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STRENGHTENING INNOVATION IN DEVELOPING COUNTRIES

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Abstract

In spite of the variety of studies regarding innovation management questions, there is still a lack of studies concerning the structuring of the innovation management activity in developing countries' firms. In parallel, there is an increasing number of studies arguing that these firms have no innovative capabilities. Traditionally, however, the metrics used for analysing the innovative capabilities of firms of this nature, such as patents and research and development investments, are incapable of understanding how the innovation process occurs. This study seeks to contribute with the filling of these existing gaps. In this sense, it suggests a total innovation management system focused on the reality of developing countries' firms, which gives rise to a group of non-conventional indicators to examine the technological capabilities, such as cadence and projects' mix, here presented and discussed.

Keywords: Total Innovation Management System; Indicators; Developing Countries; Projects; Entrepreneurship.

Introduction

Searching for the new and the unknown seems to be intrinsic characteristics to the existence of the human kind. This human impetus for novelties nourishes economic progress. Innovation, therefore, is the driven force of the world evolution. The understanding of innovation activity, however, still is far from being unified.

In terms of business, initially, the leading idea was that technology represented an exogenous variable, which firms could acquire in the market. Innovation process was a mere resources allocation activity (Zawislak and Marins, 2007). In the beginning of 1980, however, studies concerning the role of innovation activity in economic development brought up the need to organise innovation activity inside firms. Therefore, innovation management became a strategic business element.

This deliberated managerial commitment to innovation activity is relatively lower in developing countries' firms. Yet, it does not mean that there are no innovative capabilities in these firms of this nature. While firms operating in developed countries make use of advanced techniques and are naturally engaged in complex activities, composing the technological frontier, developing countries' firms still need to face a building up process to fortify innovative capabilities. The problem is that, traditionally, innovation management models are created based on the reality of developed countries' firms. This is also true for the metrics used for analysing innovative capabilities, which conventionally are indicators incapable of understanding how the innovation process occurs, such as patents and research and development investments.

This paper seeks to contribute with the filling of these existing gaps. In this sense, it proposes a total innovation management system model focused on the reality of developing countries' firms, which, in turn, leads to a group of non-conventional indicators to examine the technological capabilities of these firms.

This paper is structured as it follows. After discussing the relationship between innovation and development, questions and elements related to intra-organisational aspects of innovation activity are briefly considered. In the sequence, the paper presents the proposal of total innovation management system model, followed by the suggestion of a set of non-conventional indicator for measuring innovation in developing countries' firms. Finally, the article's conclusions are presented.

Innovation and Development

Despite the fact that firms only recognised the importance of innovation as a strategic factor for competitiveness in the 1990s, the concept of innovation and its relevance for economic development has been stressed for decades by the economic approach. Marx (1863), for instance, highlighted the need for development leads to technological progress. The interactions between economic development and technology became explicit in the Modern Industry, period which began with the Industrial Revolution. Once mechanics processes became embedded in steps of the productive process, there was the implementation of technological advances on it, which was consequently optimised. This is the logic of the wealth creation.

In the end of the 19th century, with the Economics Neoclassic School, the focus of value creation debate was redirected to market and its relations (Zawislak, 2004), based on principles like equilibrium, rationality, and maximization. In this context, the firm would be treated like an actor with a status similar to the individual consumer; a passive agent responsible for transforming optimally factors into products. The nature of the variables that the firm manipulated would not be determined internally, but externally by the market structure surrounding it. Considering the information availability and the perfect estimation capacity, the firm would behave as an automaton, once programmed, programmed forever.

In the beginning of the 20th century, Schumpeter (1912), uncomfortable with the traditional view of equilibrium and with the exogenous role consigned to innovation into economic development, argued that the economic development process was propelled by technical progress. Thus, innovation was the essence of the economic development.

As pointed by Zawislak (2004), Schumpeter's contribution was conceiving development as a process that occurs inside firms, agents that transform the economic dynamics, inducing consumers to desire new and different things which they are not used to. In this sense, technological innovation makes firms competitive and allows their sustainability in the market, guarantying extraordinary profits for entrepreneurs. Responsible for economic growth, the entrepreneurs are the agents who foment all the dynamism of the economic system, turning it competitive and source of new opportunities.

The Schumpeterian entrepreneur is stimulated by the search for profits which have not been obtained by any other agent. And these profits will only be achieved with innovation. This process leads to differences that are understood as consequences of the creative destruction (Schumpeter, 1942). Through the creative destruction process, Schumpeter (1942) states that technologies, by the same time they are creative, are destructive. The emergence of a new technology supplants old technologies. Thus, new products steal the place of old products, and new productive structures knock down structures in use. And this is the process that stimulates economic development and progress.

