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Open innovation theory: Definition, instruments, frameworks

L.S. Orlova¹¹ Financial University under the Government of the Russian Federation

ABSTRACT

Today flexibility is becoming one of the most important capability in business, because the product life cycle is reduced, the external environment of organizations is constantly changing, technologies are improving every day. In such circumstances, companies cannot afford to develop technologies exclusively in R&D departments in their companies; this is unproductive, inefficient and expensive. Companies “opened” their innovation processes to improve their innovation potential. The relevance of this work is due to the great interest of both the scientific community and practitioners in the instruments and strategies needed for successful adoption of the theory of open innovation.

The objective of this study is to provide a comprehensive review of the progress on open innovation literature reflecting the most essential topics to be covered in future research. This survey study makes a significant contribution to the research of the open innovation theory. The article offers a detailed overview of the various views and studies related to this topic. The evolution in the field of research of open innovation theory is presented here. The article is structured as follows: the link between open innovation and other theories in management, the adoption of open innovation paradigm in different industries, the influence of adopting the open innovation theory on the business, criticism of the open innovation theory, researches studying open innovation theory conducted in Russia, classification of frameworks in the open innovation theory. This article describes the state of open innovation at the intersection of research, practice, and policy.

In addition, this work focuses on the most cited publications of the most cited scientists, as well as on the work of the last two to three years. We combine bibliographic analysis of all papers on the topic published in Scopus database with a systematic content analysis of the field to develop a deeper understanding of earlier work.

KEYWORDS:

open innovation, innovation management, Chesbrough.

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Концепция открытых инноваций: понятие, инструменты и эффективность их применения

Л.С. Орлова¹

¹ Финансовый университет при Правительстве Российской Федерации

АННОТАЦИЯ

На сегодняшний день гибкость становится одной из важнейших характеристик любого бизнеса, поскольку жизненный цикл продукта сокращается, внешняя среда организаций постоянно меняется, технологии совершенствуются с каждым днем. В таких обстоятельствах компании не могут позволить себе разрабатывать технологии исключительно в отделах исследований и разработок в своих компаниях; это непродуктивно, неэффективно и дорого. Компании «открыли» свои инновационные процессы для повышения своего инновационного потенциала и повышения результативности инновационной деятельности. Актуальность этой работы обусловлена большим интересом как научного сообщества, так и практиков к инструментам открытых инноваций. В работе на основе анализа статей в международных журналах рассматривается проблематика развития теории открытых инноваций и условий и факторов эффективности применения ее инструментов. В работе структурированы исследования теории открытых инноваций: связь между открытыми инновациями и другими теориями в управлении, внедрение парадигмы открытых инноваций в различных отраслях промышленности, влияние принятия теории открытых инноваций на бизнес, критика теории открытых инноваций, исследования, изучающие теорию открытых инноваций, проводимые в России. Кроме того, эта работа посвящена наиболее цитируемым публикациям наиболее цитируемых ученых и другим исследованиям последних двух-трех лет. Мы объединяем библиографический анализ всех работ по этой теме, опубликованных в базе данных Scopus, с систематическим анализом содержания этого направления исследований, чтобы развить более глубокое понимание предыдущих исследований.

Приведены примеры классификации основных моделей в теории открытых инноваций. Сформулированы перспективные направления будущих исследований.

КЛЮЧЕВЫЕ СЛОВА:

открытые инновации, управление инновациями, Чесброу, классификация инноваций.

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1. INTRODUCTION

The term “open innovation” was coined by Henry Chesbrough in 2003. To this day, he is one of the main researchers on this topic. His first definition of open innovation was as follows: “Open Innovation is 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. Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model.” In his next work, this concept was expanded: “Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. <This paradigm> assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology.” Later in 2014, in response to the growing interest in intangible flows of knowledge, the definition of 2006 was expanded as follows: we define open innovation as a distributed innovation process based on purposefully managed knowledge that crosses organizational boundaries using tangible and intangible mechanisms in accordance with business -model of the organization.

The book “Open Innovation,” aimed at the audience of managers, was intended to change practice, helping firms go beyond both creating and commercializing innovation. For many practitioners, the concept of open innovation has given them a new language to talk about the nature of R&D, helping to shift the dominant R&D logic from internal discoveries to external interaction. It also helped encourage business leaders to experiment with a range of new models to create and commercialize innovation. Innovation scientists have also adopted this concept. It spawned conferences, numerous books,

Table 1
Number of articles for the period from 2001 to 2019.

