Abstract

Mainstream Technology and Innovation Management literature neglects the fact that laggard or latecomer firms lack of necessary innovation capabilities to compete or catch up leading competitor. Also scholars studying the phenomenon of creation of technological (innovation) capabilities in this kind of firms have biased to the technology side of the organization, neglecting the intervention of other strategic capabilities, such as marketing, IT and managerial capabilities in the process of creating the ability to innovate.

This paper attempts to provide a theoretical framework that analyzes a firm as an integral entity, including all strategic capabilities which interact during the process of creating the innovation capabilities.

It concludes with an application to a Mexican steel company that was capable to transform itself from a laggard into a global technology leader in the steel industry.

KEYWORDS:
Innovation capabilities, emerging economies, innovation framework

Introduction

This paper is concerned with how innovation capabilities\(^1\) are developed in an organization, and its focus is on the description of the process of capabilities development, that involves different steps that each capability follows affected by different factors that hamper or foster its evolution into innovative capabilities. For this purpose this study develops a theoretical framework that integrates previous literature regarding the development of technological (innovation) capabilities in latecomer firms, and extends the scope of analysis inside an organization.

The paper starts with a brief literature review, then proposes the integration of different research streams and finally suggest a framework that can provide a theoretical base for studying the emergence of innovation capabilities in a firm.

This framework is applied to the lifetime of Hylsa, a Mexican steel company that started to operate learning the most basic concepts of steelmaking, and after a process of capability building became the technology and market leader of the direct reduction iron-making process.

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\(^1\) This study considers innovation capabilities as integrative capabilities that mould and coordinate other organizational capabilities and resources in order to develop innovative activities.
Literature Review

Innovation can be defined as “the implementation of a new or significant improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations” (European-Comission, 2005, p. 46). It is a critical source of competitive advantage as its novelty translates into higher value perception from the market and because the first entrant can obtain a patent or similar protection that would result in earning monopoly profits for many years (Shy, 1995:224), however this advantage is not easily obtained.

Mainstream innovation management literature studies innovation in two large traditions. The first one is centered in business economics, mainly within industrial organization that relates innovation to market structure, such as intensity of growth of demand, market concentration, or technology opportunity. Other economics branches also participate in the innovation debate, such as transaction costs economics, agency theory, and evolutionary theory, all of them analyzing exogenous factors (Galende, 2006; see also Shy, 1995; Schumpeter, 1954, among others).

The second large tradition follows management studies that develop endogenous analysis, considering that an organization can generate its own resources to be capable to develop innovative activities (Barney, 1991; Teece, 2007; Kogut and Zandler, 1992, among others). This study follows this second tradition, as it is concerned with changes in an organization motivated by transformation of its capabilities. It includes some exogenous elements when they are critical factors that affect the development of capabilities.

Mainstream innovation management studies regarding organizations in developed countries have focused on sources of competitiveness using innovation (Bates et al., 1995), such as decisions on developing disruptive or incremental innovations (Christensen, 1997), optimizing the new product development process (Brown and Eisenhardt, 1995), or studying the relationship between innovation and performance (Coombs and Bierly, 2006), and consider firms as in an innovation race against their competitors when positive benefits are predicted. However this research is extensive, it does not consider the dynamics inside a firm that leads to develop its first innovations.

In the other side, innovation studies of firms in emerging economies have two orientations, the first refers to macro, regional and national innovation studies (Katz, 2001; Lundvall, 1995; Cimoli, 2001), and the second concentrates in the analysis of the technological dimension of the phenomenon, neglecting the intervention of non technological capabilities (Kim, 1997; Lee and Lim, 2001). In this literature a new stream of research has emerged, which studies the accumulation of technological capabilities in firms that attempt to transform themselves into innovator companies in emerging economies (Lall, 1992; Bell and Pavitt, 1995), and contributes with the notion of knowledge accumulation and different innovativeness levels.

A start-up company or a traditional company in an emerging economy does not have this ability to perform innovation activities. However it frequently develops learning activities to eliminate technological gaps with local competitors that are necessary to maintain at least a parity

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2 He analyzes elements like the innovation race (research and development –R&D- equilibrium and society welfare approach), firms cooperation in R&D, patents (R&D levels given patent duration), licensing and innovation, and government and international R&D races, biased to exogenous factors. This is the industrial organization approach.