Then, the process of creative destruction exalts innovative firms which overcome firms incapable of following this continuous and deliberated process of change. The real economic competition occurs amongst innovative firms that generate new products and remove old products from the market. The capitalistic dynamic promotes a permanent state of innovation, change, discontinuity, replacement, and creation, marked by value aggregation. Briefly, the creative destruction is responsible for the economic growth of a country and technological progress is crucial for understanding the competitive process. This stresses the need for engagement in systematic innovation activities, especially for developing countries' firms. The first step in their catching up process is facing innovation management and measurement as a key-factor for development.

Transposing Innovation to the Firm

This section discusses intra-organisational aspects of technological innovation required to sustain firms alive and competitive, such as technological capabilities and paths, routines, management, and alignment.

Capabilities and technological paths

In order to understand the different firms' innovative performances, as well as why some firms overcome others, Nelson and Winter (1982) based on the Schumpeterian approach developed the Evolutionary Theory of Economic Change. For them, the generation of new technologies is allowed by intra-organisational efforts undertaken by firms on the search for a competitive market position. Firms are exposed to a natural selection process, in which the survivors are those more technological innovative. The process of technological development is driven by organisational routines - a set of organisational abilities fundamental for the development of firms' core competencies. The productive activity represents a learning process undertaken by a routine. This routine is continuously challenged, as unpredictable problems come up requiring solution. The application of the found solution, in turn, represents a learning process, which allows capabilities development. This cycle never ends, characterising the central mechanism of the problem solving activity and of the improvement of routines and techniques.

According to Lall (1192) and Bell and Pavitt (1993), the technological capabilities of a firm represent the resources required to generate and manage technical change, embedded into individual and organisational systems. When dealing with technological capabilities, it is worth distinguishing between the concepts of routines capabilities - capability to use - and innovative capabilities - capability to change. Routine capabilities are the resources required to produce goods and services into certain degree of efficiency, using a set of factors, such as, abilities, equipment, products and production specifications, and organisational systems and methods. The innovative capacity embodies additional and distinct resources to generate and manage technological change.

Following the evolutionary approach, the Resource-based View analyses firms from the perspective of their resources - any intra-specific element, tangible or intangible, that could correspond to strength or weakness, such as brands, internal knowledge about certain technology, skilled personnel, commercial contracts, machinery, efficient procedures, and capital (Wernerfelt, 1984). Consequently, it give rises to the concept of dynamic capabilities, which stress the role of strategic management in properly and deliberately adapt, integrate, and reconfigure firms' abilities and competencies based on environmental changes (Teece and Pisano, 1994; Teece, Pisano, and Shuen, 1997).

According to this view, the competitive advantages of a firm reside into three strategic dimensions, namely: its organisational and managerial processes, its position, and its available paths. The organisational and managerial processes represent the way things are done into a firm, that is to say, its routines. The position refers to the existence of specific assets, such as technologies, intellectual property, complementary assets, clients' base, and external relation with suppliers. Lastly, the paths represent strategic alternatives available for the firm, as well as the attractiveness of significant opportunities.

Briefly, to be innovative, a firm should desire to innovate, know why to innovate, and, moreover, know how to innovate. The desire becomes a practice by the action of entrepreneur leaders. The knowing why is encouraged by the focus on value - clients and technology. Finally, the knowing how is made concrete by the management structure based on a mix of integrated projects. These are capabilities that firms operating in developing countries must develop to achieve and possibly overcome the technological frontier. In order to do so, it is essential to adopt a suitable innovation management model.

Innovation management and alignment

This paper argues that firms are agents that search to establish their own evolution path through their capabilities and technological domain, which must be aligned with a deliberated business strategy. Therefore, the way innovation activity is hold and conducted leads to different firms profiles.

According to Freeman's typology (1982), it is possible to summarise innovation strategies in adaptive, follower, and innovative (Zawislak and Marins, 2007). Firms which choose for an adaptive strategy search deliberately to develop innovation actions that only result in technological improvement. Based on a follower strategy, firms deliberately wait for other companies' movements to design their innovation actions. Finally, firms which adopt an innovative strategy deliberately seek to be technological leaders and dominant market.

Despite the strategy chosen, the main firms' purpose is to domain environment, value chain, competencies, and capabilities, that is, to sustain the growth of their technological development paths. Considering the variety of technological strategies that firms could choose, innovation management becomes a *sin ne qua non* condition to business success. Innovation management, this way, is regarded as a necessary condition for building up technological competencies, establishing organisational routines, generating profits, and supporting business competitiveness.

