallurgy Company's innovation network began with three direct relationships and two indirect relationships. Moreover, the Metallurgy Company mediated the indirect relationship between two organizations inside the network (Fig. 2).

The development of the atomization of recycled scrap alloys occurred by two direct relationships with intensive resource exchange. The relationship with the Institute for Technological Research established the channel of the Institute's know-how on atomization into the Metallurgy Company, and provided the financial resources from the governmental agencies to the Institute through the Metallurgy Company. Moreover, this relationship also enabled the Institute to obtain a favorable result and to prove the applicability of its knowledge and implementation of its institutional mission as an agency for technological diffusion.

However, innovation is not limited to technological development, but also includes the operational and commercial feasibility of the new product. The phase of operational development occurred through an indirect relationship with an expert on designing and implementing a new plant for the atomization technology. Also the sourcing operations were improved by a direct relationship structure in a joint venture with an aluminum recycling company.

The Metallurgy Company obtained more than just a new and competitive product from the technological innovation network. In fact, the relationship structures from this initial innovation network changed over time to capacitate the Metallurgy Company with the key resources to innovate its business model to internationalize the company's activities (Fig. 3)

The governmental agency that provided support to the technological innovation program, which financed the Metallurgy Company's combined R&D with the Institute for Technological Research, found that only five of the 100 companies in the agency's program were, in fact, successful in the market. Therefore, the governmental agency contracted Endeavor, a non-profit entrepreneurs club, to conduct an MBA to improve the management skills of the supported technology-based companies, with the purpose of capacitating these companies to elaborate sound business plans.

With improved management education, the Metallurgy Company organizers redesigned the business model and defined a cluster of three synergic companies. The tablets manufacturers moved to the Metallurgy Company's new facility, plant 2, with the purpose of creating additional room in the Metallurgy Company's plant 1 for the new manufacturing process with the water atomization technology. In addition, the Metallurgy Company group created a third plant near plant 2 for metal recycling. Thus, the metal recycling plant and the alloys-atomized powder could supply the tablets plant with low-cost raw material.

Endeavor invited the Metallurgy Company's founder's son to concur as a candidate for the Endeavor Entrepreneur application process, which he successfully passed.

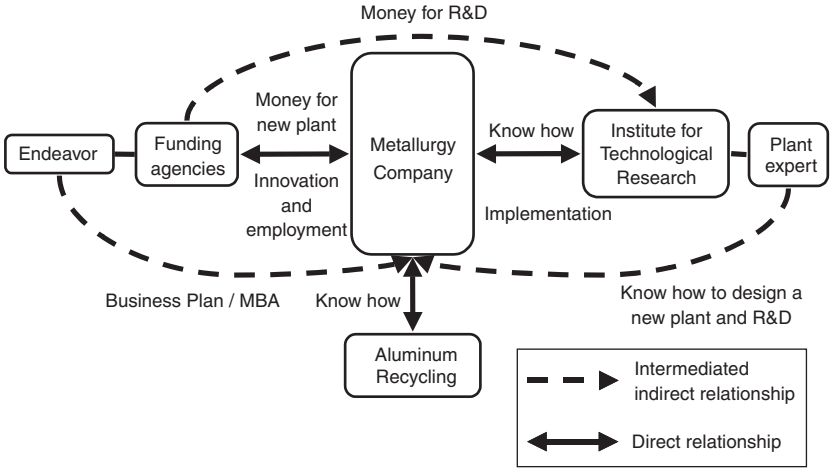

Fig. 2. Technological innovation network relationship structure.

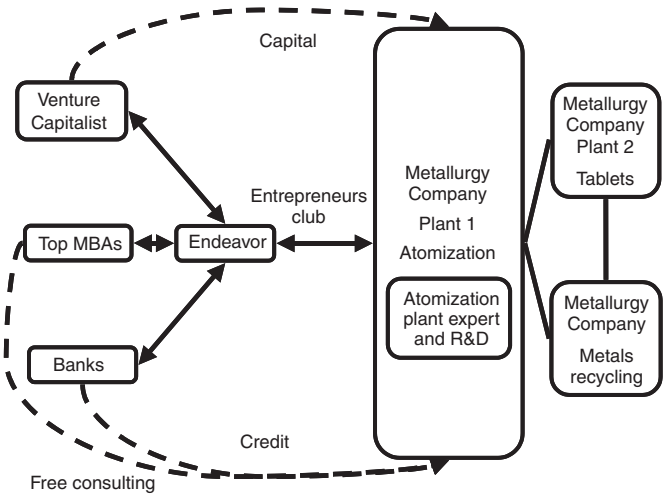

Fig. 3. Network relationship structure for innovating the business model.

