

## **R&D ADMINISTRATION IN THE HIGH TECHNOLOGY INDUSTRY: HOW TO MANAGE A PARADOX**

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### **ABSTRACT**

The competitive environment of the knowledge age is getting more complex, dynamic, and fast-moving each day. The high tech industry is intensively tied to its effects and demands for innovation, so the field of Research and Development must act strategically, generating innovations and granting success and sustainability to the business. However, there is a paradox in R&D which may lay traps and obstacles disguised by the busy day-to-day activity of the organization. The purpose of this paper is to point out directions that managers may take to cope with these contradictions in R&D administration. The R&D paradox is rooted in the conflict between exploitation, achieved by continual improvement through incremental innovation, and by exploration, which seeks new opportunities in the creation of new technologies through disruptive innovations. These two sides of the paradox demand different, and sometimes even divergent, organizations. Top management leadership is crucial for the acceptance and balancing of the contradictions created by this paradox, and can align exploitation/exploration through distributive and integrative decisions and transform companies into truly ambidextrous organizations.

**Key-words:** Research & Development. Innovation. Paradox. Ambidextrous organizations. Strategy.

## **ADMINISTRAÇÃO DE P&D NA INDÚSTRIA DE ALTA TECNOLOGIA: COMO GERENCIAR UM PARADOXO?**

### **RESUMO**

O ambiente competitivo da Era do Conhecimento é cada vez mais complexo, dinâmico e veloz. A indústria de alta tecnologia vive intensamente esses efeitos e as exigências por inovações. Assim, a área de P&D atua estrategicamente, gerando inovações e garantindo o sucesso e a sustentabilidade do negócio. Entretanto, existe um paradoxo na área de P&D que pode criar armadilhas e obstáculos mascarados pela correria das atividades diárias. Este estudo é realizado por meio de uma revisão bibliográfica e argumentação teórica. O objetivo deste trabalho é indicar caminhos para os gerentes conduzirem as atividades de P&D sob uma perspectiva do paradoxo *exploit/explore*. O paradoxo da P&D é causado pelo conflito entre eficiência, obtida por melhorias contínuas por intermédio de inovações incrementais, e pela exploração, que busca novas oportunidades na criação de novas tecnologias pelas inovações de ruptura. Essas duas faces do paradoxo exigem organizações diferentes e, frequentemente, divergentes. A liderança da alta administração é crítica no reconhecimento e no balanceamento das contradições criadas pelo paradoxo e, por decisões distributivas e integradoras, conseguem aliar *exploit/explore* e transformar as empresas em verdadeiras organizações ambidestras.

**Palavras-chave:** Pesquisa e Desenvolvimento. Inovação. Paradoxo. Organizações Ambidestras. Estratégia.

## **1 INTRODUCTION**

The organizational literature points out that efficacy can be connected with an organization's capacity to deal with what Thompson (1967) called the "central paradox of administration": the simultaneous search for efficiency and flexibility. An organization capable of simultaneously managing both conflicting demands can be classified as ambidextrous (Duncan, 1976, Tushman and O'Reilly, 1996; Raisch and Birkinshaw, 2008).

Efficiency is connected with alignment, consistency, and predictability of outcome, while flexibility is associated with adaptability, variation, and the capacity to deal with the unpredictable. These two demands are fundamentally opposed, competing with one another for resources within the organization (March, 1991). Different lines of research in the field of administration expose this paradox in a broader manner, as it relates to the tension between exploration and exploitation (March, 1991, Raisch and Birkinshaw, 2008).

Exploitation denotes the mustering of resources for uses or benefits which are already known, thereby ensuring fast results and a short-term return. On the other hand, exploration represents seeking or investigating that which is still unclear or unknown, which entails investing resources in the search for innovation in the hope of gaining a long-term return.

An accepted and present contradiction in organizations, this duality can be seen as a paradox. The broadness and centrality of this question are such that it has become a recurring theme in derived subjects, including organizational learning, technological innovation, organizational adaptation, strategic management, and organizational design (Raisch and Birkinshaw, 2008).

This paradox in the research and development field can create traps and obstacles, hidden amidst an organization's busy day-to-day activity. Recognizing and working with this paradox are not simple tasks, but they can offer advantages and may be the only way to survive in today's competitive environment.

R&D research concentrates primarily on incremental improvement, leaving aside the disruptive innovation which is a key element for the survival of high technology organizations. Due to the pressure for fast results, the natural

tendency is to seek that which is certain and reliable. For this reason, organizations tend to focus on immediate, short-term, incremental innovations as means to decrease uncertainty and more quickly improve efficiency. This behavior, also known as “myopia” (Levinthal and March, 1993), makes it difficult for organizations to sustain investments in disruptive innovations.

The aim of this work is to indicate ways in which managers can carry out R&D activities under the perspective of the exploit/explore paradox. Once the differences between exploitation and exploration in R&D activities are identified and distinctively treated within the organization, this paradox ceases to be a point of conflict and becomes instead an aid in the development of functional strategies aligned with the business, and consequently in generating competitive advantage. Moreover, a better understanding of the paradox between exploration and exploitation can point to ways of combining them.