Thus, the development and the accumulation of technological capabilities represent a complex dynamic question requiring the definition of technological strategies. Innovation is no longer a static factor easily managed. By the action of its internal leadership, firms should draw

deliberately innovation strategies, as well as the alignment with their own capabilities and business strategy. Therefore, it seems appropriate to state that developing countries' firms should draw on entrepreneurial view in order to catch up.

As important as to clearly design firm's technological strategy, it is to promote its alignment with business strategy, integrating all departments and regarding current firm's capabilities. Although necessary for achieving profitable solutions, the strategic alignment is a commonly neglected step of the innovation process, especially in developing countries. Therefore, an innovation management model for firms operating in developing countries must take this into account.

Davila, Epstein and Shelton (2006) argue that the importance of innovation rises or decreases along time, depending on the influence of a set of factors, such as innovation timing, competitive nature, and business strategy. In this way, the type of innovation position adopted by firms ought to be in harmony with corporative strategy. This convergence is achieved through strategic alignment, the process of linking the deliberately chosen innovation strategy to organisational vision, mission, targets, objectives, and strategies. In the particular case of developing countries' firms, more than the alignment itself, there is a previous need of formalisation of the innovation activity. In this sense, these sorts of firms demand a specific total innovation management system model.

Total Innovation Management System: On the Way to a Model for Developing Countries' Firms

More than being aware of the need for innovation and formulating strategies, in order to effectively generate innovations, firms should develop innovation management systems (Davila, Epstein and Shelton, 2006). Thus, the innovation management system chosen by a firm should be in consonance with its deliberated innovation strategy, being a direct consequence of it. The implementation of a total innovation management system facilitates the balance of antagonistic aspects of the innovation activity.

In the case of developing countries' firms, however, efforts are also necessary in order to turn innovation into a formalised and systematic activity. This section presents a model for innovation management focused on the peculiar requirements of these firms. This model is termed as a total innovation management system or, simply, an innovation management system. The belief is that, by implementing this model, developing countries' firms would be able to migrate from a reactive status to an entrepreneurial proactive status.

The first step on the way to the establishment of the total innovation management system is facing innovation as a core business process. This leads to the deliberated choice of an innovation strategy and to the search for strategic alignment. Once the relationship between firms and innovation is understood, it is possible to concentrate efforts on the composition of a total innovation management system that involves three basic conditions, namely: entrepreneurial leadership; value creation, which is the stimulus driver; and, lastly, an adequate organizational management structure.

Briefly, the total innovation management system here proposed should: pursue knowledge and information about all the value chain, regarding market (clients) and the search for new technologies; be based on an organisational structure which promotes a portfolio of integrated innovation projects; and supported by a techniques and tools stimulus system for entrepreneurial and creative personnel. All these elements should be aligned as well as consonant with the innovation strategy chosen - preferably a top strategy - which should be aligned with organisational business strategies.

The innovation management system proposed is concretely based on the development of a mix of innovation projects. It is through integrated and continuous innovation projects that the proposed system comes to life. Innovation projects, thus, are the way through which innovation activity is materially organised inside firms. An innovation project represents a set of activities undertaken by specialists during a period of time, structured with the purpose to supply organisational strategic objectives avoiding knowledge waste. In this sense, more than being strategically focused on continuous innovation and pursuing a tangible project's portfolio, firms should be able to carry out projects as explicit value creation activities. Figure 1 illustrates the proposed model of total innovation management system.

