

FUNDAÇÃO GETULIO VARGAS
ESCOLA DE ADMINISTRAÇÃO DE EMPRESAS DE SÃO PAULO

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Open Innovation in the Pharmaceutical Industry

SÃO PAULO

2014

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Dissertação apresentada à Escola de
Administração de Empresas de São
Paulo da Fundação Getúlio Vargas,
como requisito para a obtenção do título
de Mestre Profissional em Gestão
Internacional

Campo de Conhecimento: Gestão
Internacional

Orientador: Prof. Gilberto Sarfati

SÃO PAULO

2014

Magalhães, Ariadne B.

Open Innovation in the Pharmaceutical Industry / Ariadne Braz Magalhães. - 2014.

72 f.

Orientador: Gilberto Sarfati

Dissertação (MPGI) - Escola de Administração de Empresas de São Paulo.

1. Indústria farmacêutica. 2. Empresas multinacionais. 3. Inovações tecnológicas. I. Sarfati, Gilberto. II. Dissertação (MPGI) - Escola de Administração de Empresas de São Paulo. III. Título.

CDU 661.12

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Campo do Conhecimento:
Gestão e Competitividade em Empresas Globais

Data de Aprovação:
29/01/2014

Banca Examinadora:

Prof. Dr. Gilberto Sarfati (ORIENTADOR)

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ABSTRACT

This objective of this study is to discuss the open innovation strategy adopted by the four largest U.S. pharmaceutical companies in the last four years. Innovation has been recognized as an essential source of a firm's competitive advantage. As companies start to expand and interact on a global scale, their innovation strategy starts to change, and acquires a more integrated aspect, with increasing relationship with external actors and resources. This shift seeks to make innovation less costly and more efficient, and has an impact on the companies' results. This research will undertake an exploratory research by using two open innovation frameworks as reference, Lichtenthaler (2008) and Lazzarotti-Manzini-Pellegrini (2010). Understanding how firms currently apply an open innovation strategy is the first step for evaluating its impact on company strategy in this new international context.

KEY WORDS: Open innovation, pharmaceutical industry, multinational company, strategy

RESUMO

O objetivo desse estudo é discutir a estratégia de inovação aberta adotada pelas quatro maiores companhias farmacêuticas norte-americanas nos últimos quatro anos. A inovação tem sido reconhecida como uma fonte essencial de vantagem competitiva de uma firma. A partir do momento em que empresas começam a expandir e interagir em escala global, sua estratégia de inovação começa a mudar, e adquire um aspecto mais integrado, intensificando seu relacionamento com atores externos e recursos. Essa mudança tem como objetivo reduzir o custo da inovação e aumentar sua eficiência, e tem impacto nos resultados da empresa. Essa pesquisa realiza uma pesquisa exploratória usando dois modelos de inovação aberta como referência, Lichtenthaler (2008) e Lazzarotti-Manzini-Pellegrini (2010). Entender como as firmas aplicam estratégias de inovação aberta é o primeiro passo para avaliar seu impacto na estratégia geral da mesma na nova conjuntura internacional.

PALAVRAS CHAVE: Inovação aberta, indústria farmacêutica, empresa multinacional, estratégia

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1. Introduction

Previous research has pointed out how a firm's intangible resources can be a source of competitive advantage (Teece, Pisano & Shuen, 1997; Cohen & Levinthal, 1990). Schumpeter (1934) and Hayek (1945) have placed innovation, an intangible asset, as one of the important sources of firm competitiveness. Innovation has become a critical feature for firms that want to have a competitive strategy in the market.

More recent studies on innovation have aimed attention at the company's position within a network or system of interactions and relationships (Doran & O'Leary, 2008; Laursen & Salter, 2006; Lichtenthaler, 2008). Some of the theories that emerged from this trend are the dynamic capabilities theory (Teece & Pisano, 1994) and the concept of absorptive capacities (Cohen & Levinthal, 1990). While the dynamic capabilities theory focuses on the adaptive capability of firms, which allows them to grasp opportunities that arise in the increasingly fast-changing markets, the second theory points out the importance of a company's Research & Development (R&D) department for firm strategy. These theories provide some foundation for a specific type of innovation, which has emerged from creating new products and services by interacting with outside actors and resources: open innovation.

Chesbrough, defines it as "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough, 2003).

However, as the concept has only gained more attention in the last decades (Von Hippel 1988), there is still wide room for exploratory research, as it allows a better appreciation of the subject and how it is being currently implemented by companies. Even though there are some studies addressing open innovation, literature is limited, according to Huizing (2011).

The goal of this paper is to understand how of open innovation is implemented within firms with similar profile and from the same industry. It

focuses on the pharmaceutical industry, which is known for being innovation intensive, with Research and Development (R&D) expenses reaching the billions among multinational companies (Orsenigo, Dosi & Mazzucatto, 2006).

This thesis seeks to enhance literature through a comparative case study that analyses open innovation strategy in the pharmaceutical industry. This sector was pioneer in innovation initiatives with external collaboration, which have been increasing: the composition of alliances in the industry rose from 11% to 58% between 1991 and 2001 (Nadolna & Swiadek, 2011). In addition, in order to assess the performance effects of the external scientific knowledge, it was necessary to select an industry in which such knowledge has significant protection by intellectual property laws. Prior research points out that patents and trade secrecy are much more effective at protecting knowledge and innovations of pharmaceutical firms (Teece, 1986).

The thesis is structured in the following manner: first, there is a discussion of previous literature on the subject, which especially seeks to show the different views that were adopted with regard to open innovation, and to present the frameworks that were chosen for the study. Then, the methodology is described, presenting the research participants and introducing the frameworks chosen for the analysis. The next section consists of the analysis itself, which consists of: describing the gathered data, focusing on how the participants adopt open innovation, and classifying this adoption within the chosen open innovation frameworks accordingly. The conclusion reports the results of qualitative exploratory research and addresses the following proposition: understanding how the chosen companies implement open innovation. Lastly, the limitations and future researches on the subject are pointed out.

2. Literature review

The review on previous literature intends to give an introduction to knowledge management theories and how this led to the insertion of Open Innovation in within the subject. Next, OI literature is explored more in depth, where both positive of negative aspects of its adoption are presented. Finally, the research presents previous studies that explore how open innovation is applied in different industries, and focuses on the pharmaceutical industry, which is the focus of the thesis.

2.1 Knowledge management and innovation

A series of past studies have placed knowledge as central in strategic management, and how the composition of elements to develop strategy and firm competitiveness are associated with the creation and development of knowledge (Dodgson, Gann & Salter, 2006). Some of these theories are the evolutionary theory (Nelson & Winter, 1982), the resource-based theories (Penrose, 1959; Barney, 1986), and the dynamic capabilities theory (Teece & Pisano, 1994).

The evolutionary theory (Nelson & Winter, 1982) focuses on the dynamic process that determines firm behaviour patterns and market outcomes over time. In this theory, the focus is on the process; more specifically, the set of capabilities, procedures and internal knowledge it is made of, and how it determines the evolution of the firm's adaptive capacity, and thus, its economic efficiency.

The resource-based theories (Barney, 1986; Barney, 1991; Penrose, 1959) also refer to firms in terms of their capabilities: they are defined as an ensemble of assets consisting of tangible and intangible resources, and tacit knowledge. In this theory, both internal and external resources have a stronger effect on performance when these are rare.

More specifically, the intangible resources, such as skills, knowledge management and know-how, would have the greatest potential contributions to creating advantages (Teece, Pisano & Shuen, 1997, Nonaka & Takeuchi,

1995). In other words, it is precisely the internal knowledge pointed as being responsible for evolution by Nelson and Winter (1982) that acquires further relevance when it is tacit. This makes it more difficult to copy, and therefore, increases the firm's competitive advantage. Thus, growth and development of knowledge, and by extension, innovation, achieve a central position in the competitive process (Schumpeter, 1934; Schumpeter, 1943; Hayek, 1945; Kirzner, 1997).

2.2 Innovation Literature

Innovation is the search for and the discovery, experimentation, development, imitation and adoption of new products, new processes and new organizational set ups (Dosi, 1988). It has become an essential aspect for companies that want to conquer markets and retain their position as well as overcoming competitors. Successful innovation is central to the development of future competitive strategies of organisations. Critical factors such as quality, delivery, flexibility and cost are integral parts that an organisation requires to survive (Radnor & Robinson, 2000).

While previous researches on innovation have looked to the characteristics of the business to explain innovation performance (Acs & Audretsch, 1988; Mansfield, 1981), more recent studies have tried to focus more on the company's position within a network or system of interactions and relationships (Doran & O'Leary, 2008; Laursen & Salter, 2006; Lichtenthaler, 2008). Von Hippel (1988) and Lundvall (1988) point that interaction between users of knowledge and producers of knowledge is a source of innovation.

More specifically, the dynamic capabilities theory (Teece & Pisano, 1994) and the concept of absorptive capacities (Cohen & Levinthal, 1990) establish a justification for the interest on innovation initiatives that are associated with external interaction. The dynamic capabilities theory highlights the importance of firms having the ability to change and adapt their competences in order to be able to grasp the opportunities created by the increasingly fast changing environments. This adaptive ability would be provided by the capacity of successfully managing knowledge. Furthermore, the concept of absorptive

capacities (Cohen & Levinthal, 1990) places a firm's Research & Development (R&D) department in a central position. This would allow the firm to be able to learn from others, that is, internal R&D can enable the integration with external knowledge, and enhancing innovation as a result of this "openness". These theories provide some ground for the interest in open innovation, making it systemic and opening up the possibility for being turned into a theory itself.

2.3 Open Innovation

There are essentially two concepts of open innovation (OI). The first was introduced by Chesbrough in its 2003 book, "*Open innovation: the new imperative for creating and profiting from technology*", which defines a new model for industrial innovation. The second concept was developed by Von Hippel in 2005 (Von Hippel, 2005), which uses the concept of open-source software to analyse open and distributed innovation. The focus of this work will be on the first. According to Chesbrough, open innovation can be defined as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively' (Chesbrough, 2006, p. 1). These flows create both a set of practices for profiting from innovation, and a model for creating, interpreting, and researching those practices (Chesbrough, 2006, p. 286). Lichtenthaler takes on the dynamic capabilities theory to redefine Chesbrough's concept of open innovation: 'systematically relying on a firm's dynamic capabilities of internally and externally carrying out the major technology management tasks... along the innovation process' (Lichtenthaler, 2008, p. 148).