Consequently, the Metallurgy Company's entrepreneur joined the international entrepreneur's club and gained access to venture capitalists, special credit conditions and free consulting of top American MBAs.

Following Pyka and Küppers dynamic model for innovation networks (Pyka and Küppers, 2002) it is possible to analyze the interdependency of the Metallurgy Company's network factors along the innovation process, from R&D to market launching. In the first innovation cycle, the Metallurgy Company was founded, in the second innovation cycle the Metallurgy Company performed an incremental innovation in leaving a declining market niche and gaining access to a new market and, in the third innovation cycle, the Metallurgy Company conducted a disruptive innovation to increase its share in the global market.

In the first innovation phase, a metallurgic engineer obtained knowledge about aluminothermy in his Ph.D. and founded the Metallurgy Company utilizing this technology to produce metallic chrome.

In the second phase, the Metallurgy Company suffered from the decline of its initial market, and as a consequence, the company developed a simple technological product to gain market access to the large size aluminum producers. This development was followed by a sequence of incremental innovations that improved product performance.

Finally, to consolidate and expand its commercial activities in the international market of powder tablets for aluminum producers, the Metallurgy Company developed many alliances and partnerships to decrease its raw-material cost. Hence, the company searched product and process knowledge, in order to conduct a disruptive innovation to simplify product sourcing: the new technology allows the Metallurgy Company to utilize recycled scrap alloys instead of virgin metals as raw materials for the tablets. This strategy enables the Metallurgy Company to decrease costs and gain competitive advantage in the global market.

According to Morris framework (Morris et al., 2005), it follows a description of the Metallurgy Company's business model and its relation to the innovation network:

(a) How will the firm create value?—the Metallurgy Company creates value by delivering low-cost and high-performance metals tablets to increase resistance and plastic properties of aluminum. This value creation was improved by the water atomization technology developed in partnership with the Institute for Technological Research and with governmental financial agencies.
(b) For whom will the firm create value?—the Metallurgy Company supplies metal powder tablets to aluminum producers in more than 20 countries worldwide. Access to this market was initially achieved through incremental innovations on a very simple technological product: tablets from virgin metal powders.
(c) What is the firm's internal source of advantage?—the main source of advantage is the atomization technology and the control of metals from its own recycling operation. The recycling know-how was absorbed through a direct relationship in a former joint venture.
(d) How will the firm position itself in the marketplace?—the firm positions itself as a low price and high-performance supplier.
(e) How will the firm make money?—the Metallurgy Company makes money with high volume and medium margin products.
(f) What are the entrepreneur's time, scope and size ambitions?—the Metallurgy Company's entrepreneur ambitions are clearly stated: To be a major global supplier for the aluminum industry by 2007 and, in parallel, to further develop markets for metal powders in other industries. The knowledge and the facilitated access to capital, credit and management expertise to turn such ambitions into feasible business actions were achieved through the indirect relationships with Endeavor, an international entrepreneur's club. This network structure however, originated from the transformation of the initial technological innovation network, in which Endeavor provided management skills for technological innovative entrepreneurs supported by the government financial agency.

4. Conclusion

The Metallurgy Company case study provides three conclusions that need to be further validated by future case studies and by quantitative analysis.

Firstly, the case shows that small size companies may structure its R&D department from outside to inside, since key resources as the R&D expert and the know-how on atomization originated from the technological innovation network with the Institute for Technological Research were internalized by the company along the innovation process.

Secondly, the Metallurgy Company internationalized its operations by a specific sequence of innovation types. In order to create access to the aluminum market, the company focused on incremental innovations. But after achieving the first clients, the Metallurgy Company aimed for growth in the international market by a disruptive innovation with the atomization technology to obtain metal powder not from virgin metals, but from recycled scrap alloys.

Finally, the case study indicates that the technological innovation network not only provided the Metallurgy Company with a competitive product technology, but the innovation network also provided the necessary resources for the reformulation of the Metallurgy Company's business model. This new business model integrated the Metallurgy Company into an international entrepreneurs club, enabling access to key resources as management expertise, special credits and capital to ensure the company's global market growth.

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