This work is divided into five sections, including this introduction. Section 2 reviews a few theoretical foundations of the paradox, innovation, and R&D administration. Based on this theoretical framework, sections 3 and 4 discuss the paradoxes existing in R&D activities and innovations, and how the conflicts arising from these activities can be managed. Lastly, section 5 presents some final considerations.

## **2 THEORETICAL FRAMEWORK: PARADOX VS. INNOVATION, EVOLUTION OF R&D ADMINISTRATION, AND AMBIDEXTROUS ORGANIZATIONS**

Addressing the subject of R&D requires emphasizing the paradoxes present in these activities, the roles played by innovation, and how R&D administration has evolved. These initial steps will provide the foundation for the development of this work.

### *2.1 THE EXPLOIT/EXPLORE PARADOX*

A logical paradox consists of two contradictory propositions that are uncontested in isolation, but which together seem inconsistent or incompatible. “Organizational and management theories involve a special type of paradox—social paradoxes” (Poole and Van de Ven, 1989, p. 564).

In the literature on organizations, the word paradox defines conflicting demands and opposed perspectives. A social paradox can denote a wide variety of contradictory—but related—elements. It becomes apparent through individual or social reflections or interactions, which reveal this absurd nexus and the irrational coexistence of opposites (Lewis, 2000). Paradoxes are perceived by tensions, i.e. cognitively- or socially-built polarities that mask the simultaneity of conflicting truths. Unlike dilemmas or exclusive choices, paradox tensions are two sides of the same coin (Cameron, 1986); apparently antagonistic concepts that must go together.

A widely studied paradox in administration, which in some ways resembles that existing in R&D administration, is the stability-change paradox. Burns and Stalker (1961) drew a distinction between organizational structures that favor stable conditions (mechanistic), and those more suitable to conditions of change (organistic). Yet another paradox that can help in understanding the tension found in R&D administration is the dual search for certainty and flexibility (Thompson, 1967), which can also be seen as the short- and long-term perspectives in administration. The greater the certainty of a given situation, the less flexibility is required, but when more doubts exist, more flexibility is needed to address changes.

Paradoxes are a part of day-to-day management, and various tensions can be identified, such as those between inertia and change; today's certainty and tomorrow's uncertainty (Abell, 1999); staying the course and innovation. All of these are encompassed by a more general tension, that between exploitation and exploration (March, 1991). This is the central tension explored in this work, one which needs to be identified and administered by an organization's top management.

Means exist to work with a paradox in order to understand it better or even to manage it (Poole and Van de Ven, 1989). Managing a paradox does not entail its resolution or elimination, but rather the capture of its existing potential and the use of its synergy (Andriopoulos and Lewis, 2009).

To that end, it is first necessary to accept the paradox, and next to decide how to approach and analyze the existing tensions, either separating them (in space or time) or analyzing them jointly. These analyses offer different perspectives of the same phenomenon; therefore, paradoxes can be seen as opportunities to focus on different research questions.

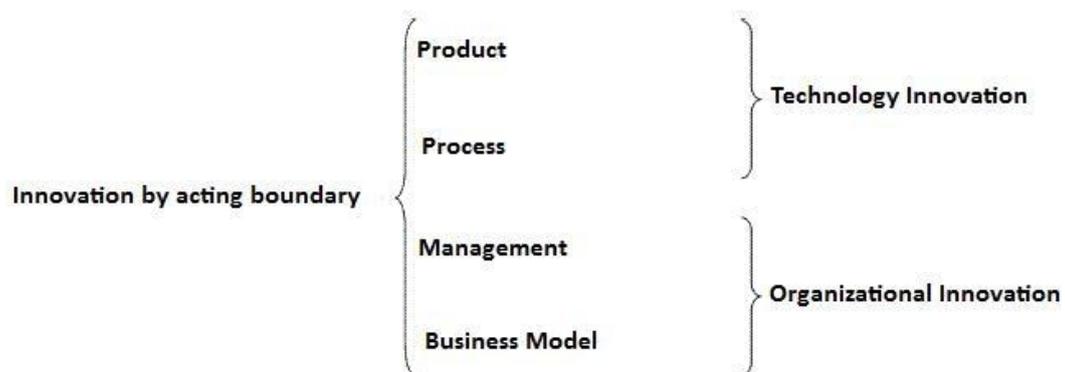
This tension between exploring and exploiting is easily observed in the technology replacement cycle, which is characterized by innovations and therefore crucial in R&D administration.

## 2.2 INNOVATION

The word innovation refers to the act of doing something new, but it differs from similar terms like invention or creativity. Unlike invention, innovation must necessarily generate some type of economic impact (Schumpeter, 1961). Invention and creativity relate to the individual and personal aspects of idea generation, whereas innovation is the organizational process of implementing the idea. Innovation can thus be considered as the process of developing and implementing a new idea (Van de Ven, 1986).

Innovation has been variously classified in the literature, among which one can find two essential aspects, the innovation's dimension and its impact. The first aspect concerns a more holistic view of the term, seeing it as able to occur in different areas of an organization under different perspectives. Innovation used to be thought of only in new product development, but it can arise in different scopes of action (Knop, 2008).

The Organization for Economic Co-operation and Development (OECD, 1992) defines innovation within the following four scopes of action: product, process, management, and business model. These four dimensions can be grouped into: (a) technological innovations, and (b) organizational innovations, as seen in Figure 1.