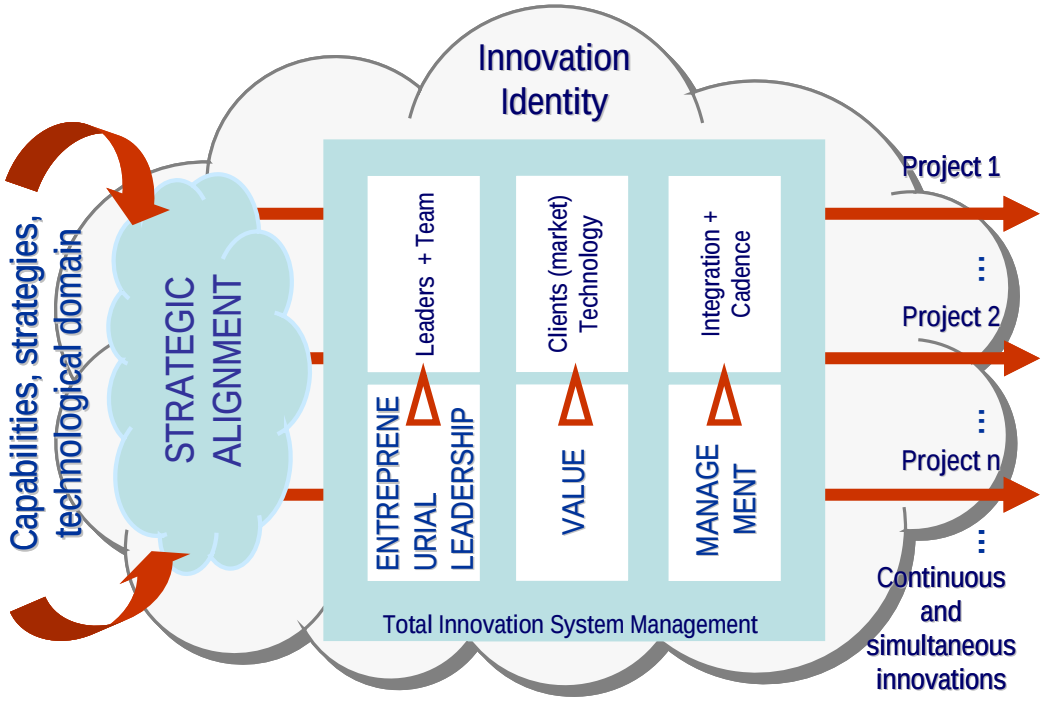

Figure 1. Total Management Innovation System

Entrepreneurial Leadership

The first key-element of the proposed total innovation management system is the entrepreneurial leadership. Even though not being a recent concept, there is a series of divergences regarding the definition of the term entrepreneur. As previously mentioned, Schumpeter (1912) is the pioneer in economic studies to discuss the role of the entrepreneur while propulsive of technological and economic development. According to Schumpeter (1912), economic development is based on three basic pillars, namely: bank credit, technological innovations, and the entrepreneur.

The entrepreneur represents the agent capable of running a new business, even though not being the owner of the capital. The ability to undertake new business is related to individual characteristics, values, and way of thinking and acting. Once entrepreneurs create new values, they nourish the dynamism of the economic system, turning it into a competitive source of new opportunities. They are the agents who foment the value creation process (Zawislak, 2004).

Afterwards, Schumpeter (1942) broadens the notion of the entrepreneur, which transcends the individual sphere and goes to the organisational scope, being characterised specially by companies' research and development (R&D) labs. This recognises and emphasises the fact that innovation activity takes place inside firms and, therefore, it ought to be structured and conducted by them internally. The search for innovation and pioneering must be disseminated through the whole organisational environment. The stronger the innovation identity of a firm, the more structured it is in terms of innovation projects.

While thinking about entrepreneurship in this kind of organisation, it is worth keeping in mind that the existence of entrepreneurial leaders is crucial, but it is also important to find this proactive posture disseminated amongst all workers. Tidd, Bessant and Pavitt (2005) point that the commitment degree of organisational leaders (high managers) and the success of innovation activities are frequently associated with each other. However, in order to avoid this relation to turn into a prescription, it is necessary to find mechanisms that reinforce the sense of involvement and support of these leaders to innovation activities undertaken by other firms' workers. Specifically, it is necessary the existence of long-term commitment with projects opposed to short-term returns, simply. This long-term orientation must exist in consonance with an entrepreneurial position, in order to diffuse innovation activity as a continuous deliberated strategic routine along the entire organisation.

The entrepreneurial leadership is responsible for defining innovation strategies, as well as aligning them with business strategies, materialising them through innovation projects. As the total innovation management system is propelled by value creation based on market and technology, project leaders are also clients' representatives

who are capable of managing internal team conflicts providing the adequate conditions for the specialists to undertake their activities.

According to Zawislak and Silva (2002), the technical knowledge about products, production systems, supplies, and distribution - spheres of entrepreneur's action - allow leaders to manage all system development, awarding the project an integrated view. The entrepreneurial leader is supposed to take decisions in such a way to mobilise the team, making it work. The team itself represents a set of individuals with different types of key-knowledge to value creation. In this sense, it is worth transposing the view that a team is only composed by internal firms' specialists. Teams should count on external agents with the continuous learning capacity of creating new knowledge, such as clients, universities, and suppliers. Therefore, fluid and opened communication involving all team is also fundamental for the successful development of innovation activities.

The entrepreneurial leadership bases the decision taking process on the search for strategic alignment. In this sense, and to create and aggregate value, in terms of innovative actions, the entrepreneur not only needs to know what to make, but also how to make it. And the decision of how to make it should be taken considering market, technology, and the capabilities pursued by the organisation. Rooted in these elements, the entrepreneurial leadership catalyses the decision taking process, choosing for a set of innovation actions materialised in the form of projects.