The concept of open innovation started to receive more attention at the end of the 20th century, when a series of factors started to erode the then dominating approach of closed innovation. One of the most impacting factors was the large increase of the amount and mobility of skilled workers, which made it more difficult for companies to control their ideas and expertise. Another important matter was the soaring availability of private venture capital, which allowed the creation of new firms outside the structure of large established organizations (Chesbrough, 2011). Universities and government labs started

to show increasing interest in creating partnerships and obtaining financial gains from their research. In addition, the development of several technologies, such as the Internet, made it easier for firms and individuals to interact and exchange knowledge (Huston & Sakkab, 2006).

Over the following decade or so, global competition has increased the need for companies to release new and more complex products. This phenomenon is associated with on-going technological progress, a short product life cycle, and technological progress. Those factors influence the fact that an innovation process is becoming more expensive and risky, and that the costs for developing specific structures becoming prohibitive (Slowinski, Hummel, Gupta & Gilmont, 2009). As a result, firms are forced to innovate faster and develop products and services more efficiently. In order to do that, they are led to a paradigm shift, and begin to create partnerships to share costs, to use external sources in order to gain access to new technologies and knowledge, and start to collaborate within an innovative network. Companies start sharing their risk with other firms and organizations, by employing outside expertise and developing alliances with other institutions.

This paradigm shift is further encouraged by social and economic factors such as requests of more and more demanding consumers, and the easier access to high risk capital (Duarte & Sarkar, 2011; Slowinski et al., 2009). Therewith, it results in a new way for companies to approach innovation, where networks become increasingly global and require individuals and institutions to adopt a more “open” perspective on the innovation process, in which collaboration and competition coexist (Calantone & Stanko, 2007; Nadolna & Swiadek, 2011; OECD, 2010). Thus, a new concept of innovation process emerges: the open innovation approach.

Different from the closed innovation model, this approach allows the company to take ideas that were not successfully developed inside and try to develop those using sources from the outside. In this model, firms create value by building up and commercializing ideas through the use of external sources, in addition to its internal ones (Chesbrough, 2011).

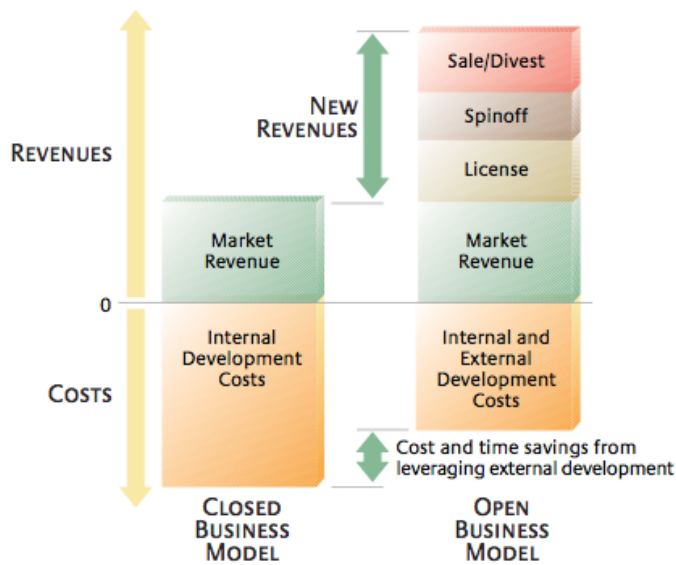
According to Chesbrough (2003), as innovation becomes a more widespread activity among different actors, firms need to make strategic and organizational changes in order to adapt to this new context, and fully appropriate the potential of their investments and capabilities. Open innovation as a business strategy becomes attractive as it allows the firm to better exploit the benefits of knowledge from the outside and export internal ideas that are not being used by the firm. This new model is starting to be considered as a necessary driver of industrial R&D, with several companies in *Fortune* 1000 already featuring external innovation budgets (Slowinski et al., 2009).

2.3.1 Advantages of Open Innovation

The open innovation model has been facing growing acceptance because it can explain events that the previous models could not. For example, the open innovation model explains the overwhelming ability of Cisco to keep up with and eventually even surpassing Lucent and its Bell Labs in the 1990s. This exemplifies the paradigm shift, from Lucent's model of "closed innovation", prevalent for most of the 20th century, when a firm creates, develops and commercialises its own concepts (Chesbrough, 2006), to Cisco's "open innovation" approach, where firms use internal and external knowledge to create and develop ideas or even export them. Cisco, currently the world's largest telecommunication infrastructure supplier, obtained much of its technology from the outside, both from alliances and partnerships as well as by acquiring tech start-ups. Lucent (now Alcatel-Lucent, after it merged with French telecommunications giant Alcatel in 2006) on the other hand, maintained its strategy focus on closed innovation, still having one of the largest R&D houses in the communications industry, its Nobel-winning and record patent-holder Bell Labs, at the same time it reports increasing net losses and falling share prices (Getz and Robinson, 2003; "Company Overview", n.d.).

The figure below illustrates the shift of the innovation model, from closed (left bar) to open (right bar):

Figure 1: The New Business Model for Innovation

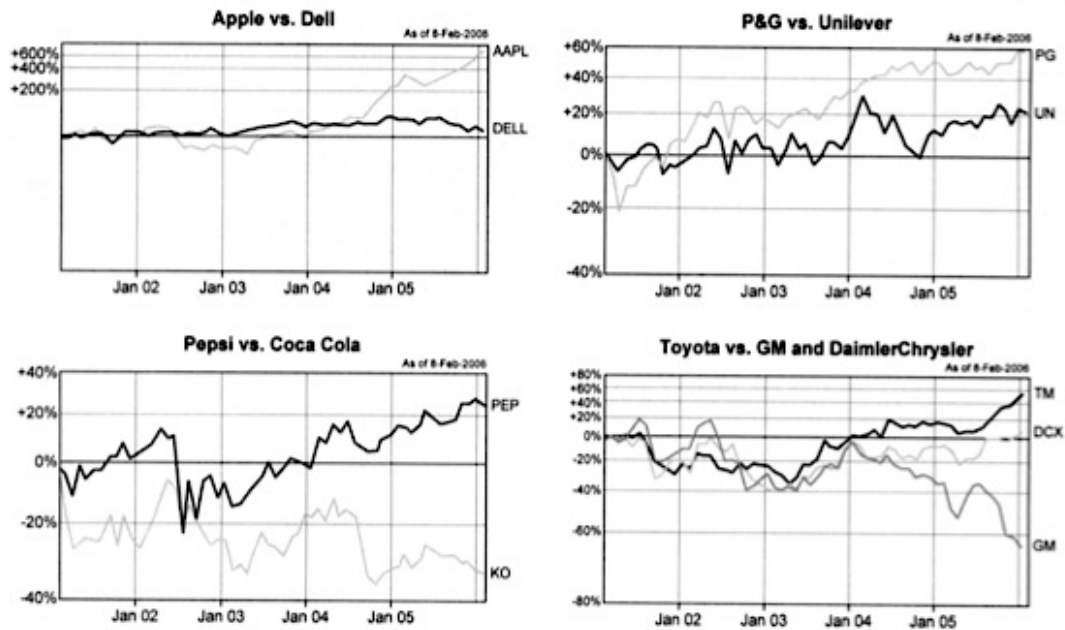


Source: Chesbrough, 2007

Companies have made a shift in their business model for innovation in order to overcome the challenges they are currently facing, which lead to increasing costs and needs for shorter product cycles. The Open Business Model (right bar) shows that a new range of revenues has been created, at the same time that there is a reduction in development costs, which are also used for external interaction.

A study by Drake, Sakkab and Jonash (2006) offers evidence to the performance improvement of companies that adopt an open business model. The graphics below show the performance evolution of main players in different industries in terms of R&D-driven sales. In every comparison, after the companies adopted the open innovation strategy (Apple, P&G, Pepsi and Toyota), they had considerably better results than each of their main competitors (Dell, Unilever, Coca Cola and DaimlerChrysler, respectively).

Figure 2: R&D-driven sales to innovation-driven shareholder returns.



Source: Drake et al., 2006

In the figure above, it is possible to see a comparison between firms that adopt an open innovation and firms that adopt closed innovation. The companies that show better performance were pioneers in adopting an open innovation strategy, and eventually achieved a leadership position in their industry (Dodgson, Gann & Salter, 2006; Huston & Sakkab, 2006). That is, firms in industry leadership positions are the ones who are effectively managing innovation initiatives beyond corporate boundaries, and across the entire innovation value chain (Drake et al., 2006).

Other studies have pointed out that managers adopt open innovation to meet company growth goals, keep up with disruptive innovation trends and increase firm resources performance (Chesbrough & Crowther, 2006). Manager engagement of open innovation is essential for its success, as it leans on coordination and integration among wide number of actors, each providing their core competencies. One of the fundamental premises of open innovation is "not all the smart people work for you" (Chesbrough, 2003b). This means that there is more value in creating the structure to connect different sources than there is in creating another internal element. In order to be successful, open innovation has to supply and leverage knowledge and information in the most widespread and free way possible. Thereby, it allows

the reduction of finding and development cycle times and the improvement of success rates in a cost-effective way (Chesbrough, 2012). Indeed, open innovation allows firms to leverage their investment in R&D much more than if they relied solely on internal knowledge (Witzeman et al., 2006).

Adopting open innovation brings a series of additional advantages to the company, enhancing its innovation process, and its operational and financial performance. In terms of innovation, some of the benefits are: early and rapid access to new technologies, attraction and access of a greater pool of specialist talents, stimulation of internal innovativeness, innovation process acceleration, internationalisation of R&D and innovation activities, and increase of overall technological innovation capabilities (Vanhaverbeke et al., 2008; Jones & Teege, 2002; Rivette & Kline, 2000). The rising use of multiple channels for technology exploration, and acquisition of ready-to-use technologies would also allow firms to reduce technological uncertainty and risk, as well as accelerate the product cycle time (Lichtenthaler, 2004; Slowinski et al., 2009). The opposite is also true: closed innovation strategies are likely to limit the return on a company's R&D investments because they result in lower licensing revenues, which frequently have high profit margins (Rivette and Kline, 2000).

In addition, open innovation can lead to gains in the company's operational and financial performance, such as: early access to business opportunities, postponement of financial compromise, possibility of early exits, economies of scale and scope in R&D, risk sharing and leveraging comparative advantages, and cost minimization through sharing. Open innovation also boosts the performance of companies through the use of alternative ways to access the market, such as licensing deals and spin-offs, as it was the case of Cisco, explained earlier (Haour, 2004; Lichtenthaler, 2004).

While firms traditionally aim to retain their core capabilities and develop them internally as much as they can, open innovation appears as a faster and less uncertain alternative to in-house development, especially when the goal is diversification, both in terms of technology and markets (OECD Innovation Strategy, 2010). Lichtenthaler (2009) has found open innovation to be

beneficial across different environmental scenarios, and tend to increase firm competitiveness (Dodgson et al. 2006; Duarte & Sarkar, 2011). Other strategic benefits, such as setting industry standards, especially through transmuting proprietary technology, make the approach even more advisable to managers as they seek to increase firm performance (Lichtenthaler, 2009; Rivette & Kline, 2000).