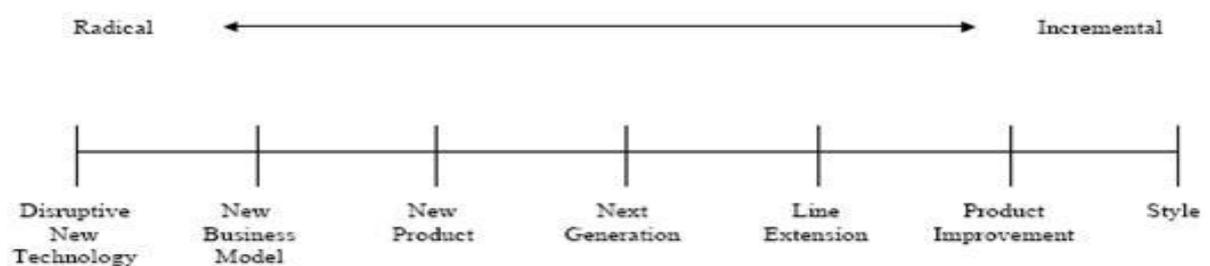
**Figure 1: Innovations by scope of action.**

Source: Knop, 2008

A continuum between two extremes is commonly found in the classification and analysis of innovations. These extremes receive different names in the literature, being called incremental, evolutionary, or continuous innovation on the one hand, and revolutionary, disruptive, or discontinuous innovation on the other.

The present work will use the terms “incremental” and “disruptive” to refer to both extremes of the impact of innovation. In this sense, incremental innovation used to be defined in the literature as innovation constituting small changes (Foster, 1988). After a study published by Henderson and Clark (1990), this definition is no longer widely accepted; it was demonstrated that a small alteration in the way a product works can generate a huge impact. For this reason, incremental and disruptive innovations are differentiated in the present work through their impact on the organization and on the market, not just the extent of technological change. As mentioned, incremental and disruptive innovations are two extremes, so other classifications of the impact of innovation between these extremes are possible.

Figure 2 shows some of these classifications. Naturally it is not a complete classification, but rather serves as an example from the point of view of the impact caused.



**Figure 2: Impact of innovation**

Source: Galbraith, 1992

By and large, incremental innovation requires only a relatively low level of effort, aimed at a small performance improvement. This type of innovation is related to the refining and convergence of ideas. Due to its results and because this form of implementation is relatively predictable, one can estimate the level of effort required to execute it; it is therefore feasible to think about fast results and efficiency.

Incremental innovations are built upon an already-established structure. They use already-existing knowledge, normally explicit knowledge, and take place in already-existing markets. Therefore, there is no attempt to change the scope of a business, the organization's strategy, or the industry's structure, insofar as already established assumptions remain the same after the innovation.

As one moves along this innovation axis toward more disruptive innovations, the characteristics become opposite. Disruptive innovations usually require a high level of effort and aim at unprecedented performance improvement. This type of innovation is associated with investigation and research, which generate varied and divergent ideas. The means of achieving this type of innovation are unpredictable, and its manner of implementation is unknown.

It is thus hard to estimate the effort and time required to obtain a disruptive innovation, which makes a quick return on investment unlikely. The investment required for generating disruptive innovations is associated with greater risk than that involved in incremental innovations. This occurs due to the unpredictable and uncertain nature of activities related to investigation and research. Activities related to the creation of these types of innovation require different organizational and personal characteristics.

Disruptive innovations occur through a disruption in the cycle of convergences created by incremental innovations (Abernathy and Utterback, 1988). The presuppositions acquired up to a certain point lose their validity and a new wave of technology, knowledge, and products or services is launched. Success is hard to come by in disruptive innovations because they entail a deep, systematic, and fundamental change, calling for a restructuring of the organization, the industry, and consumers. Despite the high risk involved, it is an indispensable activity for a high technology organization, one that can offer an important competitive advantage as first mover.

These were the concepts of incremental and disruptive innovations used in the theoretical development of this work. The activity of innovation is fundamental to the functional area of R&D of any organization, playing different roles depending on each phase of development of new technology. Both extremes of this continuum are part of the central paradox analyzed in this study, being disruptive innovations associated with exploration, through

investigation; and incremental innovations related to exploitation, through continual improvement. Recent studies (He and Wong, 2004; Jansen, 2005; Andriopoulos and Lewis, 2009) analyzed organizational ambidextrousness under this perspective of technological innovation.

### 2.3 EVOLUTION OF R&D ADMINISTRATION

As the name implies, R&D has two distinct aspects: research and development. One can understand

*research* as the process used by an organization to acquire new scientific and technical information and knowledge, and *development* as the process used to apply technical or scientific information and knowledge for product or process designs required to meet the needs of the organization or its current costumers (Endres, 1997, p. 5).

One can define the high technology industry as involving “markets with a rapid technological evolution [...] a broad array of technological alternatives, which implies lack of a dominant technology” (Rossi, 1995, p. 16). Technological diversity and its speedy dynamic oblige participants in this industry to engage in a ceaseless search for new information and continuous updating, making the inventory of knowledge both vast and quickly obsolete. Thus R&D in the high technology industry focuses primarily on incrementally improving existing technologies and/or developing new ones.