3 Schumpeter proposes two factors, size of the firm and market concentration.
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These activities create “new” things inside the firm, such as new operational practices as a consequence of the acquisition of new machinery, or developing new business models or processes in attempts to reduce costs. All of them bring “newness” to the company that could be “new to the company” innovation adoptions. In this way the firm can start the development of innovation capabilities. These low level innovations have a special meaning in this paper, which is that developing them at different ascending newness levels the company can start the process of creation of the innovation ability in the firm.

The emergence of innovation capabilities in organizations is the central topic of this study, and it tries to identify different stages that can explain this phenomenon analyzing how each strategic capability evolves in its innovativeness levels, starting from its creation, developing initially only basic routines towards its transformation into a source of innovation activities, when it becomes capable to mould and coordinate other organizational capabilities in order to develop innovative activities.

The resource-based view (RBV) considers a firm as a bundle of resources and capabilities that are the sources for sustained competitive advantage (Barney, 1991). This literature is relevant as it states that a firm is not locked to its actual resource portfolio, but it can regenerate itself by reconfiguring its resources, creating new competitive proposals. Extensive studies in RBV have analyzed different approaches when explaining capabilities development. In this way firms are able to create innovation capabilities. This study also includes the dynamic resource based view (DRBV) that considers that all organizational capabilities follow a lifecycle-like behavior, providing a theoretical base for analyzing the development of capabilities in an organization.

This paper identifies different gaps in the literature review:

- Mainstream innovation literature neglects the nature and explanation of the emergence of innovation abilities in laggard companies.

- In the technology capabilities literature, there is not an explanation of how is the process of the creation of innovations capabilities, and are biased towards “hard technology” elements, neglecting the intervention and interaction of other non technological elements.

The development of innovation capabilities in an organization based in an emerging economy has not been properly explained, as studies at the firm level regarding innovation in emerging economies have used the traditional Bell and Pavitt (1995) taxonomy, that considers only technological and its supporting capabilities in their argumentation (Dutrénit, 2000; Figueiredo, 2001; among others), but they have neglected other strategic capabilities and the interactions between them during this process.

In addition to this, the incorporation of dynamics and the analysis of context effects in RBV will contribute to the strategic management theory incorporating empirical evidence of emergent issues, such as the DRBV and the inclusion of lifecycle approaches to the analysis of capabilities development.

**The Integrative Theoretical Framework**

From Lall to Bell and Pavitt, and further

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Bell and Pavitt (1995) when studying variations in efficiency and competitiveness in firms in emerging economies using similar technologies identified that the different levels of accumulation of technological capabilities was part of the explanation of differences of performance between industries.\(^5\) Based on Lall (1992), they differentiate basic production capabilities and technological capabilities according to the level of cumulated knowledge and experience. They identified six different functions, grouped in primary and supporting activities. The former one generates technical change while the latter one develops linkages with other firms, institutions, and capital goods producers (p.83), and it is illustrated in Table 1. This taxonomy has been extensively used in empirical studies to picture the level of technological capabilities achieved by firms in emerging economies (as Figueiredo, 2001; Dutrénit, 2000).

It has also received criticism because of its static characteristic: it is useful to identify a current innovation position but it does not provide information about how the organization reached a specific level of innovation maturity (Figueiredo, 2001). In other words, it does not consider the dynamism that is inherent to the changes in capabilities over time.

Another gap in this literature is the lack of analysis of the relationship between different functions inside an organization while developing innovation capabilities. The Bell and Pavitt framework separates them when they analyze innovativeness levels. As a consequence of this limitation, this framework only considers a restricted group of organizational capabilities (closely related to technological innovation). Indeed they call their framework the “industrial technological capabilities framework”, neglecting other types of organizational capabilities that have significant effects on the evolution of innovativeness levels of the firm. Advanced technological capabilities, even when it involves dynamic capabilities features, by themselves cannot guarantee value creation nor rents for the firm. It is necessary to be organized in a business oriented way.