In addition, the increase of patent licensing, which is another facet of open innovation initiatives, allows the firm to secure value of corporate technology assets that otherwise would not be used inside the firm. This would even allow it to make strategic partnerships to access new markets. IBM, for example, earned \$1.7 billion dollars from licensing technology only in 2000 (Kline, 2003). As intellectual property assets represent between 50% and 70% of the market value of public companies, the fostering of open innovation is likely to further enhance this value (Kline, 2003).

In sum, adopting an open innovation model allows the company to more effectively create and capture value. This is possible both by leveraging ideas through external interaction and using the strategic resources not only within the organization but also in outside businesses. This makes up potential to reduce cost and time, increase revenue scope and enhance the company's position in the industry it operates.

2.3.2 Challenges of Open Innovation

At the same time there is evidence that the adoption of an open innovation strategy would be beneficial to the firm's performance, some literature points out the possible drawbacks and challenges that it might generate. Lichtenthaler and Ernst (2009) and de Wit et al. (2007) claim that there is still limited use of open innovation practices, and this might be justifiable. One of their arguments is that global competitiveness has driven companies to focus on short-term results, by cutting expenses for long-term research that could lead to disruptive innovation.

Other disadvantages, marked by Keupp and Gassman (2009), and Huizingh (2011), impact both in the innovation process and in firm performance. Open innovation can have high transaction and financial costs and intellectual property conflicts. The low level of appropriability might affect innovation, as well as the lower level of control the company would have over this process. It is also important to point out that opening up too much inside knowledge and technology could become an obstacle for the enforcement of a company's intellectual property rights. This could eventually create antitrust issues, competition barriers and market conflicts (Kline, 2003).

The flow of ideas faces even more obstacles in the case of partnering universities and government labs. Given the fact that research has to be selected by specific academic and research departments, there is a lower possibility of cross-discipline disruptive innovations. In addition, even though the permission for universities to patent their discoveries has been beneficial to academic researchers, it makes it more difficult for associated companies to obtain financial returns from these innovations (Chesbrough, 2006).

In addition, human resource management and the management of different partners are important constituents of open innovation, since successful innovation might often depend on involving external partners in the company's innovation activities. In order to apply an open innovation initiative, the company has to consider three spectra of strategy: (1) its own long-term strategy; (2) its partner's long-term strategy; and (3) the 'interconnectedness' of the companies regarding business unit and supply chain (Slowinski et al., 2009). For the initiative to be successfully implemented it is pivotal to integrate external innovation into the company's internal processes, and develop specific organizational arrangements, which will require significant settings. This can make the management of the innovation process more complicated and quarrelsome, which may result in the loss of competences and greater dependence on external parties (Dodgson et al., 2006; Keupp & Gassman, 2009).

However, some of these drawbacks can be overcome when some factors are taken into account when implementing an open innovation strategy. It is important to analyse the cost-benefit of acquiring external knowledge and technology. It is also fundamental to evaluate the environment surrounding the company, by taking a closer look into geographical and sectorial specificities, and the level of industry competitiveness, all of which are likely to impact on open innovation performance (Lichtenthaler & Ernst, 2007; Lichtenthaler, 2009).

Another crucial aspect on which relies the effectiveness of a company's external innovation activities is determining its goals and define the strategy accordingly. The key aspect of open innovation is that it happens across boundaries, including the internal ones. In other words, the whole firm will be interacting with various external sources, from universities and federal laboratories to venture capitalists, international patent-holder firms and even direct competitors. This would be possible by making a change in the firm's culture, by making policies explicit and actively engaging high-level management (Dodgson et al., 2006; Kline, 2003; Slowinski et al., 2009). These changes, in turn, will solely have viability after the adjustment or even remaking of the whole business model, as well as the effective intake on the this new model from all the important actors who are inside the company (Chesbrough, 2006).

2.4 Open Innovation across industries

The open innovation model is being increasingly adopted in several industries, among which computers, semiconductors, telecommunications, communication systems biotechnology, automotive, and even military weapons and aerospace. In these industries, the focus of innovation has shifted from internal R&D laboratories in mega-companies to manifold organizations, such as start-ups, universities, associations and other institutions. This tendency has gone beyond technology-intensive industries

and is now being embraced by other businesses like health care, fast-moving consumer goods, banking, and insurance (Chesbrough, 2003). Some examples of open innovation initiatives are investment banking UBS's Idea Exchange, consumer electronics Best Buy's resilience initiative and healthcare company GlaxoSmithKline's Spark Program (Birkinshaw et al., 2011).

A prominent example in literature regarding open business adoption comes from the consumer goods industry: Procter & Gamble (P&G), which went further and even changed the name of their R&D department to Connect and Develop (C&D), to make evident their commitment to an open and interactive innovation strategy (Dodgson et al., 2006). This shift happened after P&G recognized that most solutions to the company's problems were actually outside the company. They started to look for complementary technologies by creating alliances with other companies and competitors, participating on collaborative networks, and buying start-ups that are keen to pursue entrepreneurial actions. They also began to actively license their patents in order to increase their return on investment. These initiatives allowed them to turn more technologies into products. Their strategy was described as "replacing the not-invented-here syndrome with the proudly-found-elsewhere approach" (Witzeman et al., 2006, p.27).

Procter & Gamble's open innovation initiative was not only implemented in the R&D department; it created a change in P&G's culture: 'C&D is more a way of life than a technological strategy. It is about your mind-set. It is ensuring you are open day and night to new possibilities' (Dodgson et al., 2006, p.338).

This shift brought many other advantages to P&G: it allowed it to innovate beyond areas of expertise, by using technologies and organizational resources that lay outside the company, it improved the product quality, because of the larger number of innovative ideas that can be accessed, it reduced innovation risk through collaboration, and it also allowed faster monetization of value, as ideas can be more easily put forward by resources, thus creating value. This new strategy has been successful also in financial terms and in terms of innovation performance: P&G currently has more than

50% of total research initiatives coming from innovation with external partners (Dodgson et al., 2006).

Several cases of successful OI implementation can be identified in the literature, such as life sciences (Rothaermel and Ku, 2008), microprocessors (Chesbrough et al., 2007), and consumer goods (Dodgson et al., 2006). However, even though several aspects of open innovation strategy are common across industries, there are some peculiarities that have to be pointed out. There is some research on how an open innovation strategy can have diverse outcomes in different sectors, which affects the likeliness of its adoption. Scholars have identified some factors that impact the introduction of open innovation initiatives, such as technology intensity (Duarte & Sarkar, 2011), the level of appropriability (Laursen & Salter, 2006), technology development costs, time of product cycles (Chesbrough, 2007), among others. At the same time, one can also identify industries taking radically different positions concerning open innovation: the nuclear-reactor industry, for example, which mainly still relies on inside, closed innovation, and on the other side, there is the entertainment industry, which has used an open innovation strategy for a long time, with associations and alliances between production studios, talent agencies and independent producers.

Given the peculiarities of OI implementation across industries, the next item will focus on the subject in a specific industry, the pharmaceutical industry, which will be the research subject of this thesis.

2.4.1 OI in the Pharmaceutical Industry

The pharmaceutical industry is highly driven by science, research and technological development, which make innovation even more relevant. In this sector, R&D processes can last up to thirteen years, and the cost of developing a drug can reach 1.2 billion dollars (PhRMA, 2013). However, only one of five thousand product-ideas and one of ten thousand substances actually arrive at the market. From the drugs that arrived at the market, roughly 30 per cent actually generate revenues that compensate or overcome the R&D costs. This means that a firm has to market between two to four new

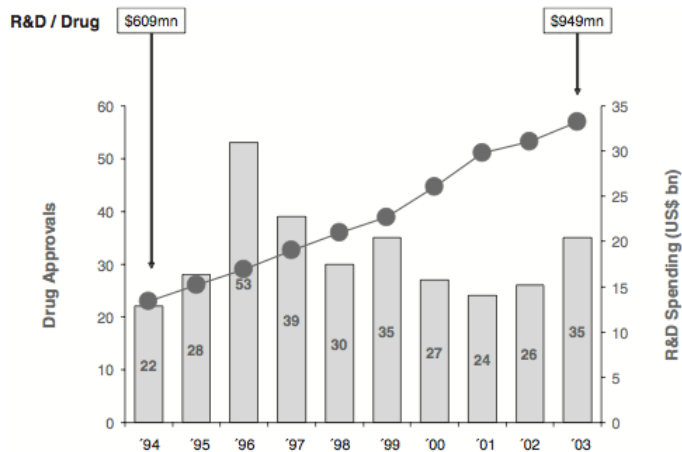
drugs every year in order to maintain its growth (Gassman & Reepmeyer, 2005).

According to Gassman and Reepmeyer (2005), because of its extremely high costs of R&D, need to share risks, complementary assets and the need to fast access to markets, the pharmaceutical industry shows high and increasing levels of networking; its current R&D operations can be defined as a net of company agreements and alliances, rather than in-house R&D centres. Open innovation in the pharmaceutical industry does not involve only traditional firms, but also biotechnology and genomics-based companies, as well as several service providers, like contract research organizations and contract manufacturing organizations, among others (Orsenigo et al., 2006).

The pharmaceutical R&D process involves a series of stages: drug development pipeline, screening and research technologies, global cooperation networks in clinical research and testing, and cooperation agreements with competitors and biotechnology start-ups. All these stages have been facing challenges: the pipeline output is low and decreasing, the R&D costs are rising fast due to more complex clinical trials and more expensive technologies (PhRMA, 2013), and patented products have been having lesser shelf life, given prolonged clinical trials and administrative processes (Gassman & Reepmeyer, 2005).