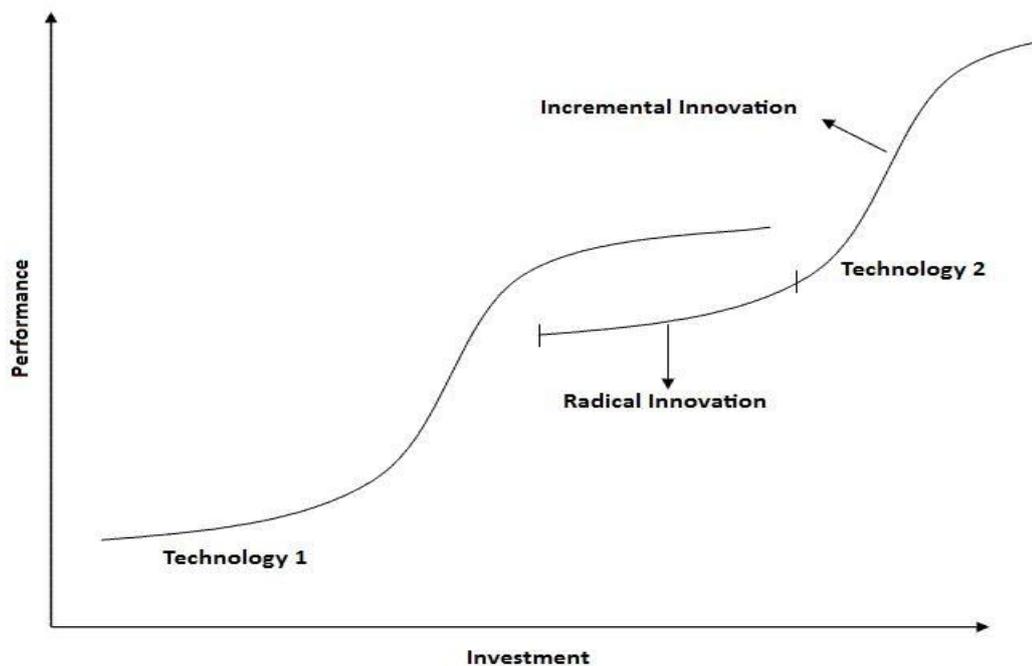
Technology, like innovation, is a very broad term. According to Rosenberg (cited by Tushman and Anderson, 1986), it can be defined as tools, devices, and knowledge that serve as intermediaries between input and output (process technology) and/or create new products or services (product technology). This work will simply refer to the manner in which something is done. Here technology can be understood as a process, a technique, or a methodology inserted in a product, process, or service; technology is the application of knowledge to obtain a result. Therefore, new technology is always associated with change and innovation.

Foster (1986), observing a given technology’s performance in relation to investments made in its development, considers that each technology evolves as an S-curve. The performance increases with greater investment, but eventually reaches a ceiling, above which improvements become impractical

According to Sahal (1981), these limits are imposed by the phenomenon of scale (objects become too big or too small), or by the complexity of the system. At this point, the only way to continue improving performance is through a redefinition (or disruptive innovation) of the technology (technique, method, or process). After this improvement, performance increases start over, through continual incremental innovations, until the moment when it reaches such a maturity that various new technologies are competing to replace it, in an endless cycle.

This cycle of technology replacement is represented in Figure 3. According to the figure, "Technology 1" starts an exponential curve, increasing the performance according to the increase in investments until reaching a point at which this increase starts to attenuate. During this phase, technology performance no longer increases significantly; therefore it is more interesting to make investment in new technologies, which can overcome the performance of the current technology.

Initially, incremental innovation plays an important role in promoting significant growth, whereas in the second phase a disruptive innovation plays a more significant role. Thus "Technology 2" arises from a disruptive innovation, and will later need incremental innovations to improve its performance.



**Figure 3: Technology replacement**

Source: Adapted from Foster (1986)

Although clear and didactic, this model gives the false impression that changes can be easily controlled and even predictable, but in reality the various stages, dimensions, and activities involved are not clearly identifiable. Nevertheless, the model is useful in understanding the continual existence of opposing demands regarding stability and change. Understanding the dynamic of technology replacement makes clear an organization's inherent need to simultaneously manage and deal with this tension.

A number of studies have tried to define how to manage innovation, and over time there has emerged an analysis which classifies the forms of management into four different R&D generations, associated with the contexts of different periods (Miller and Morris, 1999).

Fitting under the first generation was the management style predominant between 1940 and the mid-1960s. R&D in this period was boosted by the large number of businesses started after the Second World War, and is marked by a complete absence of planning, with scientists providing inventions and business managers producing and selling them.

According to the authors, this was the "hope strategy," wherein managers delivered resources to scientists and hoped that some invention suitable for commercialization would emerge. The scientists made decisions about future activities which were not explicitly connected with the business strategy, while the business side saw R&D as a sector that should be isolated in order to create more effectively.