There is a variety of innovation actions possibilities available for the entrepreneurial leadership, going from an autonomous position, in which firms undertake the innovation activities by themselves, to an acquisition position, in which firms, because of the lack of internal capacity, choose to buy the technology developed by other agents. In between these two extremes, there is a hybrid form, named cooperation, wherein firms search for partnerships with external agents, in order to complement their capabilities.

This hybrid form by which firms, establishing strategic partnerships try to complement their internal capabilities with the capabilities of external agents is named open innovation (Chesbrough, 2003). The open innovation mentality helps firms to consolidate their innovation identity, as they search for innovative solutions through technological and scientific cooperation.

Shortly, these possibilities set could be understood as a trade-off curve, in which firms could choose to make or buy innovation, or, besides, choose options in between these extremes. The way the entrepreneurial leadership chooses to develop firms' activities impacts directly on the way decisions regarding projects development are taken. Obviously, the successful conduction of this process depends on the existence of an internal organised structure for innovation. Therefore, developing entrepreneurial actions means innovating.

Client and Technology: Focusing on Value

The creation of new values is the essence of the innovation activity. An innovation becomes concretely an innovation when there are commercial transactions involving the new device, product, process, or system. Consequently, to be an innovation, the new creation must be commercially diffused. Therefore, the focus on value represents the concernment that firms have about their clients, that is, their consumer market.

In order to successfully generate value, the goods and services (products) supplied by firms should match the needs of their clients. By being capable of meeting clients' needs with the development of new products, firms achieve their higher aim, which is profiting, especially in an extraordinary way. This value creation mechanism focused on clients can be named demand pull. Yet, this is only one piece of the value creation process. Equally important is the conduction of the innovation activity based on technological development itself, regarding the technological domain that firms seek to pursue. This is the technology pull approach (Dosi, 1982).

As highlighted by Zawislak and Silva (2002), there are other elements besides clients (market) and technology which also create value, namely: the kind of raw-material, the suppliers' quality, and the sales channels. When integrated, they compose the firms' value chain. The value creation process should consider all the knowledge base that firms already contain, besides generating new knowledge that allows the development and the strengthen of innovative technological capabilities. Therefore, anchored in a dynamic knowledge base, solidified by the focus on clients and technology, developing countries' firms would be able to continuously and increasingly create and aggregate value.

Management and Organisational Structure

As pointed by Zawislak, Nascimento, and Graziadio (1997), differently from the traditional management activity, in which there is basically the management of material resources, the management of innovation requires the creation of a set of tools and techniques which allows firms to manage knowledge and their improvement. Therefore, innovation management is oriented to the management of an existent knowledge base, available information, and, even so, creativity. Creativity, a propos, is the element that acts in order to modify information, generating new knowledge that improves firms' problem solving capacity, that is, improve its innovative capabilities.

Regarding the fact that for each sort of technology there is supposed to be a specific level of technological capability, a strategy, a kind of information, and a degree of creativity, it is plausible to imagine that there are different ways to organise and manage the structure of innovation

activity at developing countries' firms. However, there are characteristics which should permeate all and any organisational structure focused on innovation, namely: integration and continuity.

For a couple of years, the innovation activity was structured and conducted linearly and sequentially by organisations. Each functional unit used to be responsible for the isolated execution of specific tasks (Zawislak and Silva, 2002). Actually, even nowadays, it is possible to find, especially in developing countries, cases of firms that organise their innovation activities with a linear rationality, based on stanched isolated R&D departments or discontinuous punctual projects.

Afterwards, however, there was a change on the prevalent structure for innovation and matrix structures became the most frequent organisational form for displaying the innovation activity. This sort of structure combines a functional structure set by departments with a project organisation. There are two managers acting, the functional manager and the project manager, and they are looking for the simultaneous tasks execution.

Nowadays, as a consequence of innovation activity complexity, it is necessary to surpass the matrix forms. The implementation of an integrated structure which propels the development of innovation projects by firms is an imperative, especially for those catching up. The notion of integrated projects allows the understanding of projects as a set of minor projects - subprojects - divided in order to facilitate the management of multiple solution alternatives. Therefore, by the same time the subprojects are handled separately, they are interdependently explored. This allows the generation of efficient solutions, as well as the exploitation of the knowledge acquired with other projects. In this kind of structure, projects are the boosting elements of the innovation activity. Moreover, they are a measure for organisational learning and innovative capacity.

As firms engage in innovation projects, they not only improve their technological domain, but also build up an own internal rhythm of project development based on their technological capabilities. Thus, the internal capacity of undertaking an amount of "X" projects in a certain period of time tends to create this internal rhythm of project development, here named internal technical cadence.