\(^5\) Bell and Pavitt (1995) classified industries in supplier intensive, scale intensive, information intensive, science base, and specialized supplier industries, each one of them having a different nature and sources of technological knowledge (p. 79).
Table 1 Bell and Pavitt’s taxonomy (1995), based on Lall (1992)

<table>
<thead>
<tr>
<th>Basic production capabilities</th>
<th>Facility user’s decision-making and control</th>
<th>Project preparation and implementation</th>
<th>Process and production organization</th>
<th>Product centered</th>
<th>Developing linkages</th>
<th>Capital goods supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaging primary contractor.</td>
<td>Preparation of initial project outline.</td>
<td>Routine operation and basic maintenance of ‘given’ facilities.</td>
<td>Replication of fixed specification and designs.</td>
<td>Procurement of available inputs from existing suppliers.</td>
<td>Replication of unchanging items of plants and machinery.</td>
<td></td>
</tr>
<tr>
<td>Securing and disbursing finance.</td>
<td>Construction of basic civil works</td>
<td>Efficiency improvement from experience in existing tasks.</td>
<td>Routing QC to maintain existing standards and specifications.</td>
<td>Sale of ‘given’ products to existing and new customers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Officiating at opening ceremony.</td>
<td>Simple plant erection.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**TECHNOLOGICAL CAPABILITIES (CAPABILITIES TO GENERATE AND MANAGE TECHNICAL CHANGE)**

|-------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|

(Source: Bell and Pavitt, 1995)
This study looks for an approach that does not limit to ensure self-sufficient technical abilities, but to start the commercialization stages of technological activities, which generate value and rents. It differentiates itself from Kim, Bell and Pavitt and Figueiredo in that all of them were concerned only with technical development without taking into account the integral nature of a firm, as the requirements to begin the commercialization of their technological discoveries. These additional requirements could imply that capabilities different from technological ones will also follow a similar behavior of accumulating knowledge to become sources of innovation.

Also, capabilities that create other innovation types different from technological ones are not properly considered in this framework (e.g. service, new market, intrafirm process, business model innovations). Most innovations developed by firms in emerging economies are of these types, such as “Patrimonio Hoy”, a new business model for selling cement with a corporate social responsibility approach, the ready-mix concrete distribution systems that reduced delay from 3 hours to 20 minutes, both of them world-class innovations developed by Cemex, a Mexican cement producer (Sull, 2006). Another example is the development of the “OEC model” (Overall, Everyone, Control and Clean), a managerial innovation based on control systems and personal accountability at all levels of the organization, designed by Haier, a Chinese white appliance manufacturer (Yi and Ye, 2003; Atoche-Kong and Cobas-Flores, 2010) that is a critical component of Haier’s competitive advantage that allowed it to become the third largest white appliances producer in the world.

Towards a new integrative product/service/process innovation model

What happens after a firm in an emerging economy acquires the required innovation capabilities? This point implies that these organizations have caught-up their competitors in the technological frontier, and then they are already competing in a global arena, not just defending their local markets.

There are already many multinational corporations (MNC) that have arisen from emerging economies. Beausang (2003) reported several Chilean and Brazilian cases; also there are other cases such as CEMEX, Vitro, and “America Móviles” in Mexico; Haier Group or Lenovo from China; Tata from India; Petrobras and Embraer from Brazil, etc. The emergence of a MNC from these economies locates them at global competitive levels, and the development of innovation capabilities is a necessity to compete at least with parity in these new markets.

Dahlman et al. (1987) reported the Mexican cases of Vitro and Hylsa, which not only reached the technological frontier and advanced innovation capabilities but they also begun to commercialize their innovative processes around the world (p. 766-767), and their findings evolved later into the Bell and Pavitt taxonomy. However Dahlman et al. studied only the technical dimensions of the emergence of the ability to innovate in a firm, providing a partial analysis of a more complex phenomenon. This study attempts to provide a more extensive explanation of this process.

Indeed Dahlman tell us that both companies reached advanced levels of technological capabilities, but not high innovativeness levels as these companies require other capabilities to exploit (commercialize) their technological developments. For example, many authors consider that without marketing capabilities an organization cannot generate rents from its innovations (Becker and Lillemark, 2006; Baker and Sinkula, 2007; Keskin, 2006; Wei, 2006).
Teece (2007) states that the foundations of enterprise success transcend simply being productive at R&D and spend heavily on R&D and new product development, but it must also generate the complementary organizational and managerial innovations needed to achieve and sustain competitiveness.

The process of developing innovation capabilities does not finish when firms begin to compete at the technological frontier, indeed they begin a new innovation challenge: to sustain a global competitive position in their industries. This strategic attempt implies to develop different strategies, as to focus on new product development (NPD), marketing, and market-sensing processes, covering the six types of innovations discussed in this report. A question emerges, should they follow the same innovation trajectories than their peers in developed countries, or should they develop their own approach, combining lessons from the catch-up stage with “traditional innovation strategies”? This paper attempts to discuss this new question when it analyzes advanced innovativeness levels reached by the case studied.