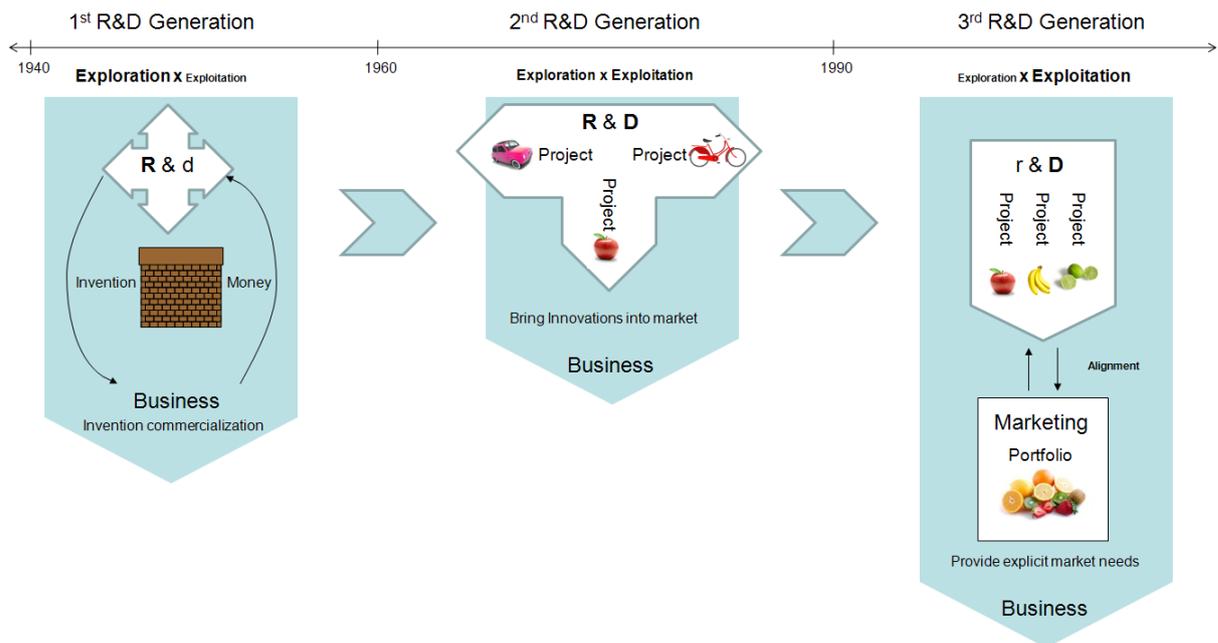
After this period, R&D centers were established as an essential function for modern industry, and practically all major corporations conducted R&D. The size of these centers and respective investments were defined according to somewhat unclear rules, such as a percentage of sales profits.

In this period, corporation managers perceived the need to drive the efforts of their personnel toward discrete projects in order to align them with the business. Thus, within R&D centers, investments were allocated on a project basis, which provided more control over the activities, but which still often bore no relation with the corporation business. This scheme predominated from the mid-1960s until the early 1990s.

The so-called third generation emerged from the need for greater integration and alignment between technologies and business. Studies such as those conducted by Prahalad and Hamel (1990, 1994) contributed to an understanding of the importance of addressing core competences in tune with the business.

A clear evolution and improvement can be perceived from an organization based on projects, which could be interrelated or fully disconnected, to an organization where projects are aligned with the product portfolio, which in turn is defined according to business objectives. This generation is also marked by investments in quantitative tools to better control and follow up projects and to more efficiently measure opportunities and risks, and thus better invest capital by choosing the best-aligned projects with a higher chance of success.

The evolution of the three generations is illustrated in Figure 4.



**Figure 4: Evolution of R&D administration paradigms**

Source: Authors

Miller and Morris (1999) wrote about what they call the fourth generation of R&D. The evolution from the third to the fourth generation arose from the lack of an efficacious exploration process. The idea of including customers in the process of product innovation is appealing, because with the customer lies the desire, the will, and the need for new functionalities or products, which are often

hidden in tacit knowledge. Until then, Marketing was in charge of determining customers' needs, and R&D had the responsibility to provide the technology. This division of responsibilities works well for incremental innovations in existing businesses, but does not yield results when the aim is disruptive innovation and tapping into new markets.

Through an examination of the tension between exploration and exploitation, one can analyze the evolution of thinking on administration of the functional R&D area. One can clearly note how the trend of investments by management intensifies at each different paradigm to one or the other side of these tensions. The first generation shows a clear tendency towards the extreme of exploration and almost no concern with exploitation. This stage of abundant new ideas is followed by a decrease in the pace of inventions and an increase in competitiveness, giving way to the need to focus on exploitation. This focus on exploitation extends from the second to the third generation, first on projects and then on portfolios and various methodologies.

Indeed, unprecedented improvement has occurred in continuous innovations. However, this focus on research which offers lower risk, greater efficiency, faster economic results, and the use of explicit knowledge of the market in order to align technologies and business, has somewhat limited the ability of large corporations to generate radical innovations or to tap tacit knowledge in the marketplace.

The study of the fourth generation thus draws attention to the lack of elements that facilitate disruptive innovations within the innovation processes used by corporations. Miller and Morris (1999) evidently perceive the impact caused by this evolution focused on efficiency, but do not clarify its root cause. This study argues that this root can be the need to manage the paradox between exploration and exploitation.