On the other hand, it is recognised that the proposed total innovation management system is rooted in the focus on clients and that external demands do not necessarily follow the internal technical cadence. Yet, as this system is partially pulled by clients, there is also an external imposition of an accurate rhythm for innovation projects, here called market cadence.

For instance, take a firm that is initially able to undertake one project per year by itself, but filling its clients' needs requires the development of two projects per year. Specifically, this firm has an internal cadence of one project per year and an external cadence of two projects per year. So as to effectively create and aggregate value, this firm should structure itself in a way that it would be able to satisfy its clients' demands. This, in turn, requires the capability of executing two projects per year. In order to do so, this firm must search for new resources of different sorts, such as financial, administrative, and human, with the purpose of developing integrated and simultaneous projects. Consequently, there is the enlargement of firm's knowledge base and the development of new technological capabilities. This, in turn, leads to the improvement of the firm's internal cadence, granting it a faster rate.

Shortly, based on an innovation identity that goes through the entire organisation, it is easy to understand that firms' strategic focus is on the alignment of the available technological capabilities with the strategic business aims. Moreover, firms' efforts and initiatives undertaken are rooted in an entrepreneurial leadership profile that, being aware of market needs and technology availability, adopts a management system organised through a portfolio of integrated projects, apparently more adequate and more balanced.

Integrated Projects' Portfolio

An innovation project represents a set of structured activities undertaken with the intention to match firms' strategic aims, aggregating value and avoiding knowledge waste. Put this way, innovation projects turn the total innovation management system into life, representing the base of innovation activity. As it is a total management innovation system, projects are continuously conducted in an integrated way.

The conduction of an integrated projects' portfolio represents simultaneous innovation. Explicitly, innovation activity, besides integrated, becomes functional in a flexible and continuous way. Therefore, more than contributing to the consolidation of an organisational innovation identity, the existence of a projects' portfolio of this nature allows firms to obtain scale and scope gains. In terms of scale, firms benefit because there is a set of data, or, worthily, information and knowledge, which are shared and utilised in more than one project, such as physical structure, leaders, team, and time. Regarding the scope, the gains emerge from the possibility to surpass the solutions of a specific project to other projects, which also implies time saving.

In parallel, it is worth stressing that pursuing a project mix also corresponds to an increase in the possibilities of organisational development, once it guarantees a more varied set of possible ideas that could be converted into innovations. Moreover, this portfolio gives firms more discernment to choose the ideas in which to invest.

A projects' portfolio is composed by a set of specific projects that, although conducted simultaneously, have peculiar characteristics. Each project can be founded on a specific technology, making use of a series of

resources and requiring different degrees of efforts to be developed. Additionally, each project can lead to diverse commercial and strategic results (Romano, 2005). A projects' portfolio can be composed by projects that vary from day-by-day projects to overwhelming projects. Day-by-day projects are those projects rooted in the existent organisational knowledge base and capabilities. Overwhelming projects, in turn, are those projects focused on radical products, process or technologies, which represent a novelty. The variety of projects nature can lead firms to the adoption of micro strategies for each project, depending on the outline of them. Once these projects are rooted in organisational strategies, their micro strategies naturally converge, so that the projects' portfolio itself, although composed by projects with distinct micro strategies, is structured with a specific strategic position, in order to align innovation actions to firms' business strategy.

At this point, it is also crucial the action of the entrepreneurial leadership, in the sense of designing the strategies and the priorities of each project, constantly searching for the equilibrium between clients and technology. And how the entrepreneurial leadership is able to turn all these into practice? It is through a sensor that allows the selection of technologies and projects in which to invest. These mechanisms are known as technology innovation funnels (Tidd, Bessant and Pavitt, 2005).

The technology funnel is focused on scientific and technological development. This funnel allows the selection of radical technologies that could lead to the development of overwhelming projects with multiple alternatives. The innovation funnel, in turn, represents the process of selection of the more value aggregative ideas proceeding from the technology funnel, materialising them via innovation projects. This is the funnel where innovation management effectively occurs, so that it is possible to face it as an innovation multi projects funnel. Although functioning in different ways, technology and innovation funnels are integrated, being the latter nurtured by the former, especially in the case of overwhelming projects.

Realising that the innovation process, even when structured, is an extremely complex activity does not require huge efforts. The proposed total innovation management system, rooted in integrated and continuous innovation projects' portfolio, engenders tangible ways for developing countries' firms to manage innovation. Once this portfolio is aligned with organisational strategies, it makes possible to create value, either through day-by-day or overwhelming projects.

Therefore, the well-succeeded conduction of these integrated projects requires the existence of the entrepreneurial leadership, in order to encourage the engagement in diverse projects, as well as the implementation of a dynamic organisational management structure that allows the development of integrated projects. Finally, developing countries' firms must keep in mind that they need to create value, otherwise, even undertaking huge efforts, the innovation activity (innovation projects) will not succeed.