The graph below shows the increase of R&D costs per drug overtime, while the number of drug approvals remains stable:

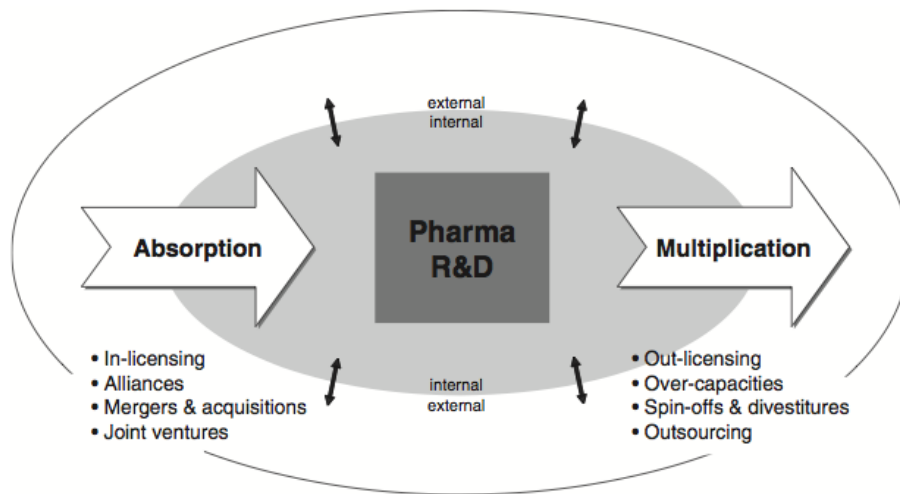
Graph 1: Drug Approvals and R&D Spending between 1994 and 2003.



Source: PhRMA, 2004.

These challenges are the result of some shifts the pharmaceutical industry has encountered. As it was argued before, there is indeed more focus on short-term goals, with a higher level of early-stage research and projects that do not result in outbreaks. When one jumps to the final stages of drug development, it is also possible to identify some issues and higher attrition rates, which results in a longer development time. In addition, there is growing need for more differentiated and targeted new drugs, which would only be possible to provide with wide clinical research. Thus, the firms' contend relies on increasing efficiency in all stages, balancing short-term and long-term objectives while it expands its operation range, by focusing on niche-markets. This requires a change in their organizational structure, so that it complements its competencies with external knowledge. According to Gassman, Reepmeyer and von Zedtwitz (2004), between 20 and 70 per cent of the firms' R&D is already spent outside their home country, and the former standard of integrated R&D structure is already showing decrease; therefore, the pharmaceutical industry is outperforming several other technology-intensive sectors regarding R&D internationalization. This new organizational arrangement, which has become one of the fundamental goals in innovation management (Figure 4), will allow companies to adequately adapt to the emerging phenomenon of globalized pharmaceutical R&D, grounded on open innovation initiatives.

Figure 3: Model of reviewed structure of pharmaceutical firms' R&D department.



Source: Gassman & Reepmeyer, 2005

Even though the pharmaceutical industry has been showing evident trends regarding organizational structuring, such as R&D internationalization and adoption of open innovation patterns, there are still some hurdles that pharmaceutical companies need to confront. Some of those are restricted efficiency, and troubles in know-how transfer and in the alignment of corporate strategy with R&D strategy. They frustrate the full embrace of open innovation and open way to alternative paths to its adoption (Gassman & Reepmeyer, 2005).

Some examples of different types of adoption of an OI strategy in the pharmaceutical industry can be found in the literature. Huston and Sakkab (2006) highlight the foundation of InnoCentive by Eli Lilly in 1998, which is an online platform made to connect companies with individuals and institutions to help solving scientific problems. The use of this technology marketplace, alongside Innovaro, is described by Birkinshaw et al. (2011): Roche Diagnostics resorted to them in 2009 to obtain possible solutions to some technological problems it was facing, which were refraining some R&D programs from being built up.

It is possible to identify this tendency in the pharmaceutical industry towards a

more interactive and integrative innovation strategy. Some initiatives, such as Enlight Biosciences, a group founded by J&J, Eli Lilly, Merck, Novartis and Pfizer that targets at identifying and licensing promissory R&D leads, are an example of this trend. Pharmaceutical companies such as Merck, Novartis, Pfizer and AstraZeneca have engaged on several open innovation initiatives together even though they are direct competitors, given the importance of giving the industry common knowledge ground (Perkmann & Salter, 2012).

By analysing the changes more broadly, a clear shift can be observed, from FIPCos (integrated pharmaceutical companies that develop drugs internally and then market them) to FIPNets (integrated pharmaceutical networks that involve several stakeholders in drug development, among which pharmaceutical companies, CROs, and academic research centres). In this new arrangement, all stakeholders participate in the decision process and share risks and returns of innovation (Kaitin, 2011). This approach has been identified as being particularly suitable to the pharmaceutical industry (“Open innovations to pursue new projects”, 2012).

Even though empirical studies have arisen in past years, the literature on open innovation still has some gaps. Bianchi, Cavaliere, Chiaroni, Frattini and Chiesa (2011) developed a research that defined inbound and outbound innovation activities, and pointed that firms have more inbound than outbound initiatives. This would mean that companies could be failing to seize potential profits (Van de Vrande, Lemmens & Vanhaverbeke, 2006). Procter & Gamble uses only 10% of the technologies it develops (Huston & Sakkab, 2006) and Motorola projects it could potentially earn about \$10 billion dollars per year in licensing out (Lichtenthaler, 2007).

In 2010, eight pharmaceutical companies spent more than 5 billion dollars in R&D, with Pfizer leading the group at \$9.4 billion (Kaitin, 2011). The percentage of R&D spending directed at external resources was at 25%, and it is expected to reach 40%, which is evidence of the trend towards external interaction (Gassman & Reepmeyer, 2005).

However, this trend does not always seem to lead to better results in

performance, and in some cases, it even made them worse. For example, pharmaceutical companies have adopted some open innovation strategies, such as acquisitions, in-licensing transactions and the adoption of more flexible design agreements in the past years. However, these initiatives have had some unexpected results, such as increasing the workload entanglement of R&D programmes, and elevating the costs of drug development (Getz, 2011). This has led to some initiatives to cut costs, among which austere job reduction. Between 2008 and 2010, the pharmaceutical industry discharged more than 157.000 employees (Alsumidaie, 2012). Other challenges faced by the pharmaceutical industry are the rising cost and length of drug development, and loss of patent protection on several blockbuster drugs (OECD, 2012).

Given the fact that the traditional pharmaceutical innovation model is being questioned, and at the same time the changes in innovation strategy could not lead to better performance altogether, the issue becomes more critical. Even though most of the open innovation approaches seem to be adding value, the measurement of the initiatives as well as the effectiveness of the strategy as a whole is being put in doubt. It becomes evident that the pharmaceutical giants have to have a better appreciation of the financial worth of open innovation (Alsumidaie, 2012; "Open innovations to pursue new projects", 2012).

Comparative studies and theory have a lot of room for exploration (Duarte and Sarkar, 2011). There is still a lack of a clear understanding of external sources of innovation, both inside and outside the organization, and how to quantify it and thus optimize performance through this approach (Chiesa et al., 2008; Enkel and Lenz, 2009, Enkel et al., 2011; Lichtenthaler, 2009).

In practice, a major project that has been put to work in 2012 can give some answers to this gap: the launch of first drug development firm based on open innovation, Transparency Life Sciences (TLS). It is based on the creation of a crowd sourced web platform that allows all stakeholders to be involved in the design of clinical studies, from patients to researchers. The initiative is based on three principles: collaborative intelligence, wide use of ICT in patient-centric clinical trials, and data transparency. This new approach emerges as

the pharmaceutical industry reaches a critical point in which productivity gains could only be achieved through innovative ways to clinical drug development. The main objective of this initiative is to prove that the adoption of open innovation in drug development can decrease costs and enhance productivity (PR Newswire, 2012).

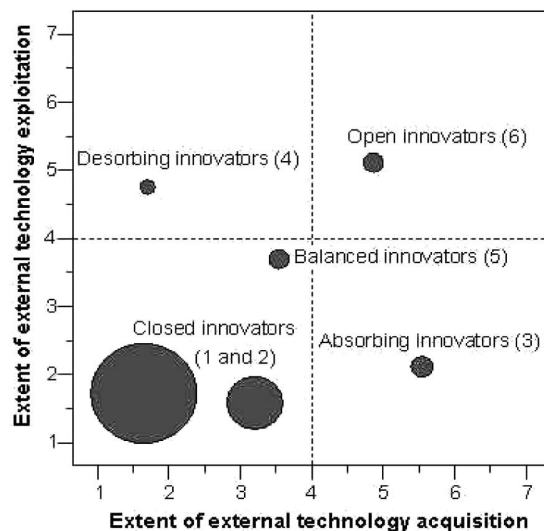
However, is it also essential to analyse more in depth the current OI initiatives undertaken by active players in the industry and evaluate their effectiveness. Huizing (2011) made an analysis on open innovation literature and has found that initial studies have been made. They have a tendency to be descriptive, which helps understanding the concept. The use of frameworks to explore current open innovation strategies is a way of addressing the issue. One of this frameworks was developed by Lichtenthaler in 2008, through a large-scale investigation that evaluates how OI is being applied in different industries. In this model, the level of open innovation is defined by two variables: the **extent of technology acquisition** and the **extent of external technology exploitation**. According to the level of intensity of the companies in both variables, it is possible to generate a hierarchy that indicates the extent to which they are adopting OI.

Lichtenthaler used a hierarchical analysis to classify innovation openness in six clusters. Clusters 1 and 2 are considered closed innovators, as they follow the closed innovation paradigm, even though Cluster 2 acquires a considerable part of technology from external parties. Cluster 3 is composed of “absorbing innovators”, which have strong reliance on external technology acquisition, or inbound open innovation, but a low level of technology commercialization (outbound open innovation). Cluster 4, the “desorbing innovators”, are the opposite of cluster 3, as they have a higher level of external technology commercialization, but present a lower level of external acquisitions. Clusters 3 and 4 are open innovation adopters, but only on one direction.

Finally, companies that belong to clusters 5 and 6 are considered as adopters of an open innovation strategy. The difference between them is that Cluster 5, the “balanced innovators”, undertakes technology transactions at a significant

but limited extent, while Cluster 6, the “open innovators”, and engage fully on open innovation initiatives, as they seek to capitalize their technology assets through commercialization. The figure below depicts the clusters according to their degree of each variable.

Figure 4: Lichtenthaler Framework.



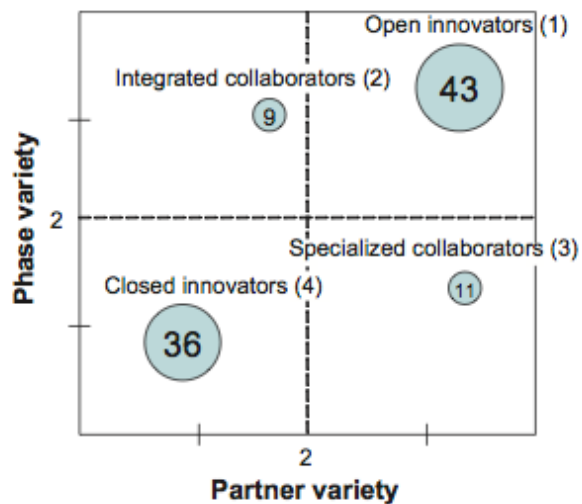
Source: Lichtenthaler, p.150 (2008)

The analysis undertaken by Lichtenthaler has some interesting findings: the companies that pursue an open innovation strategy have a higher operating margin than the others. Firms that follow an open innovation strategy are more likely to have a diversified product portfolio, to pursue radical innovation and to have a corporate venturing unit. However, these firms are also R&D-intensive, and tend to see open innovation initiatives as complementary to the internal ones, rather than substitutes. As it has been pointed out, previously in this study, Lichtenthaler also signals the significance of exploring companies' current innovation, which is precisely the focus of this thesis.