## 2.4 AMBIDEXTROUS ORGANIZATIONS

Tushman and O'Reilly (1996) called companies that know how to address the exploit/explore paradox "ambidextrous" organizations. This name fits, since these companies not only possess facilitating elements to generate disruptive

innovations and new knowledge, but also key elements for efficiency. To be called ambidextrous, these companies, besides being leaders in the technologies that predominate in their market of operation, have to know how to deal with change when discontinuities occur and still remain market leaders.

Ambidextrous organizations need to be able to deal with both the present, i.e. businesses already in the market; and with tomorrow, namely new businesses that may enter the market (Abell, 1999). For each of these aims, a different form of organization is required, thereby hindering the corporation's task of excelling today and tomorrow.

Researchers recognize more and more the importance of balancing and synchronizing apparently contradictory tensions. According to Burns and Stalker (1961), for a company to be more efficient it needs to exert a more rigid and formal control, and to be innovative it needs more flexibility and less formality, which may seem like mutually exclusive qualities.

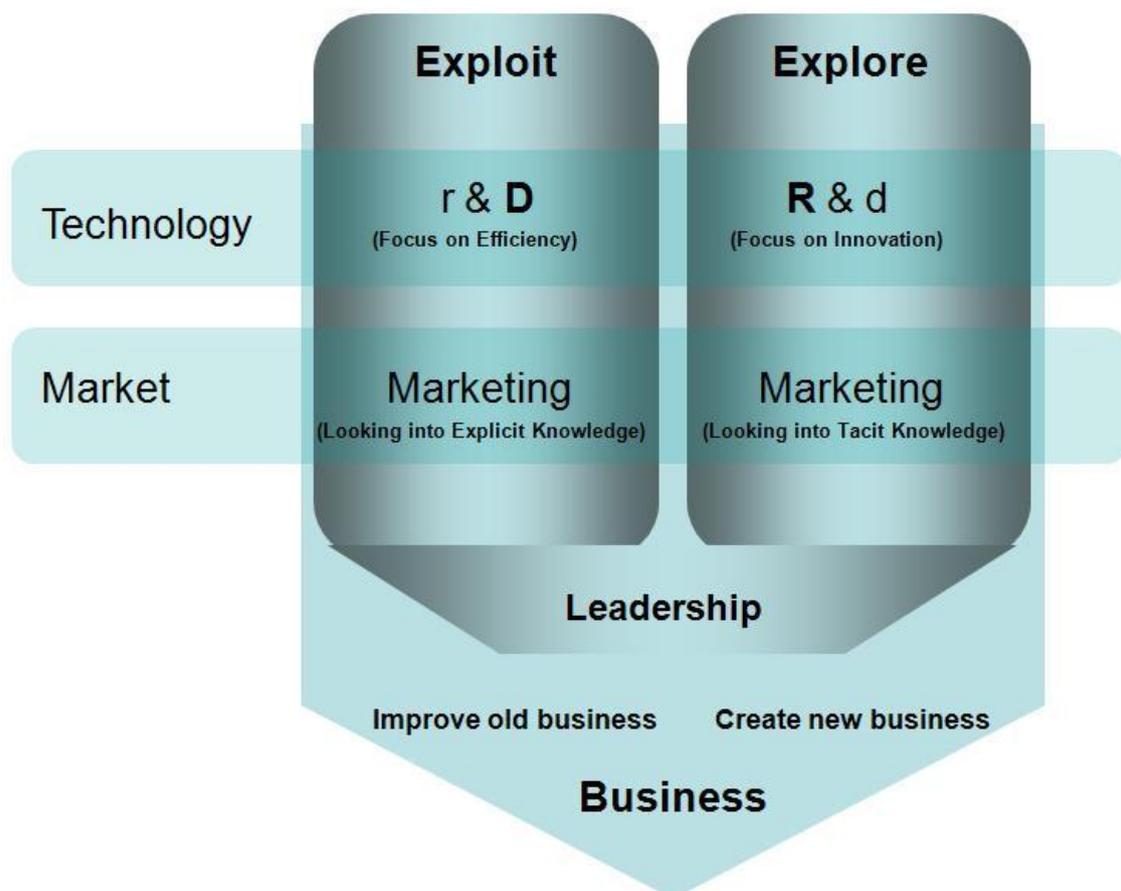
In this context, ambidextrous organizations are those capable of dealing concomitantly with these and other contradictions. In short, they would be complex organizational forms, composed of multiple internally inconsistent architectures, which would be able to operate simultaneously with efficiency in the short term and revolution in the long run (Tushman; O'Reilly, 2004).

The concepts of ambidextrous organizations and fourth generation management complement one another to explain how to address the exploitation-exploration paradox. If one understands that the tasks of efficiency and incremental innovation require a different approach than that of disruptive innovations, and assumes that Marketing must seek different types of knowledge to either improve current products or understand what the market wants and lacks, one can conceive a new model for R&D administration. Such a model involves more than just the R&D functional area; Marketing also needs a differentiated structure to work with these existing tensions.

Top management must invest both in exploration and exploitation. These investments mean implementing two different forms of organizing and managing, each focused on one end of the tension extant in the paradox. Both Marketing and R&D should have these two different objectives, and the exploring environment should not contaminate the exploiting environment, or vice versa.