Without NPD strategies it is not possible to create innovation, as product development is defined as the transformation of a market opportunity into a product available for sale. Unfortunately there is little provision of indigenous high value added products from emerging economies that require high levels of research (e.g. Embraer, Tata Motors, Lenovo, Haier, among others). Instead of that most products designed and manufactured in emerging economies are commodities that do not require high R&D efforts. However there are many MNCs from these countries that offer world-class services, business models, and processes, like Cemex, America Moviles, Tata Software, Natura, Televisa, “Cinépolis”, etc.

For these reasons a new integrative innovation model is required, that can conjoin all strategic capabilities of an organization.

Towards an Integrative Framework of Innovation Capabilities Development

This part introduces the research framework that draws on the dynamic resource based view and the technological capabilities literature. Both of them provide strong frameworks for partial explanation of the research phenomenon of this research; however none of them are sufficient to explain the creation of innovation capabilities, that is the aim of this paper.

The innovativeness levels framework

Previous research has explored the nature of how technological capabilities evolve to become innovative capabilities through knowledge accumulation, and this process requires continuous efforts and is subject to path-dependence effects (Bell and Pavitt, 1995). In Table 1 they suggest that technological capabilities start as basic production capabilities, to later, through indigenous technological efforts, acquire mastery on new technologies. This way this capability ascends to basic, intermediate and advanced levels. In a similar way, using a more elaborated framework, Figueiredo (2001) expands the steps necessary to transform a “routine” technological capability into an “innovative” technological capability. He proposes a 9 steps framework, 4 at routine levels and 5 at innovative levels. Both frameworks draw on Katz (1987), Dahlman et al. (1987), and Lall (1992), and the accumulation process proceeds from simple to more complex categories.

This study follows this tradition, but also differs substantially from them. The first difference is that it refers to innovation activities rather than only technical proficiency or mastery that was the intention of the Bell and Pavitt framework. To obtain innovative mastery at least two components
should evolve together: the capacity to develop novelty products (or services), and the capacity of obtaining rents from it. The first task can be developed from any strategic capability in the organization, as this framework involves all kinds of innovations and not only technological ones. Also other complementary capabilities can participate in this process, according to the nature of the innovation being developed. The second difference comes from the need to include all intervening strategic capabilities in the framework.

Previous frameworks have used technical functions. Instead of that, this framework uses strategic capabilities. It is required to cover all capabilities existent in an organization. Previous studies with multiple capabilities intervening in the innovation processes consider marketing and technological capabilities, such as Becker and Lillemark, (2006), Danneels (2007), and Baker and Sinluka (2007). Others with partial explanations are Collins and Hitt (2006) and Rothaermel and Deeds (2004), as they study relational capabilities and innovations; finally, Di Benedetto et al. (2008) develop an empirical study relating strategic capabilities and radical innovation, where they develop a capabilities taxonomy covering all areas of an organization. This paper adopts the Di Benedetto et al. (2008) capabilities taxonomy that comprises capabilities in all functions of a company, and each one of them with different components. This taxonomy was developed with participation of managers in previous studies, with statistical validation of consistency (DeSarbo et al., 2005), and applied in other analyses that required an integral vision of a firm, such as DeSarbo et al. (2006) and Song et al. (2007).

1. **Marketing capabilities**: these permit the firm to better implement its marketing programs. Its components are: Knowledge of customers, Knowledge of competitors, Integration of marketing activities, Skill to segment and target markets, Effectiveness of pricing programs, Effectiveness of advertising programs

2. **Market linking capabilities**: these allow to increase competitiveness by detecting changes in the market and environment. Its components are: Market-sensing capabilities, Customer-linking capabilities, Durable relationship with suppliers, Ability to retain customers, Channel-bonding capabilities

3. **Technological capabilities**: these allow to maintain costs and/or achieve product differentiation. Its components are: NPD capabilities, Manufacturing processes, Technology development capabilities, Predicting technological changes, Production facilities

4. **IT capabilities**: these allow for the diffusion of technical and market information throughout functional areas. Its components are: IT systems for NPD projects, IT systems for functional integration, IT systems for technical knowledge creation, IT systems for marketing knowledge creation, IT systems for internal communication

5. **Management capabilities**: these affect profit performance and increase execution of strategy. Its components are: Integrated logistics systems

6. Cost control capabilities, Financial management skills, Human resources management capabilities, Profitability and revenue forecasting, Marketing planning process
Accumulation of innovativeness in strategic capabilities

With these two components, the cumulative approach is applied when creating innovation abilities and the use of strategic capabilities that comprises a company as a whole. It is necessary now to define the stages and nature of the accumulation process, and its stages.