Indicators for Measuring Innovation

The proposed total innovation management system gives rise to another critical issue for developing countries' firms. Although they are commonly seen as passive in terms of innovation (Viotti, 2000; Cassiolato *et al*., 2001; Katz, 2004), the metrics traditionally employed to analyse the innovative capabilities of these firms present several limitations. In this sense, this section highlights the restrictions of these conventional indicators and proposes a set of non-conventional indicators for measuring innovation at these firms.

The Limitations of Conventional Indicators

Traditionally, indicators related to R&D and patents are adopted to measure the degree of development of innovative technological capabilities of firms, industries, and countries, regarding both developed and developing contexts. Consequently, the technological capabilities of these agents are being assessed through metrics such as personnel dedicated to R&D activities, percentage spent on R&D, and number of patents registered in the United States.

In the Brazilian case, for instance, it is possible to observe the utilisation of patents statistics and other quantitative measures, such as R&D expenditures, education expenditures, illiteracy rate, and percentage of high qualified scientists and engineers engaged on R&D activities, to examine technological capabilities (Viotti, 2000; Cassiolato *et al*. 2001). Yet, in spite of the merits of these studies, it is worth mentioning that these conventional indicators are limited and seem to be less useful to the context of developing countries' firms.

Firstly, indicators related to R&D activities and patents are prevailing merely at specific industrial sectors of developed countries, such as the United States, Germany, United Kingdom, and Japan. In these countries, firms, besides having deeply enough levels of R&D investments, are intensively engaged in the production of international patents. Therefore, the application of these conventional indicators in the context of developing countries' firms appears irrelevant, once they, in general, have not reached sophisticated levels of innovative technological capabilities to conduct R&D activities yet.

In addition, international patents statistics, in particular from the United States, are usually accepted as a superior measure of technological qualification. These statistics are available for long time horizons and provide quantifiable statistics details that could be examined according to the geographic region and the technical area. Although this could be truth, assessing innovative capabilities based on international patents statistics could be

tendentious, limiting the evaluation of developing countries' firms that does not present significant exportation volume of specialised products with own brand to the American market.

In firms located in developing contexts, such as South African, Latin American, Asian, and even Eastern European countries, it is relatively rare to find R&D activities formally structured as they are in developed countries' firms. However, innovative technological activities are undertaken by departments of engineering, quality, and maintenance. Repeatedly, these organisational departments represent the units where innovative technological capabilities of developing countries' firms are found. Yet, it is impossible to measure them by means of conventional indicators.

Emerging Non-Conventional Indicators

The emerging non-conventional indicators proposed in Table 2 were created based on the dimensions of the innovation management system previously presented.