Another framework identified during the research is the one produced by Lazzarotti, Manzini and Pellegrini in 2010. It is directed at examining the possible models for a company to adopt an open innovation strategy. The framework takes into account two variables, **partner variety** and **innovation phase variety**, which according to the authors, had not been thoroughly investigated in previous studies. These variables are directly proportional to the extent of the use of OI by a company. The partner variety can be

measured through observing the number and type of partnerships with external parties, such as alliances, consortia, and joint development, and the number of ventures with external partners. In accordance with the authors, the innovation phase variety can be measured by analysing the number and type of phases of the innovation funnel in which OI is adopted. Therefore, as the companies of this study belong to the pharmaceutical industry, this variable will take into account the extent to which open innovation is adopted throughout the pharmaceutical research pipeline, which depicts the traditional innovation model. Because of that, collaborations and acquisitions that do not relate to the pharmaceutical drug pipeline will not be taken into account.

Figure 5: Lazzarotti-Manzini-Pellegrini Framework.



Source: Lazzarotti, Manzini & Pellegrini, p.16 (2010)

3. Methodology

The main focus of Chesbrough's concept of open innovation is related to the changes it generates on business strategy and at the organizational level. This study contributes to the research of innovation with regard to strategy by analysing how the four largest pharmaceutical companies in the U.S. implement open innovation.

The research methodology of this thesis is based on exploratory research, as the analyzed subject has limited available content. According to Gil (1999), exploratory research has as a goal to provide more familiarity with the issue, in order to make it more explicit or to build hypotheses. This research is qualitative, and can be classified as a comparative case study. It is based on two existing frameworks, which are used to rank the level of innovation openness adopted by a company.

The analysis used existing literature on the subject, including empirical studies and qualitative investigation. Because previous research on open innovation is limited, as it only received more attention in the last decades, other sources were also used, such as professional business reports and studies made by institutions from the industry.

3.1 Participants

The subjects of the study are the four largest public pharmaceutical companies from the United States that belong to the top-tier of the industry, which focuses on the development and marketing of blockbuster drugs. This choice of purposive sample was made according to a study by Forbes (2013), which for defining the biggest companies used a methodology that takes into account four metrics: sales, profits, assets and market value; all figures are consolidated and in U.S. dollars. The pharmaceutical industry was chosen because partnerships and alliances with external actors are widely adopted in this segment (Nadolna & Swiadek, 2011). Thus, an analysis of companies that have expressive operations in the industry will lead to a more grounded conclusion drawn from the proposition. This research aims at understanding how the chosen companies implement open innovation.

3.1.1 Election and justification of participants

Gassman and Reepmeyer (2005) argued that open innovation is more appropriate in contexts characterized by globalization, technology intensity and knowledge leveraging (as cited in Huizingh, 2011). Previous research has also shown that large companies seem significantly more likely to engage on collaborative innovation than small and medium-sized enterprises (Bianchi et al., 2011; Keupp & Gassmann, 2009; Lichtenthaler & Ernst, 2009), and that firm size and industry are important factors for determining the level of innovation (OECD, 2009; OECD, 2010). The firms chosen for the analysis have similar size belong to the same industry, the pharmaceutical industry, which is technology-intensive and knowledge-intensive, and so are good candidates for the adoption of open innovation.

Regarding the choice of public companies for the study, they were selected because of information availability. As it has been mentioned before, given the impact of firm size and industry on innovation level, this research focuses only on one industry, and compares large multinational companies. The chosen industry is the pharmaceutical because it presents a series of characteristics that make evident the industry's tendency towards an Open Innovation paradigm, such as focus on external partnerships and creation of collaborative networks, which in turn result in specific management and budget for external collaboration and the remodeling of internal processes to improve collaborative innovation activities (Langley, 2005). Given the fact that the environment affects substantially the chosen strategy of innovation, a further filter was applied: only companies from the United States were considered for the study, which are four: Pfizer, Merck & Co, Abbott Laboratories and Eli Lilly & Co.

The pharmaceutical industry is divided in four tiers in terms of firm strategy: top-tier, mid-tier, small pharmaceuticals and biotechnology (Business Wire, 2003). Because company strategy directly affects how it approaches innovation, only companies from the top-tier were selected. Firms from the top tier focus on drugs that lead to disruptive innovation in the pharmaceutical industry: the so-called blockbuster drugs. These companies have a more

robust R&D department and higher research costs, and thus, invest more in emerging methods of innovation (Business Wire 2006). According to Kessel (2011), the traditional pharmaceutical business model, followed by top-tier firms, involves the conduction of clinical trials, the identification of new blockbuster drugs, and intensive marketing initiatives to promote these drugs. In this study, the focus is on pharmaceutical companies that follow the classic model. The Forbes ranking of biggest pharmaceutical firms can be observed below.

Table 1: United States' Biggest Public Companies in the Pharmaceutical Industry.

Rank	Company	Country	Sales	Profits	Assets	Market Value
1	Pfizer	United States	\$59 B	\$14.6 B	\$185.8 B	\$201.4 B
2	Merck & Co	United States	\$47.3 B	\$6.2 B	\$106.1 B	\$133.3 B
3	Abbott Laboratories	United States	\$39.9 B	\$6 B	\$67.2 B	\$53.6 B
4	Eli Lilly & Co	United States	\$22.6 B	\$4.1 B	\$34.4 B	\$62.5 B

Source: Forbes (2013). The World's Biggest Public Companies – Pharmaceutical Industry

3.2 Procedures

The procedures consist of collecting the relevant data, both from literature and business reports from the industry and the analysed companies, and applying the open innovation measurements that will allow addressing the proposition. The processes are detailed next.

3.2.1 Data collection

The data collection uses existing open innovation literature and information and reports publicly available on the companies chosen for the study. The study consists of applying the Open Innovation frameworks on the chosen companies by using the information collected on them. The application of the frameworks is made by placing the participants within the classification defined by the authors, which classify firms according to their level of OI adoption. The innovation openness can reflect the use of partnerships and alliances, acquisition of smaller firms and technology or specific enquiries with outside specialists.

3.2.2 Data analysis

The outcome of the analysis aims at the following proposition: understanding how the chosen companies implement open innovation. As it has been mentioned before, this analysis will be made by evaluation the innovation strategy adopted by the companies through the use of two Open Innovation frameworks.

3.2.2.1 Open Innovation measurement

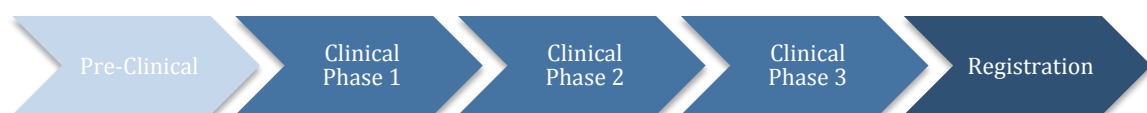
The analysis of the participants regarding their innovation strategy is based on two frameworks, and their level of openness will be ranked accordingly.

One of the frameworks used is the one developed by Lichtenthaler (2008). It portrays the present state of open innovation in practice. In this model, the level of open innovation is defined by two variables: the extent of technology acquisition and the extent of external technology exploitation. The first measure, external technology acquisition, concerns the assimilation of external technologies, and can be observed through the level of strategic partnerships, in-licensing contracts, among others. As for external technology exploitation, which concerns the commercialization of technology assets and knowledge, which leads to grasping their financial and strategic capacity. This variable can be measured through observing the sale and licensing of technologies and other types of know-how.

The second framework, created by Lazzarotti, Manzini and Pellegrini (2010), divides innovators in terms of partner variety and phase variety, resulting in four profiles: open and closed innovators, and integrated and specialized collaborators. Partner variety is measured through observing the amount and type of partners, which include universities, research centres, public institutions, competitors, suppliers, customers, service companies, and companies from different sectors. According to the authors, the second variable, phase variety, can be measured by analysing the number and type of phases of the innovation funnel in which OI is adopted. Therefore, as the companies of this study belong to the pharmaceutical industry, this variable will take into account the extent to which open innovation is adopted throughout the pharmaceutical research pipeline, which depicts the traditional innovation model. Because of that, collaborations and acquisitions that do not relate to the pharmaceutical drug pipeline will not be taken into account.

The pharmaceutical research pipeline is composed of pre-clinical or discovery projects, three clinical phases, and drug registration. Phase 1 involves the first human tests in a small figure of healthy volunteers to verify tolerability and possible dosing. Phase 2 consists of testing the molecule's efficacy against the disease in a limited number of patients. Finally, the last clinical phase (Phase 3) consists of testing the molecule in a larger population, so as to prove effectiveness and safety, by taking into account regulatory issues. The last stage refers to the registration of the molecule. The figure below illustrates the pipeline:

Figure 6: Pharmaceutical Drug Development Pipeline.



Source: CSL Behring Website (2013)

In order to make it possible to place the companies within both frameworks, the exploratory analysis of their level of OI adoption will be classified into weak, average, strong, and very strong. These classifications are directly proportional with the described OI intensity for the different variables.

The choice of frameworks allow the firms' approach to be evaluated with regard to inbound and outbound open innovation, and thus, admits a more complete interpretation of the companies' strategies. Inbound open innovation concerns inward technology transfer, and outbound open innovation involves to outward technology transfer (Chesbrough & Crowther, 2006). This means that both internal and external technologies can be better appropriated and leveraged when they are used in interaction between the company and the external environment.

Some limitations of the study need to be pointed out. Firstly, the sample refers only to four large industrial companies. As such, the results may not directly be transferable to very small firms, which have substantially contributed to the recent trend towards outbound open innovation (Arora, Fosfuri & Gambardella, 2001). Secondly, the findings reflect the current situation in only one country, the United States. It is possible that different results are drawn when one takes into account firms with different countries of origin (Lichtenthaler, 2009). However, this research helps to fill a gap in the literature of open innovation, as it is an exploratory analysis of OI adoption of firms within the same industry, which has been insufficiently approached in previous works.

4. Results and Analysis

The proposition of this paper is to understand how the four largest pharmaceutical companies in the U.S. implement OI using two different frameworks.