The focus of R&D (emphasis on development) that seeks to exploit is on generating more performance for the dominant technology, which offers low risk by using methodologies that optimize development. For its part, Marketing should be alert to tailor its product portfolio to customers' needs. On the other end of the tension, R&D (emphasis on research) which seeks new technologies to overcome the maximum performance foreseen for the current technology performs a riskier job, and should have a high tolerance for errors. As for Marketing, it should seek tacit knowledge in the market (Miller and Morris 1998) as it attempts to foresee customers' needs and desires.

The principal authors who recognized this paradox in the area of innovation are Michael Tushman, Jay Galbraith, and William Abernathy. A compilation of the ideas about the fourth generation of R&D administration and ambidextrous organizations can be seen in the scheme represented in Figure 5.



**Figure 5: Scheme based on the literature about ambidextrous organizations and 4<sup>th</sup> generation R&D.**

Source: Authors

### **3 PARADOXES IN R&D ACTIVITIES AND INNOVATION**

In R&D, a high technology company can choose to invest in efficiency and rapid results—thereby maintaining a portfolio of products that sell well and are already inserted in the market—or in new ideas, enabling the creation of products that will replace existing ones, thereby decreasing its short-term profit but prolonging its permanence in the market.

Companies often adopt only one of these two positions, investing either in efficiency (exploitative) or in exploration (explorative). The first option may seem the most attractive, because by maintaining focus on improving current products or services, customers remain satisfied and purchase more. On the other hand, the company's view of the future market shortens, and equipment becomes obsolete when a new technology emerges. Incremental innovations are important in these activities, insofar as they provide the necessary continual improvement of products and/or services.

In choosing the second option, a company will have the opportunity to project its future, and the chance to become a market leader and pioneer a new technology. However, its customers may become dissatisfied with weak improvements in the company's current offerings, and choose another supplier before the new technology reaches the market.

Exploration and exploitation activities yield opposite results in relation to risk and return. Whereas investments in exploitation usually have a lower cost, lower risk, and short-term returns, investments in exploration involve a high cost, elevated risk, and long-term returns.

Thus the paradox of R&D is formed. The choice between exploitation or exploration seems necessary, considering that each one brings different needs in terms of organizational structure, culture, strategy alignment, and ways of analyzing the market. However, in the 21st century's fast-changing environment, managers need to maintain continual improvement (exploitation) in the short term, while simultaneously thinking about long-term business survival and sustainability, which is only attainable through exploration.

Although this problem permeates all industrial sectors, it is more obvious in the high technology industry because of the extremely dynamic environment found there. In the cement industry, for instance, changes are slow and

predictable, which flattens the S-curve of innovation. In this scenario, one should worry more about exploitation methodologies and fast results than about foreseeing possible market revolutions.

In contrast, the telecommunications sector witnesses changes at a very high speed, with products quickly losing their value due to the entry of new technologies. Unlike the cement industry, a much higher sensibility to new markets and technologies is necessary in this sector. Market and technology co-evolve, and different approaches are required depending on the dynamism of the environment where organizations operate.

#### **4 ADDRESSING R&D ACTIVITY IN ITS PARADOXICAL CONTEXT**

The assessment of most Strategic Planning processes of large companies, found in the literature on administration which is often used by practitioners, allows one to identify a sequence of activities that resembles the following: (1) analysis of internal and external environments; (2) definition of mission, vision, and values; (3) conception of strategies at different levels; (4) implementation of strategies; (5) evaluation and strategic control. This process simply seeks to align organizational features, opportunities, and threats in the environment in which a company competes (Miles and Snow, 1994; Andrews, 1996).

This widely used process applies tools or frameworks such as the five competitive forces model, generic strategies, the cycle of industry evolution (Porter, 1980), the value chain (Porter, 1985), and resource assessment (Barney, 1991; Grant, 1991; Barney and Hesterly, 2006), particularly in the diagnosis (environmental analysis) and the conception of strategies.

A detailed study of these planning instruments indicates that this process tries to identify the dynamics of the prevailing competitive structure, and the organization's possibilities and limitations, in order to then act upon the company's activities and resources so as to advantageously position it in the environment. This process is built upon an already existing infrastructure, and upon easily identifiable and usable (explicit) knowledge, thereby imposing, often incidentally, the need to focus exclusively on incremental innovations.

This occurs because the managers' decisions are strongly based on the structure, the strategy, and the competences that are working well, at times creating biases vis-à-vis the possibility of change or restructuring. This belief in what "works well" may limit future competitive capacity precisely because the creation of tomorrow's business may rely on different bases and premises, which require new structures, strategies, companies, and knowledge.

[W]hen structure, strategies, and competencies all reinforce one another, managers are psychologically more resistant to changing them [...]. Levinthal and March [...] suggest that managers are myopic—privileging short term over long term, close rather than far, and certainty of success over risk of failure (Smith and Tushman, 2005, p. 525).

Current management models and instruments thus lead managers to make decisions about the future under the dominant paradigm of the present, leaving the company extremely vulnerable to the discontinuities marked by disruptive innovations, limiting their R&D guidelines to incremental innovations. The first important task required to improve R&D is to recognize this paradox by identifying the trade-off that emerges between exploiting and exploring.