Previous studies have proposed different stages that a capability follows in the process to become innovative, and all of them are compatible with the capability lifecycle approach. Kim (1997) identifies three stages: imitation, creative imitation and innovation. In the other side Figueiredo (2001) proposes a more complex scheme with 9 levels: a routine stage, with four levels (basic, renewed, extra basic, pre-intermediate), and an innovative stage, with five levels (extra basic, pre-intermediate, intermediate, high-intermediate, advanced). The first attempt was to apply Figueiredo’s scheme, but initial analysis of data collected in field work found it complicated because of the excessive number of levels.

The classification of levels comprises two large phases, following former works: routine and innovative phases, respectively. In the Hylsa case study all strategic capabilities are analyzed since their foundation, where they started with basic and routinary learning process, until it reached maturity as a capability. These first part capabilities do not develop innovative activities, and this framework covers the routine part. It is compatible with Kim and Figueiredo’s criteria that these stages are characterized by learning efforts and limited to operational practice. For the purpose of this framework this phase is divided in two stages: the basic and advanced routine levels.

Following Lall (1992) and Bell and Pavitt (1995), the basic level is considered when the capability is learning to operate, characterized as “routine operation” by Bell and Pavitt, and “routine production” and “replication” by Figueiredo. In the capability lifecycle it is the foundational stage. Advanced routine level is the development stage in the lifecycle, and characterized by “efficiency improvement from experience in existing tasks” by Bell and Pavitt, and “improved replication” and “routine engineering services” by Figueiredo. In this framework, following these characteristics, and based on the stages of the capability lifecycle, basic routine will be characterized by “learning to operate,” and the advanced routine as “independence on operations and maintenance,” when a capability has reached its maturity, using an innovativeness approach.

In the innovative phase, other factors intervened. As these capabilities are attempting to develop their first capabilities, the newness concept is important, as first intents might not be considered as innovations by the mainstream literature. Garcia and Calantone (2002) provide some insights, with the scope of innovation. They differentiate innovation to the firm, industry, country and the world. However not all capabilities are intended to generate innovations but to adopt to gain competitive advantage. Innovation adoption literature (Rogers, 2003; Damanpour, 1988; Damanpour and Schneider, 2006) talks about exploration (initiation) and exploitation (implementation) of innovations. However, the marketing literature classifies adoption as innovators (first adopters), early adopter, early majority, late majority, and laggards (Mahajan et al., 1990), and always in a geographical scope (e.g. local first adopter versus world first adopter). This diversity in innovation generation and adoption asks for multiple criteria when assessing innovativeness levels. This study uses three levels in the innovative phase (drawn on Bell and Pavitt framework): basic innovative, intermediate innovative, and advanced innovative.
The description of the innovative phase follows a combination of outcomes of the innovative activity developed by each strategic capability, as innovation adopter and generator. In the basic innovative the firm is not an innovation generator but it is exposed to innovations via adoptions, with this exposition hence rising its possibilities as innovation generator. There are several cases collected in the field work where some capabilities started their innovation capabilities in this way.

<table>
<thead>
<tr>
<th>Innovativeness levels</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ROUTINE</td>
<td></td>
</tr>
<tr>
<td>Basic routine</td>
<td>Learning to operate</td>
</tr>
<tr>
<td>Advanced routine</td>
<td>Independence on operations and maintenance</td>
</tr>
<tr>
<td>INNOVATIVE</td>
<td></td>
</tr>
<tr>
<td>Basic Innovative</td>
<td>Follower adopter of best practices/ innovations</td>
</tr>
<tr>
<td>Intermediate Innovative</td>
<td>First adopter and attempts to develop own innovations, local innovator</td>
</tr>
<tr>
<td>Advanced Innovative</td>
<td>First adopter and world-class innovator in industry</td>
</tr>
</tbody>
</table>

Table 2 Innovativeness level framework, preliminary
(Own elaboration, based on Bell and Pavitt (1995) and Figueiredo (2001))

This framework attempts to establish a clear distinction between each innovativeness level reached by strategic capabilities. However, there is theoretical information that might conduct to a more detailed framework.

**Strategic capabilities and innovativeness levels framework**

The framework should include the strategic capabilities that were selected using the Di Benedetto capability taxonomy, and specialized literature can provide the characterization of innovativeness for each one of them, as there are enough innovation studies regarding each strategic capability.