This chapter is structured starting from the presentation of the innovation strategy of the participants, where details about the data gathered are presented. The next topic discusses the results regarding Open Innovation adoption, finalizing with a brief summary of the findings and how they address the thesis proposition.

4.1 Innovation Strategy

The analysis consists of the evaluation and classification of the innovation strategy of each of the participants, focusing on their OI level. In order to carry out this analysis, two frameworks were chosen. They allow the assessment of the whole spectrum of open innovation, namely the inbound and outbound. First, the open innovation analysis of the research participants is made. Next, the frameworks are applied and the companies are classified according to their level of innovation openness.

The next sections discuss the gathered data on open innovation for the research participants and apply the chosen frameworks accordingly.

4.1.1 Pfizer

According to an OECD report on Knowledge Networks and Markets (OECD, 2012), Pfizer has a prominent position in the pharmaceutical industry regarding external interaction, which is made evident by the several initiatives it is involved in.

In 2010, Pfizer Global Supply (PGS) has re-evaluated its innovation approach, as it found the need to renew its methodologies, by looking for new ways to access knowledge outside the organization. The company formed an

international team to be responsible for leveraging the development of the new strategy. This team encompasses several organizational levels, which have equal say in the decisions. Pfizer's relatively small innovation headquarters aims at preparing coaches to lead innovation initiatives around the world and adapt them to local needs (Drakulich, 2012).

Pfizer has a unit focused on R&D, *Pfizer Worldwide Research & Development* (WRD), which has created a cell to focus on external interaction, the *External Research & Development Innovation* (ERDI). Pfizer is very active regarding partnerships and acquisitions. It is currently involved in around 800 alliances in several phases involving research and development. Many of those initiatives involve partnerships with research institutions, such as the University of California, the Scripps Research Institute, the University of Pennsylvania, and the Shanghai Institute of Biological Sciences, among others. It created a strategic alliance with CRO ICON to expand innovation initiatives and decrease costs (Alsumidaie, 2012; OECD, 2012).

Perkmann and Salter (2012) made a research on how companies can have successful partnerships with universities. By taking into account two aspects, which are the expected time for collaboration and the level of secrecy of the partnership's outcomes, four models of university-industry collaboration can be observed: the idea lab, the grand challenge, the extended workbench, and deep exploration. The pharmaceutical industry has examples of two types of them: grand challenge and deep exploration.

The first type of collaboration present in the industry, the grand challenge, where companies and the academia gather to structure the innovation system and solve societal challenges. Deep exploration, on the other hand, is a longer-term partnership that seeks to solve fundamental challenges by focusing on new areas of expertise. One of its examples are the Pfizer-Scripps partnership, signed up in 2006. Pfizer made available \$100 million to Scripps Research Institute so as it has the right to license up to fifty per cent of Scripps' discoveries, providing that it shared royalties that might arise.

Pfizer also has initiatives for emerging markets: it has made alliances with Indian companies such as Aurobindo Pharma, Claris Life Sciences and Dr.

Reddy's Laboratories to develop new drugs (Unnikrishnan, 2011). Another example is the agreement between Pfizer and the Drugs for Neglected Diseases organization, which allows associate institutes to screen around 150 thousand compounds in Pfizer's library that would be applicable on the African sleeping sickness, visceral leishmaniasis, and Chagas disease (Witty, 2011).

ERDI works alongside the *Pfizer Venture Investment* (PVI) group and the Centers for Therapeutic Innovation (CTI) to engage on innovation initiatives both in research and in business. PVI is the venture capital branch of Pfizer, and the CTI are an open innovation network responsible for establishing partnerships with Academic Medical Centres (AMCs).

Pfizer Venture Investment

The PVI uses a \$50 million annual budget to invest on firms that are developing compounds and technologies that have the potential to improve Pfizer's pipeline in any phase of development. It supports new business structures, such as consortium-based technology development (Ablexis), product-out licensing (Clovis Oncology), business spin-offs (Zarco), as well as funds that help improving healthcare development in developing countries such as Brazil and China (Pfizer, 2013). Other initiatives made by the PVI can be pointed out as examples: it partnered with Zacharon Pharmaceuticals Inc. in 2011 to research on treatments for lysosome storage disorders and other rare diseases, the same reason for which it acquired FoldRx Pharmaceuticals in 2010. One of the companies PVI backed, Avid Radiopharmaceuticals Inc., was later sold to Eli Lilly, one of the companies analyzed in this thesis (Brian, 2011).

Centers for Therapeutic Innovation

The CTI seek to jointly discover and develop therapeutics with the Academic Medical Centres (AMC), giving full access to Pfizer's resources, including its technology. Their goal is to make the project reach Phase 1 of the clinical trial. The CTI are managed by a Joint Steering Committee (JSC) that has members from Pfizer and the AMC, and have equal say in the decision-making process

regarding the programs and initiatives (CTI, 2012). One of its most recent of the 21 alliances the CTI has in the United States is with the Children's Hospital of Philadelphia (CHOP), which aims at turning biomedical findings into new treatments (Pfizer, 2013). Other partners include: NYU Langone Medical Centre, Rockefeller University Hospital, Memorial Sloan-Kettering Cancer Centre, Mount Sinai Hospital, Columbia University Medical Centre, Albert Einstein College of Medicine, and Weill Cornell Medical College.

Pfizer's Annual Report of 2012 highlights some initiatives made for that year:

- Partnership Cystic Fibrosis Foundation Therapeutics (2012): non-profit drug discovery and development associated with the Cystic Fibrosis Foundation, has a program with Pfizer in the Pre-clinical research phase;
- Partnership with Duke University (2012): pre-clinical research with Duke University's Stedman Centre focused at understanding mechanisms related to human resistance to insulin;
- Partnership with Nodality (2012): use of Nodality's Single Cell Network Profiling (SNCP) technology as tool for development of drugs to treat autoimmune diseases, focus on clinical research;
- Partnership with Advance Clinical Electronic Research (2012): aimed at enhancing the use of electronic health records in clinical research;
- Creation of TransCelerate BioPharma (2012): non-profit consortium formed by pharmaceutical industry leaders, including Abbott and Eli Lilly, to accelerate the development of new medicines in the clinical research phases;
- Acquisition of NextWave Pharmaceuticals (2012): allowed Pfizer to gain exclusive rights of Quilivant XR in the United States

Another important action is the Enlight Biosciences consortia: a venture that seeks to identify and structure early R&D for promising leads and then licensing or selling them to the founding companies. Three of the four analysed companies are involved in this initiative: Pfizer, Merck, and Eli Lilly. It is (Getz, 2011).

Pfizer's open innovation initiatives cover the whole drug development pipeline, from the pre-clinical phase to registration and commercialization. It is specifically active in the most extended phase, the clinical one, where it went further and created a 100% virtual clinical trial "REMOTE" in 2011 alongside the FDA (Food and Drugs Association). Its success has made Pfizer decide to use this model in future processes (Alsumidaie, 2012).

When we confront the information gathered from Pfizer with the variables of the OI frameworks, it is possible to identify that the company adopts a rather opened innovation strategy. It presents a high level of collaboration in all phases of the drug discovery pipeline (phase variety) as more than 800 partnerships with organizations from various backgrounds (partner variety), which are the variables considered in the Lazzarotti-Manzini framework.

In addition, Pfizer also engages on both inbound and outbound open innovation, represented by the variables of technology acquisition and technology exploitation variables from Lichtenthaler. Even though it is much more active in the inbound aspect, it has outbound initiatives, such as the sale of capsule drugs maker Capsugel to private equity firm Kohlberg Kravis Roberts & Co. in 2011. It also has showed the intention to sell or spin off its nutrition and animal-health businesses (Brian, 2011).

4.1.2 Merck

Merck has identified the need to create an innovation culture nurtured by the interaction between internal and external partners, and it has been adapting its innovation strategy accordingly (Drakulich, 2012). Partnerships became more and more important, and are currently a fundamental part of the company's strategy. It currently spends around \$8 billion per year on R&D initiatives, which traditionally consist mainly on venture funding. Merck has made several acquisitions, being the most important Schering-Plough for \$47billion (Alsumidaie, 2012). Sanofi Pasteur and Merck have created an equitable-owned joint venture in 1994 to develop and market vaccines across Europe, which it is now one of the leading vaccine institutions worldwide (Merck, 2009).

Venture funding, which is the most important branch of Merck's innovation strategy, features several initiatives and substantial investments. Only in 2011, the company has budgeted over \$750 million in venture capital to funds in order to develop businesses in early-stage life sciences technology, including the initiatives undertaken by the Merck Research Venture Fund. Merck has created other organizations, such as the Global Health Innovation Fund (GHIF), which focuses on firms specialized in diagnostic and related services, and Merck BioVentures, responsible for the development and manufacturing collaborations. One of the undertakings of the GHIF was Remedy Informatics Inc., which develops and provides medical-research software to several academic medical centres and pharmaceutical companies (Timothy, 2012).

Merck has also created a joint venture with Sun Pharmaceutical Industries, an important Indian multinational pharmaceutical company, to develop, produce and commercialize innovative branded generics in emerging markets (Journal of India, 2011). With a considerable focus on the emerging markets, Merck also created joint ventures with Brazilian Supera Farma and Chinese Simcere. It has created Hilleman Laboratories, a joint venture created with Indian Wellcome Trust (Witt, 2011). Merck's venture capital strategy is targeted at advancing to Phase 3 of the drug development pipeline where it can be a first mover at the moment the originator product has its patent expired (Business Wire, 2011; Udayan, 2011).

However, the results of these initiatives show some flaws. In 2001, Merck bought Rosetta Inpharmatics for \$620 million, which was disincorporated seven years later (Udayan, 2011). These flaws are one of the reasons why Merck has decided to expand its approach in open innovation. In 2012, it created a \$90 million worth alliance with non-profit drug research centre Calibr to start operations in La Jolla's Torrey Pines Mesa area, a major hub of scientists do research on life science at the early-stage phase. Because of this alliance, it can opt to have exclusive commercial license to any small-molecule therapeutic candidates or proteins created by Calibr. Pfizer is also operating in the hub through \$50 million collaboration with scientists from UC San Diego Health Sciences (Kelly, 2012).

Another important aspect of Merck's innovation strategy is its partnerships with academic institutions, which represent over 30% of its major licensing deals. If one considers all types of transactions, the interactions with academia reach the thousands. This type of partnership usually focuses on early stage research and the first stages of clinical trial. One significant example is the partnership made by Merck and nine universities in 2011, which focuses on research that might lead to the eradication of HIV. Another example is the alliance made in 2012 with Novo Nordisk Foundation Centre for Basic Metabolic Research at the University of Copenhagen. In the same year, the firm created the Merck Initiative for New Targets (MINT), which will further facilitate two-way collaborations with academic groups (Demain, 2012).