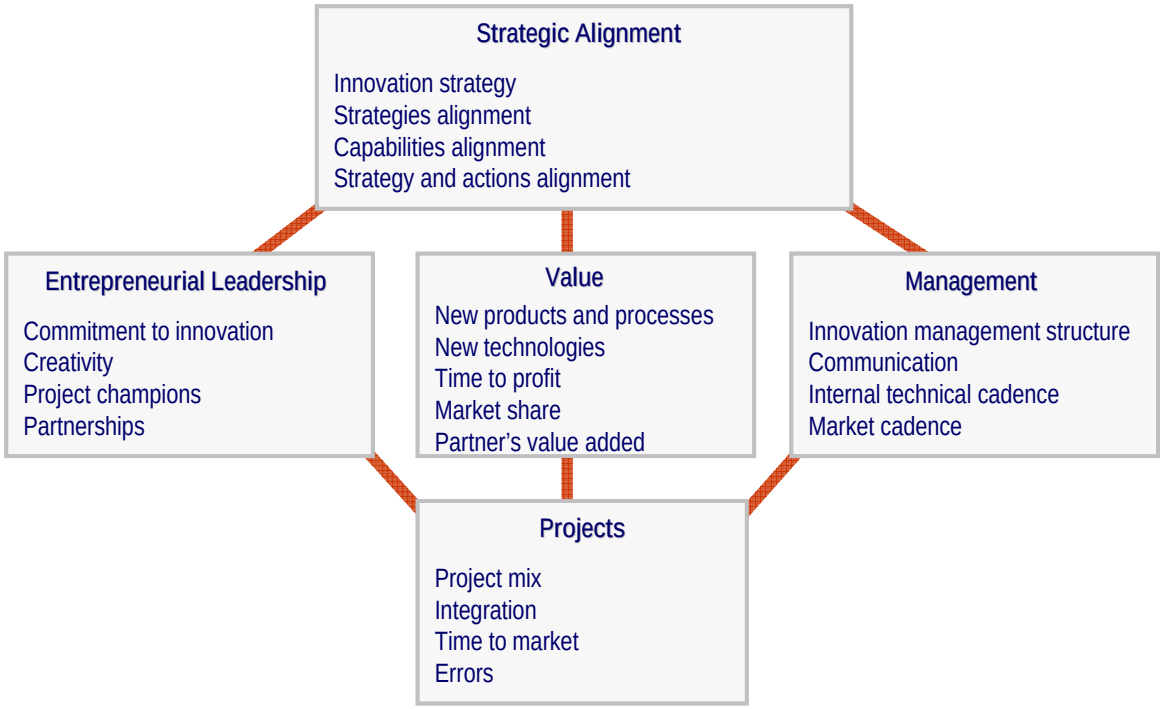

Figure 2. Emerging non-conventional indicators

In terms of Strategic Alignment, four indicators are proposed. Innovation strategy, tracks the internal process of innovation strategy selection, assessing the degree of deliberation involved. Strategies alignment assesses the alignment between innovation and business strategies. Capabilities alignment measures the alignment between the chosen innovation strategy and the firm's technological capabilities. Strategy and actions alignment measures the convergence between the innovation strategy chosen and the innovation actions undertaken, in order to point eventual gaps among them.

Four indicators are also proposed for Entrepreneurial Leadership. Commitment to innovation measures employees' engagement in innovation through individual performance evaluation and feedback. Creativity assesses the amount of ideas generated and converted into projects in a certain period of time. The Project champions' indicator evaluates the medium number of individuals who propels innovation projects. Partnerships, assesses the contribution of external agents to innovation by measuring the percentage of joint researches and projects that succeed.

Regarding Value, five indicators are suggested. New products and processes, refers to the number of new products launched and processes implemented in a certain period of time. New technologies, reckons the number of new technologies successfully developed and used in a time

interval. Time to profit estimates the medium time to profit of new products and processes. Market share, as the name says, estimates the evolution of firms' market share in a certain period of time. Partner's value added measures the percentage of value added by firms' partners.

The indicators for Management compress measures for structure and rhythm of innovation activity. Innovation management structure evaluates the existence of a structure of innovation management, as well as its degree of formalization and adequacy. Communication assesses the existence of communication channels that facilitate innovation activity. The last two Management indicators refer to the pace of project development. Internal technical cadence measures the number of projects that a firm is able to develop by itself, propelled by itself as well, in a certain period of time. Market cadence measures the number of projects that a firm should develop in a certain period of time in order to match costumers needs and expectations.

The last set of indicators refers to Projects. The first indicator, Project, represents the evaluation of the projects' portfolio; it comprises the joint evaluation of the nature of the innovation projects (day-by-day or overwhelming projects), the area, the time frame, and the amount of funding. Integration tracks the aggregate performance of all projects developed in determined time interval, evaluating the proceeding scale and scope gains. By Time to market, it is measured the length of time that it takes from a product conception to its availability for sale what encompasses all the phases of an innovation project. Lastly, the indicator termed as Errors evaluates the mistakes related to innovation projects; it measures projects' delays and the percentage of aborted projects.

Final Remarks

Innovation management is a capability that must be improved by firms, especially by those operating in developing countries. In order to strength innovation activity in developing countries, this study proposed a total innovation management system for firms which operate in this context.

Besides facing innovation as a key-factor for competitiveness, the successful functioning of the proposed total innovation management system requires the alignment of deliberated innovation strategies with business strategy. Based on the development of integrated innovation projects, this system allows the formal orientation of innovation activity in a way to solve problems and generate new applications, according to market needs and technological advances. The systematic implementation of the proposed innovation management system would help developing countries' firms to develop and sustain new advanced innovative capabilities, engaging in a winning technological path.

Moreover, the proposed system gives rise to a set of non-conventional indicators proper to examine the technological capabilities of developing countries' firms. The non-conventional indicators presented focus more on intra-organisational aspects of innovation activity which the conventional indicators are not able to capture. Hence, the adoption of these measurements would allow developing countries' firms asses their innovative performance more accurately.

Lastly, it is important to highlight that although these firms face a common set of challenges, each individual firm should try to adapt the proposed system to its peculiarities. The mere copy of ideas is not enough to guarantee the successful establishment of the total innovation management system neither the alignment between innovation and business strategies. Besides that, it is worth keeping in mind that the proposed indicators are not stanched. Once strategies and even firms change, it sounds interesting to change technological capabilities metrics. The most important aspect is that they should be in consonance with organisations' proposals and operational context.

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