Even if Table 2 provides a qualitative distinction between one innovativeness level and the others, this study considered that it was needed a more comprehensive explanation of each level.

The first task was to provide a more detailed explanation of each level, with characteristics that correspond to each level. Literature referring innovation for each strategic capability exists as to identify when a capability is still “learning to operate” and when it is “developing local innovations.” The process is shown with the case of technological capabilities, a similar process was developed for all others capabilities.

Combining the Bell and Pavitt and Figueiredo’s framework, it is possible to establish a detailed description of each innovativeness level for the technological capabilities. For example, Bell and Pavitt (1995) describe as basic production capabilities, which corresponds to basic and advanced
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routine in the new framework: “engaging primary contractor,” “routine operation and basic maintenance of ‘given’ facilities,” “replication of fixed specification and designs,” “replication of unchanging items of plants and machinery,” “efficiency improvement from experience in existing tasks,” “routing QC to maintain existing standards and specifications,” “sale of ‘given’ products to existing and new customers.”

Figueiredo (2001, 2002) describes similar features for its “basic routine.” For its “renewed,” “extra basic,” and “pre-intermediate” levels, which is equivalent to the “advanced routine” level, is characterized as: “use of certifications (e.g. ISO 9002, QS 9000, 9002,” “stability of machinery and shop, improved plant coordination.” “routine engineering services in new and/or existing plant, simple ancillaries engineering,” “broad outline of project planning,” among others.

The detailed description of the “basic routine” level for technological capabilities, using this literature, is: “Initial plant installation,” “learning to operate equipments,” “external dependence on technical issues,” “new to the firm technological adoptions,” as described in the Figueiredo and Bell and Pavitt frameworks.

After analyzing them and adapting those features for the purpose of a proper description of the first innovativeness level, the basic routine level, resulted in a detailed description as:

Basic routine innovativeness level or “learning to operate:” “Initial plant installation, learning to operate equipments, external dependence in technical issues, new to the firm technological adoptions.”

Advanced routine innovativeness level or “independence on operations and maintenance:” “Engineering or similar department in operation, local adaptations to equipment and processes, cost-efficient technical support, adaptation of products.”

This process was replicated to the innovative levels (from basic to advanced ones). For the other strategic capabilities between 2 to 4 studies describing different levels of maturity and/ or innovation in marketing, IT and management research were employed, analyzed and combined. Table 3 summarizes the innovativeness levels framework.
<table>
<thead>
<tr>
<th>ROUTINE</th>
<th>Innovativeness levels</th>
<th>Main features</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROUTINE</td>
<td>Basic routine</td>
<td>First installation, operations with high external technical support, no engineering or process improvement departments, purchase of solutions with external consultancy. New to the firm innovation adoptions.</td>
</tr>
<tr>
<td>ROUTINE</td>
<td>Advanced routine</td>
<td>Engineering or process improvement departments that provide independence on operations and adaptations, external linkages for advanced learning, cost-efficient operations, high valued added external support. New to the local industry innovation adoptions.</td>
</tr>
</tbody>
</table>

| INNOVATIVE | Basic Innovative | Gatekeepers start to operate (technology, market), innovative firm: first adopter in region, country, extensive use of external consultants for high value added own solutions. First organizational structures supporting innovation development (initial R&D or similar departments). Cost-efficient operations, and first new products/ processes/ services in market or operations. New to the local industry innovator, recognized as good adopter. |
| INNOVATIVE | Intermediate Innovative | Gatekeepers in full operation (technology, market), participation in international innovation events (academy, industry). Mature organizational structures supporting innovation activity (R&D or similar departments, working in collaborative way). 2nd, 3rd generations of new products/ processes/ services in market or operation or operation. Innovative products/services start to internationalize. Premium prices based on high value added products/services. Initial collaboration with external entities developing innovations. New to the country innovations. |
| INNOVATIVE | Advanced Innovative | World-class innovations in market/ operation; efficient organizational structure supporting innovation activities. Continuous renewal on strategic intents. Industry technological-leader on some products/services lines (national, international). Continuous innovation projects with recognized external partners. High participation of sales/costs based on innovative products/services or internal operations. New to the global industry/world innovations. |

Table 3 Strategic capabilities and innovativeness levels framework
An Application in the Development of Innovation Capabilities at Hylsa

This section draws on Hylsa’s historical descriptions and attempts to application of the proposed framework which comprises the lifecycle and innovativeness framework. The specific interest of using this framework is to obtain an explanation of how innovation capabilities emerge and are developed in an organization, and why some strategic capabilities develop higher innovativeness levels than others (e.g. the innovativeness heterogeneity in different technological capabilities reported by Figueiredo (2001)).