Regarding the Perkmann and Salter (2012) model of collaborations, which has already been cited before, Merck has an important initiative in the Grand Challenge type of collaboration. This type of partnership seeks to structure the innovation system and solve societal challenges. Alongside GlaxoSmithKline and Novartis, it has founded the Structural Genomics Consortium, which focuses on early research on proteins applicable in drug development, at the pre-clinical and first phase of the drug development pipeline.

Merck also has important collaborations with other pharmaceutical companies, ranging from small laboratories to large multinationals. In 2008, Merck and Orchid Research Laboratories started collaborating so as to share risks and benefit from innovative research that is being made in emerging markets. Another very important partnership is the one between Merck and AstraZeneca, which began in 1994, when Merck and Astra formed a joint venture to develop and market Astra's new products. Their most recent agreement was signed in 2009, in order to conduct early-stage trials of the companies' cancer drugs. This partnership has won the Scrip Award for "Best Partnership Alliance" in 2010. The Scrip Awards are one of the most prestigious awards in the pharmaceutical and biotechnology sector. Another example of partnership: the one with Alectos, a Canadian biopharmaceutical company that develops new small molecule therapeutics (Merck, 2010).

Merck is recognized in the industry for being the best pharmaceutical partner, according to a survey made by the Boston Consulting Group in 2010. Currently, Merck has over 80 partnerships with companies in 15 different countries and nine research fields, including vaccines, biologics and research and enabling technologies (Merck website). Merck has won other awards for the Excellency of its partnership: it has won the Scrip award in 2010, as mentioned above, and Deloitte Recap's ALLICENSE 2013 Breakthrough Award for the company's collaboration with German biotechnology company AiCuris, signed in 2012, which allowed Merck to develop and market AiCuri's portfolio of investigational drugs that target the human cytomegalovirus (Merck, 2013).

In 2012, Merck closed 61 significant deals, making the year the most successful in terms of licensing. In the first two months of 2013, Merck had already made new deals with Adimab, Lycera, Samsung Bioepis and Luminex Corporation. In 2013, Merck has already raised \$20 million to PatientSafe Solutions, which will be used to increase the performance and adoption of mobile solutions related to the health system and clinical efficiency (Global Data, 2013).

Regarding the variables considered in the Lichtenthaler framework, Merck presents an average level of OI adoption: even though it has several initiatives regarding external technology acquisition, given its energetic focus on venture capital, it does not show significant initiatives with regard to exploiting its innovation products.

As for the Lazzarotti-Manzini framework, Merck shows a high level of open innovation: even though its partners are not very diverse, they are present in every stage of the drug development pipeline. In addition, given its commitment to make its partnerships successful, which has resulted in several awards, even a limited amount of partner variety is believed to yield superior results.

4.1.3 Abbott Laboratories

Abbott's commitment to open innovation can be evidenced by the creation of the Acquired In-Process and Collaborations Research and Development (IPR&D) sector. Some of these initiatives, as well as companies and technology acquisitions are detailed in the 2012 Annual Report:

- Acquisition of Piramal Healthcare Solution, leader in the Indian branded generics market, for \$3.8 billion (2010);
- Acquisition of Belgian Solvay's pharmaceutical business for \$6.1 billion, which further increases its position in emerging markets (2010);
- Acquisition of STARLIMS Technologies for \$100 million, allowing Abbott to increase its operation and know-how in laboratory informatics (2010)
- Acquisition of Facet Biotech Corporation for \$430 million, allowing Abbott to improve its clinical research pipeline (2010)
- Collaboration with Biotest AG to develop and market a treatment for psoriasis and rheumatoid arthritis for \$85 million (2011)
- Collaboration with Neurocrine Biosciences to develop and market a drug to treat endometriosis for \$75 million (2010)
- Abbott IPR&D projects:
 - o Acquisition of drug AP214, drug under development for use on cardiac surgeries, for \$110 million (2012);
 - o Collaboration to develop and market JAK1 inhibitor (phase 1), for \$150 million (2012);
 - o Partnerships with Reata Pharmaceuticals: IPR&D collaboration of \$400 million to develop oral antioxidant inflammation modulator (2011), IPR&D acquisition of \$238 million licensing rights of bardoxolone methyl, used for treating chronic kidney disease, outside the United States (2010), and acquisition of Reata equity interests of \$124 million in 2010 and 2011;

Abbott's engagement on innovation led to the creation of biopharmaceutical firm AbbVie, which focuses on research and development of advanced therapies (AbbVie, 2013). AbbVie is responsible for several collaborations; all

of them focused on clinical phases 2 and 3. Its most recent initiatives are:

- Acquisition of Facet Biotech Corporation in 2010: \$430 million expense, allowed AbbVie to improve its early and mid-stage pipeline
- Galapagos (2012): phase 2, research on drugs that treat autoimmune diseases
- Alvine Pharmaceuticals: phase 2, focus on developing a new treatment for celiac disease;
- Bristol-Myers-Squibb: phase 2, research of elotuzumab on patients with multiple myeloma
- Biogen: phase 3, research on daclizumab for weakening multiple sclerosis
- Collaboration with Seattle Genetics (2012): \$28 million, development of Antibody-Drug Conjugate, clinical phases
- IPR&D Projects:
 - o Acquisition of ABT-719 from Action Pharma in 2012 for US\$110 million IPR&D expense
 - o Licensing of CKD for US\$238 million in 2010 and \$188 million in 2011

The analysis of Abbott's innovation initiatives from the spectrum of Lichtenthaler's framework shows an average level of openness: it is considerably engaged on external technology acquisition, which can be explicitly observed by the fact that it created a company (AbbVie) to focus on such initiatives, as well as its IPR&D sector. However, regarding technology exportation, it shows a low degree of commitment. The most significant activity from this aspect was the launch of GAIN, which seeks to make available to the public genome studies for six ordinary diseases (Attention Deficit Hyperactivity Disorder, diabetic nephropathy, major depression, psoriasis, schizophrenia and bipolar disorder) (OECD, 2012).

In relation to the Lazzarotti-Manzini framework, Abbott's level of innovation openness is relevant: it has a reasonable coverage of the drug development pipeline, with Abbott covering phase 1 and commercialization, and AbbVie covering phases 2 and 3 of the clinical trial, even though the pre-clinical

phase is not cited. With regard to partner variety, it was considered to be average; it is largely focused on mid-size and large pharmaceutical companies, leaving the valuable academic partnerships aside.

4.1.4 Eli Lilly

By the end of 2012, Eli Lilly had about 7.700 employees working in R&D activities. Its R&D expenses were \$5.28 billion in 2012, \$5.02 billion in 2011, and \$4.88 billion in 2010. Even though it has a robust internal R&D structure, Eli Lilly recurs to outside knowledge to supplement its innovation initiatives, collaborating with educational organizations, as well as pharmaceutical and biotechnology firms. Eli Lilly was one of the pioneers in the solver communities, in which large corporations; institutions and governments publish research challenges to be solved by an international community of individuals. It created InnoCentive, launched in 2005 as a spin-off of the company. This virtual market currently adds up to 250 thousand individuals, among which several researchers from over 200 countries, and over 30% have a PhD (Pisano & Verganti, 2008).

Alongside the other research participants, Eli Lilly is also active with regard to venture funding, having created Lilly Ventures, which focuses on biotechnology and medical technology. It currently has US\$200 million invested in twenty-four investments, among which, InnoCentive (Lilly Ventures website). Other four companies supported by Lilly Ventures have become independent or have been acquired by other companies. Eli Lilly has also founded Lilly Asia Ventures, which operates mainly in China, in the life sciences and healthcare industries, and currently has twelve companies in its portfolio (Lilly Asia website).

In 2010, Eli Lilly has made two significant acquisitions related to pipeline drug development: Alnara (protein therapeutics for the treatment of metabolic diseases) and Avid (molecular radiopharmaceutical tracers in PET scan imaging), for \$291.7 million and \$346.1 million, respectively (Eli Lilly, 2013).

More recently, it has engaged on several collaborations, which are highlighted in Eli Lilly's 2012 Annual Report:

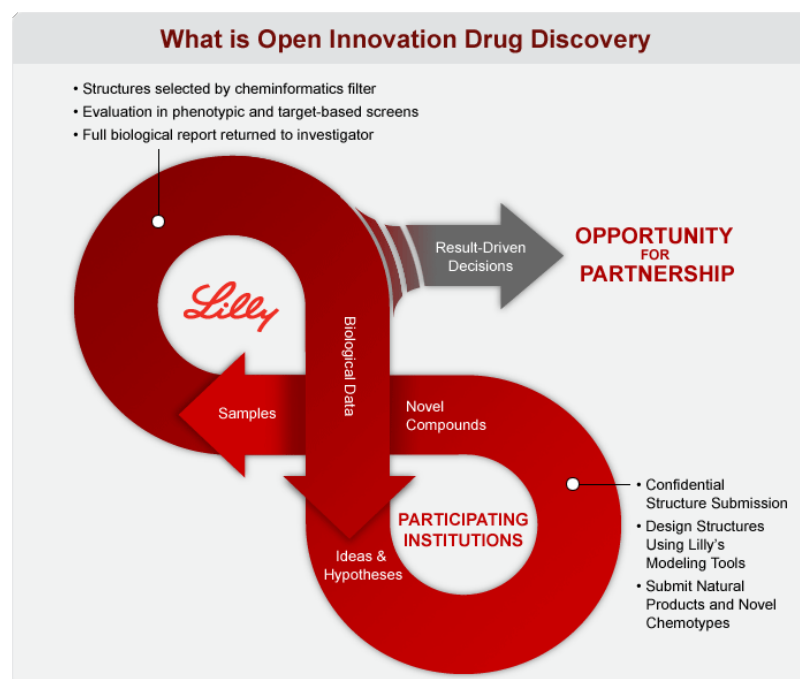
- Collaboration with Boehringer Ingelheim in the field of diabetes, which resulted in a \$388 million IPR&D expense (Eli Lilly Annual Report 2012). There was another agreement with Boehringer to develop and market Cymbalta outside the U.S. and Japan, but it was terminated at the end of 2012.
- Collaboration with Bristol-Myers Squibb Company (BMS) to develop Erbitux (treatment of tumours) in the U.S., Canada and Japan, at the clinical phases. There was another agreement with BMS to develop and market Necitumumab in Phase 3, but it was terminated in the last quarter of 2012;
- Collaboration with Merck to develop Eribtux in Japan, at the clinical phases;
- Collaboration with Daiichi Sankyo Corporation to develop and market Effient;
- Collaboration and licensing agreement with Incyte Corporation to develop and market Incyte's JAK inhibitor compound used for the treatment of autoimmune diseases. The cost of the agreement was of \$515 million;

One of the company's major corporate responsibilities is to improve health for people in need, especially in developing nations. Its effort is reflected in the creation of programs that aim to create collaborations to fight the non-communicable diseases in emerging countries. The first is the Lilly MDR-TB Partnership, launched in 2003, aims to address multi-drug resistant tuberculosis in poor regions. It is receiving a \$120 million contribution from Eli Lilly, which has also share the technology behind its initiatives with pharmaceutical companies from developing countries, such as Aspen Pharmacare in South Africa and Hisun Pharmaceutical in China. An extra \$15 million was provided to the Lilly TB Drug Discovery Initiative, a non-profit branch that seeks to accelerate the discovery of novel drugs to treat TB by relying on researchers from around the world (Eli Lilly, 2010).