Recognizing the duality present in R&D activity does not simply entail a distinction between the short and long term in operations and budget planning. A strategic view is required, a view into the future and the steps the organization should take on a still uncertain course. Thus the focus of analysis is on top management and how CEOs should consider the exploit/explore paradox.

Exploitation activities are connected with improving current products/services/processes in an organization. This indicates that efficiency is achieved through incremental innovations and the excellent management of current activities. Exploration activities concern the creation of the new, not only for the organization, but for the market. Exploration is thus conducted through disruptive innovations and organizational change, as seen in Table 1.

<b>TOP MANAGEMENT SCOPE</b>	
<b>EFFICIENCY</b>	<b>EXPLORATION</b>
<b>EXCELLENT MANAGEMENT OF CURRENT ACTIVITIES</b>	<b>PROMOTION AND MANAGEMENT OF CHANGE</b>
<b>INCREMENTAL INNOVATIONS</b>	<b>DISRUPTIVE INNOVATIONS</b>

**Table 1: Function duality at top management level.**

Source: Authors

The central point demonstrated here is that managing current activities with excellence means organizing for a specific task. Organizational processes and practices are ultimately very well defined, leaving little room for initiatives and attempts toward innovation. On the other hand, the strategic task of prospecting by top management should not be merely a mental exercise, an inspiring discourse for tomorrow, but should translate into present action—action which is often contrary to a company’s meticulously planned and executed day-to-day activities.

Acknowledging these two opposite sides of an organization—one that organizes present growth and one that disrupts for future change—and that these practices are concomitant should be the starting point for top management in its R&D decisions, in order to balance investments between efficiency and revolution. Care should be taken not to fall into the trap of pure efficiency (exploiting), while believing that revolution (exploring) will only begin in the future upon the arrival of change.

The very statement that this is a conflicting environment in which the two sides of an organization require different actions, and that one occurs to the detriment of the other, demonstrates the internal confusion caused by the exploit/explore paradox. Company employees may feel lost and without focus, because ambiguity ultimately brings insecurity. Thus a central role in managing the paradox is the role of leadership exerted by top management, who should be able to wear two “hats”:

- First, the chief executive must be prepared to pursue both excellence today and change for tomorrow. This readiness should be one of the distinguishing criteria for selecting candidates for the company’s highest office.
- Second, just below the top, there may be room for more specialization, with accent being applied either to today’s management or preparations for tomorrow. Nevertheless, in the top-management team, all managers must be able to wear both hats (Abell, 1999, p. 78).

These individuals in directive positions can achieve internal harmony within this paradox by negotiating between efficiency and revolution, based on two criteria: (1) the first has a distributive nature, balancing the trade-offs between the faces of the paradox; (2) the second has an integrative nature, identifying synergies (Smith and Tushman, 2005).

Distributive decisions are those in which resources are divided into each R&D activity, whether it is focused on efficiency or innovation. The correct identification of each face of the paradox and the management of this division should provide both parts with the resources required for the performance of their activities, attuned with the possibilities of the organization, and should avoid disputes that could shift the focus of the true contribution of each activity to the organization as a whole.

Moreover, an attempt needs to be made to identify the stages of the S-curve where each of the technologies involved are located. The nearer to the maximum point of growth of the established technology, and the nearer to the launching of new technology, the greater the indication to decrease investments in exploitation (of a product becoming obsolete) and increase investments in exploration.

Although exploitation and exploration are on two different, often conflicting sides, opportunities and connections between them may occur. Thus, integrative decisions are those where managers are able to identify these synergies, creating creative solutions with mutual benefits. Both distributive and integrative decisions entail creating an organization able to support the conducting of two radically different types of business, one focused on efficiency and the continuance of the current business, and the other dedicated to exploring new opportunities and generating new markets for future growth. This makes a company truly ambidextrous.

## **5 FINAL CONSIDERATIONS**

The objective set forth by this work was to indicate possible paths for managers to carry out R&D activities under the perspective of the exploit/explore paradox, a conflict that is often masked by the daily activities of many high technology companies. Through the understanding of this paradox, this work sought to indicate a few paths for managers to address contradictions, in order to obtain a more profitable outcome from this critical and expensive activity.

After the literature review, it becomes clear that paradoxes present in various aspects of organizational studies can be also found in the functional R&D area. The sides of the paradox discussed were called exploit and explore: the

former relates to incremental innovations at the stages of “exponential” growth in the S-curve, and the later relates to disruptive innovations, accounting for the discontinuing and replacement of one technology with another. These sides require different—and at times conflicting—structures, strategies, competences, knowledge, and culture.

For R&D to function within the paradox, leadership from top administration is crucial, since individuals in a conflicting environment may feel confused and insecure and lose their focus. Executives in senior positions can maintain control over and harmonize these contradictions by basing their decisions on two criteria: distributive and integrative.

Overcoming inertia in a successful organization is difficult. Nevertheless, the focus of the high technology industry on the exploitation aspect of R&D activity, through incremental innovations, will ensure its continual success only until the beginning of the next technological wave. Thus, only those organizations that achieve a harmonious balance between exploitation and exploration are able to become truly ambidextrous and capable of surviving and competing in the Knowledge Era.

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