This framework is applied analyzing how each capability reaches higher innovativeness levels from its creation, when it developed basic routines and learned how to operate, to its transformation as a source of innovation activities, when it becomes capable to mould and coordinate other organizational capabilities and resources to develop innovative activity.

This section briefly describes the evolution of strategic capabilities, first emerging and reaching maturity routine levels, and later starting its innovative activity identifying changes in innovativeness levels in their history.

Briefly, Hylsa was founded in Monterrey in 1943 using obsolete equipment. After a tough learning curve, it was capable to develop its proprietary Direct Reduction Process (DRI, called HYL ©) 1953, and since 1970’s it started to commercialize its technology selling whole DRI plants worldwide, becoming the technology world-leader in this process.

Because of limitations of this paper length, only the initial and final stages of development of one capability is presented, in this case, the IT capability.

IT capabilities in the first years of “Hojalata y Láminas”

Automation applications emerged in initial years. The first two generations of Hylsa’s machinery were operated and controlled manually, with lots of operator intuition, but the third generation (the continuous process) included basic electronic process controls, embedded on the equipment control systems (with installation and support dependent from external consultancy). Hylsa was a laggard in this kind of technologies, also starting to learn how to operate these control systems, configured at the basic routine innovativeness level (learning to operate). This learning process in this field was a priority in Hylsa, some years later, with the Puebla plant installation. Hylsa did not hesitate to assign significant resources to train a group of technicians and operators abroad on not just how to operate, but to gain autonomy on maintenance of the new automatic equipments that was purchasing. The importance of this capability in Hylsa’s innovative activities was still in its foundational stage.

IT capabilities at the Innovative Stage at Hylsa

Hylsa reached high innovativeness levels in these capabilities after those initial years of basic learning. This capability study is divided in the automation control systems and the information system components.

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43 Defined as “complex bundles of skills and accumulated knowledge that enable firms to coordinate activities and make use of their assets” (Di Benedetto et al., 2008).
Automation Control Systems

The automation department began to operate in 1960’s as part of the engineering department, and its first computer based process control for an EAF (in 1968) was already developed, starting as a mature capability (advanced routine). Hylsa operated old machinery in part of its history: in the beginnings, and also between the 70’s and 80’s, period where Hylsa delayed investment caused by its financial crisis. Then the need to obtain extra savings was a survival issue. In those years efficiency efforts using automation control systems was limited by the existing technology (e.g. relays) and that was the reason this department was named “ingeniería eléctrica” (electrical engineering) department in those years. This urgency sense pushed to develop its first own innovations, reaching quite soon the Basic Innovative level.

Around 1981 this component acquired special importance with the emergence of Programmable Logic Controllers (PLCs) that were available just at the end of the 70’s. Initially they were applied to the “acería” sections, as that was the process with more savings possibilities. For example, EAFs could turn on/off in a way to not only reduce but to optimize energy costs, adapted to CFE’s invoicing schemes. With some successful automation projects, the use of PLC’s extended in all possible equipments where Automation department could identify savings potential with complex automation systems (e.g. mills control systems). Some initial objectives were to stabilize processes, and with this achievement Hylsa could propose to reach new optimizations goals that could not be thought before process stabilization. Even not modern machinery, this department attempted that it performed as new ones. Since 1981-2, this department changed its name to “Automatización” (automation), as now it really was automating Hylsa’s old equipments. Since then all new equipments were “upgraded” thanks to proprietary automation solutions based on PLCs. Whole production lines, formerly with relays based control systems, were completely re-engineered by this department to automated control systems using these PLCs. Hylsa was the first adopter of PLC technology, and rapidly became a local innovator. An interviewee reported that the production manager in those years was the main sponsor to import this kind of technology. Without this support this technological change would not have been possible. Local innovations and first adopter behavior meant that in those years this capability was at “intermediate innovative” level.

At the end of 80’s almost all production lines were automated, eliminating manual data input, improving not only process, also the steel quality. Timing control (production, idle, setup, etc. times) was under total control of supervisors, linking PLCs with production systems by the end of 80’s and 1990. As reported by Gonzalez and Ortiz (1998), Hylsa could connect automation control systems with managerial information systems, reaching the fifth level of automation at the end of the 90’s. Nowadays every manager has access to real time information from all equipments from the plants in his information system (temperature, timing, production, productivity, energy usage, scrap, among others).