An additional program created to improve health in developing nations is the Lilly NCD Partnership, which focuses on the diabetes field. Lilly intends to invest \$30 million over the next five years, to support agreements in four developing countries. It has already partnered with Public Health Foundation of India, Population Services International, and Project Hope in India, Carlos Slim Health Institute in Mexico, Donald Woods Foundation and Project Hope in South Africa, and it is currently defining its alliances in Brazil (Eli Lilly, 2011).

Finally, other important initiatives in the field of open innovation are the Phenotypic Drug Discovery and the Target Drug Discovery, which aim at developing compounds. Together, they cover the completely pre-clinical and clinical phases of the drug development pipeline (Open Innovation Drug Discovery Website). They are the materialization of Eli Lilly's commitment to become a part of a Fully Integrated Pharmaceutical Network (FIPNet), which has been pursued by expanding its level of collaborative research with several different partners, such as institutes, biotech and universities. This process is depicted below.

Figure 7: Lilly's Open Innovation Drug Discovery process.



Source: Open Innovation Drug Discovery Website

When Eli Lilly's open innovation strategy is confronted with both Lichtenthaler's and Lazzarotti-Manzini frameworks, it shows a high level of openness. At the same time it covers all drug development pipeline by engaging on collaborations with partners from several backgrounds, it has a wide array of acquisitions and venture investments, some of which are exported to the external market.

The next session shows a summary of the exploratory research and places the participants within the frameworks elected for the study.

4.2. Research results

The analysis of the companies' innovation strategy and their level of openness resulted in the following charts:

Table 2: Lichtenthaler Framework – Results.

Company/ Variable	LICHTENTHALER FRAMEWORK	
	External Technology Exploitation	External Technology Acquisition
Pfizer	Sale of Capsugel and Avid Radiopharmaceuticals Inc, expected sale/spin-off of nutrition and animal-health businesses	PVI with a US\$50MM annual budget, acquisition of NextWave Pharmaceuticals, creation of TransCelerate Biopharma and Enlight Biosciences, US\$50MM hub with UC San Diego
Merck	61 licensing deals in 2012	Venture funding of over US\$750MM only in 2011, Acquisition of Schering-Plough, GHIF, Merck BioVentures, Sanofi-Merck vaccines joint venture, joint ventures with companies from three developing countries, US\$90MM Calibr research center
Abbott Labs	Licensing of CKD in 2010 and 2011, GAIN launch	Several acquisitions, creation of AbbVie
Eli Lilly	Four Lilly Venture investments sold	Lilly Ventures with US\$200MM invested and 24 companies, Lilly Asia Ventures, acquisition of Alnara, Avid

Source: own elaboration

Table 3: Lazzarotti-Manzini Framework – Results.

Company/ Variable	LAZZAROTTI-MANZINI FRAMEWORK	
	Partner Variety	Innovation Phase Variety
Pfizer	800 alliances with organization from diverse backgrounds, CTI	OI initiatives in all phases of the drug development pipeline
Merck	80 alliances with organizations from diverse backgrounds, recognized as the best pharmaceutical partner in 2010	OI initiatives in all phases of the drug development pipeline
Abbott Labs	Collaborations with Biotest AG, Neurocrine Biosciences, JAK1, Reata Pharmaceuticals, Seattle Genetics, Bristol-Myers-Squibb, Biogen. No academic partnerships	OI initiatives in the clinical phases and commercialization; no initiatives in the pre-clinical phase
Eli Lilly	Collaborations with Behringer Ingelheim, Bristol-Myers-Squibb, Merck, Daiichi Sankyo, Incyte. Lilly US\$120MM MDR-TB Partnership, Lilly US\$30MM NCD Partnership, Lilly US\$15MM TB Drug Discovery Partnership, Phenotypic Drug Discovery, and Target Drug Discovery	OI initiatives in all phases of the drug development pipeline

Source: own elaboration

The exploratory research of the firms' innovation strategy led to the results depicted above. These classifications are used next to place the participants within the frameworks.

In the Lichtenthaler Framework, firms with a strong or very strong classification in both variables belong to cluster 6. These are: Merck and Eli Lilly. Companies that have a strong/very strong level in one variable and are classified as "average" in the other variable belong to clusters 3 or 4, according to their inclination towards a higher level of technology acquisition (Pfizer and Abbott Laboratories) or technology exploitation, respectively.

In the Lazzarotti-Manzini-Pellegrini Framework, firms with a strong or very strong classification in both variables belong to the "open innovators" cluster (Pfizer, Merck, and Eli Lilly). Companies that have a strong/very strong level in one variable and are classified as "average" in the other variable belong to the "integrated collaborators" cluster (Abbott Laboratories) or the "specialized

collaborators” cluster, according to their inclination towards a higher level of phase variety or partner variety, respectively.

Table 4: Open Innovation Classification

Companies	Lichtenthaler Framework	Lazzarotti-Manzini Framework
Pfizer	Cluster 3	“Open Innovator”
Merck	Cluster 6	“Open Innovator”
Abbott	Cluster 3	“Integrated Collaborator”
Eli Lilly	Cluster 6	“Open Innovator”

Source: own elaboration

Taking the Lichtenthaler framework, all companies follow the open innovation paradigm. However, Pfizer, and Abbott are classified as “balanced innovators” (Cluster 3), while Merck and Eli Lilly belongs to cluster 6, of “open innovators”. Regarding the Lazzarotti-Manzini framework, three companies show a higher engagement to open innovation: Pfizer, Merck, and Eli Lilly. As Abbott has a lowest level of partner variety, it is classified as an integrated collaborator.

Thus, both Eli Lilly and Merck have an innovation strategy that is most targeted at open innovation, as they are placed in the clusters that relate to the most engaged level of OI adoption. Next, Pfizer is classified as an “Open Innovator” in the Lazzarotti-Manzini-Pellegrini framework, but its classification in the Lichtenthaler Framework indicates that it has still not fully explored the benefits of outbound innovation. The company that shows the lowest level innovation openness is Abbott; it is placed in the same cluster as Pfizer in Lichtenthaler. In addition, it is the only participant that is not considered an “Open Innovator”, but an “Integrated Collaborator” in the Lazzarotti-Manzini-Pellegrini framework, given its limited variety of partners with regard to both type and number.

The analysis showed that multinational pharmaceutical companies do have a high degree of open innovation, as all the participants showed important

initiatives, especially in terms of collaborations, present in all the drug development pipeline, and external acquisitions, evidenced by the creation of companies that specifically focus on venturing. This is consistent with previous literature, which indicates that this industry is going towards a more integrated mode of innovation. Eli Lilly makes it evident that its current strategy is targeted at being fully adapted to the pharmaceutical innovation network (FIPNet).

The next section concludes the analysis by relating it with the proposition posited at the beginning of the thesis. It is succeeded by the indication of the limitations of the research as well as possibilities for future research on the topic.

5. Conclusion

The focus of the paper was to discuss how the four largest pharmaceutical companies in the U.S. implement OI using two different frameworks. Previous studies have discussed how open innovation is being currently applied (Huizing, 2011). However, there is still limited literature on exploratory studies focusing on a specific industry.

Following the suggestion of previous research, this paper aimed at helping to address this gap on literature, by making an analysis that seeks to show better understanding of the application of OI in a specific industry, the pharmaceutical one. As it was described in the methodology, this study used the Forbes' ranking that indicated the four largest pharmaceutical companies from the U.S., which follow the traditional strategic model of this sector, based on the launch of blockbuster drugs. The analysis used two frameworks that evaluate both inbound and outbound open innovation, as well as collaboration intensiveness and OI reach throughout the innovation process. They were applied through a qualitative evaluation of each participant's innovation strategy, in order to determine the level of innovation openness of the participants, which were placed within the frameworks accordingly.

The proposition presented at the beginning of the paper was to evaluate the innovation strategy of four pharmaceutical companies using two frameworks. The research allowed a better understanding of how OI is currently being applied in the pharmaceutical industry. It is an evidence of what has been pointed by Lichtenthaler in his 2008 study, that open innovation is currently being led by larger companies, and that the pharmaceutical companies of the sample do present a high classification in the variables pointed by the author, which cover both inbound and outbound innovation.

The open innovation field still has room for further studies: this study can be a first step for defining more clearly the specificities of OI strategy and how it impacts on company performance, both in terms of innovation output as well as in financial terms.

However, it is important to highlight there are several factors that can influence the results of such analysis, such as the small targeted sample and the choice of variables. The next section discusses the limitations of the study, and possibilities for future research.

6. Limitations and future research

This thesis attempted to add to current innovation literature by making an exploratory analysis that evaluates the level of openness of firms' innovation strategy within the same industry. It aimed at considering the different aspects of OI adoption and how firms with resembling profiles adopt them. However, some limitations can be pointed. The analysis focused on only one industry, the pharmaceutical industry, and more specifically, on large north-American multinationals that follow the traditional model of the sector. This means that if the same analysis was made in other industries or firm strategy, the results could be different.

This study aimed at considering all aspects of an open innovation strategy by adding inbound and outbound initiatives and their presence throughout the innovation process. However, even though the frameworks that were applied to evaluate OI were comprehensive in this sense, it is also possible to analyse the innovation strategy by using different variables. Some of those variables are: the type of network the firm is involved in, the profile of the researchers, the innovation pattern, and the innovation process itself, among others (Enkel, Bell & Hogenkamp, 2011; Whitley, 2002). The different choice of variables could also lead to different conclusions.

Nevertheless, this research adds to open innovation, as it is analysis of OI between firms with similar background, which has been insufficiently approached in previous works.

This study also opens up to wide opportunities for future research. The next step could be analysing the relationship between the level of OI adoption and its impact on the company's financial performance, both within industries and across them. A possible outcome of future research could lead to the identification of best practices of open innovation strategy according to the industry, and company profile and the context it faces, which could enhance its financial and innovation performance.

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