Once this component was mature and developing local innovations with Hylsa’s equipments, the need to improve the “equipo propietario” for commercializing HYL process plants required new requirements, the development of automation control systems for new-to-the-world equipments, transforming “Automatización” as world class innovator. Since the mid 90’s, all HYL plants

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44 CFE: “Comisión Federal de Electricidad,” the government energy provider, which works as monopoly in Mexico.  
45 Interview to an automation department manager (with over 35 years of experience working at Hylsa).
included proprietary automation control systems, designed by this department, reaching the 
Advanced Innovative level.

Information systems

As reported in section 7.5.1, the information systems department was created in 1963. In the initial years Hylsa adopted VISA standards, using common mainframes corporate-wide, and scale economies advantage, becoming local first adopter. Even if mainframes’ main application was for managerial use, early for local steel industry, R&D started to use mainframe calculation power to run process simulations when designing technological innovations.46

When the mainframe era came to its end at the end of 80’s, Hylsa adopted the new IT strategy: “downsizing,” which involved the move of legacy applications to networked computers, taking advantage of the new performance of mini-computers and personal computers, minimizing cost on data analysis and processing. Soon, “client-server”47 solutions arrived, and also Hylsa was among first adopters in Latin America, using the Oracle database.48

Also, when the 2YK problem49 was approaching, Hylsa was the steel producer that invested more on confronting this technical threat,50 taking a critical decision, to move to SAP ERP,51 becoming the first Latin American companies to adopt this emergent technology.52 Later SAP (SAP, 2001), the leading ERP provider, reported Hylsa as one of its best success cases using its Supply Chain Management modules.

Internet use in its operations was adopted by Hylsa in 1995, becoming also a regional first adopter. It intensified its application in 1999, using its “eManufacturing” processes that cover the supply chain management control. Soon other applications emerged, as “eBusiness”, “eProcurement”, using eCommerce technologies, as Business-to-Business solutions (B2B) and Customer Relationship Management (CRM) applications. Using them, large and small customers use Hylsa’s internet portal, with the correspondent permission grants, to follow up their orders, even if they are still in the plant.

Hylsa, as IT first adopter, reached Intermediate Innovative level at its IT Capabilities (information systems). As a whole, IT Capabilities reached between Intermediate and Advanced Innovative levels, becoming also an Innovation Capability as in its both components worked as the integrator capability that conducted other ones to develop innovative activity.

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46 Interview to former R&D researcher.
47 Client-server solutions involve a centralized data base that serves to a large number of clients that were based on Unix or other operating systems, optimizing the processing power and integrating all the company’s data.
49 “Y2k problem” was named to the threat that computers would recognize 01/01/2000 as 01/01/1900, causing massive bad calculations in all information systems.
50 El Financiero, July, 30th, 1999, “La industria siderúrgica prevé la canalización de inversiones superiores a los 25 millones de dólares en proyectos Y2K.” All Mexican steel industry invested 25 million USD to this project, Hylsa was responsible of 14.1 million USD (56% of all industry).
51 ERP: Enterprise Resource Planning. It is a modern information system that emerged in the late 90’s, that includes not just efficient and validated integrated information systems, but also best practices in all business processes in one industry. This was reached thanks to economies of scale of main ERP providers, each one of them had over 10,000 installations worldwide of standardized and optimized processes.
Conclusions and Further Research

This paper has the purpose to develop an integrative framework that properly explain the phenomenon of the creation of innovation capabilities in an organization based in emerging economies. This framework extends the scope of Bell and Pavitt framework, covering all strategic capabilities presented in a firm.

This framework was illustrated with the application of the analysis of the framework to the evolution of the IT capabilities at Hylsa. Thanks to this framework each advance in the innovativeness levels of the components of this capability can be identified. This capability started at Basic Routine levels, as Hylsa started to learn this emergent field (end of 50’s), and, pushed by crisis senses strategies, rapidly developed into high innovativeness levels, transforming in an innovation capability by itself (it served as one of the drivers and integrators of the innovative activities at Hylsa).

Further studies can apply this framework and analyze main drivers and inhibitors to the development of innovation capabilities in a firm. Also interaction between different strategic capabilities can be considered, as foreseen in the example shown, no capability develops in an isolated form but with continuous cooperation with other strategic capabilities.

References

Capítulo 10 – Innovación y tecnología