Year	Number of articles	Year	Number of articles	Year	Number of articles
2001	1	2009	49	2017	194
2002	1	2010	116	2018	219
2003	2	2011	121	2019	152
2004	5	2012	130	2020	1
2005	8	2013	137		
2006	5	2014	164		
2007	18	2015	164		
2008	33	2016	179		

Source: compiled by the author.

and hundreds of articles. As a result of this interest, governments are also increasingly trying to redirect their political framework towards open innovation.

Interest in the topic of “open innovation” is only increasing. This conclusion can be made by examining the number of references to the phrase “open innovation” in the Scopus database (see table 1).

In addition to the impressive number of articles the interest of the scientific community in this topic is indicated by the number of citations of the most influential articles (see table 2).

The Open Innovation paradigm is being studied by scientific communities in almost all countries of the world. The relevance of this study is indicated by the fact that Russia is not on the list of countries actively publishing on this topic (table 3).

Understanding the need to seek innovation outside the enterprise was before Chesbrough. The concept of the absorptive

Table 2
The most influential articles (sorted by total number of citations for all time)

	Article	Total number of citations	Average number of citations a year (2015-2019)
1	How open is innovation?	1009	141.6
2	Open innovation in SMEs: Trends, motives and management challenges	852	118
3	Open innovation: State of the art and future perspectives	716	108.2
4	Leveraging external sources of innovation: A review of research on open innovation	522	101.2
5	Open innovation in SMEs-An intermediated network model	522	75.8
6	Innovation contests, open innovation, and multiagent problem solving	396	51
7	Modeling a paradigm shift: From producer innovation to user and open collaborative innovation	365	58.4
8	The industrial dynamics of Open Innovation - Evidence from the transformation of consumer electronics	343	30.2
9	Open innovation in practice: An analysis of strategic approaches to technology transactions	313	27.2
10	Managing open innovation	285	24.8
11	The rest	23985	3560

Source: compiled by the author.

Table 3
Number of studies in countries

Number of articles by countries		
Country	Number of articles	Share in total, %
USA	204	12
Germany	179	10,5
Italy	177	10,4
China	166	9,8
Great Britain	164	9,7
Spain	119	7
Finland	83	4,9
South Korea	74	4,4
Sweden	74	4,4
France	66	3,9

Source: it is made by the author.

capacity of Wesley M. Cohen and Daniel A. Levinthal [Cohen, Levinthal, 1990] concerned the special competence that companies are developing by having an R&D department. They are using it not only for managing internal innovations, but also in order to be able to receive and use external ideas, science and other types of knowledge invested in innovations. Rosenberg, Lundwall, Pavitt, and von Hippel, among others, examined the interactive, interdisciplinary, and interorganizational nature of innovative learning.

Traditional R&D views suggest that successful innovation requires control; this assumption is the main idea of the old closed innovation paradigm [Трачук, Линдер, 2017]. Within this paradigm, the competitive advantage is due to the unique knowledge that firms protect as exclusive intellectual property. Firms intentionally limit and strictly control the flow of information across organizational boundaries. Cross-border activities are accompanied by comprehensive contracts or limited to long-standing partnerships. In contrast, Chesbrough's conceptualization of the innovation funnel divides the sources of innovation, new product development and commercialization, believing that firms increase innovation efficiency by acquiring and commercializing innovation in a wider external innovation network.

Chesbrough compares "closed innovation" with a game of chess, where the most important skill is to count a few steps forward, while the paradigm of "open innovation" is a game of poker, management needs to constantly adapt to new technologies, new information, new opportunities to compete.

2. THE LINK BETWEEN OPEN INNOVATION AND OTHER THEORIES IN MANAGEMENT

Since its inception, open innovation has had strong links with a resource theory at the company, as well as with the prospect of dynamic opportunities associated with it. For example,

[Teece, 2007] pointed to open innovation in his discussion of dynamic opportunities that allows firms to "sense" and "exploit" opportunities. Other scholars have emphasized the link between open innovation and the theory of resource dependence Alexi et al., 2013]. In addition, there are close (and often researched) links between open innovation and research about absorptive capacity [Spithoven et al., 2011; West, Bogers, 2016]. Researchers Jens Christensen and Michael Olesen studied the concept of open innovation in the perspective of industrial dynamics [Christensen et al., 2005]. They examined how differently positioned commercial players in the industry innovation system use different innovative strategies to use a technological paradigm characterized by a rich set of capabilities and a complex and distributed knowledge base. In this context, open innovation implies that firms will depend on critical external knowledge to successfully implement their innovation efforts. The main point of this article is that the specific ways of managing open innovation in various companies in relation to emerging technology reflect their different position in the considered innovation system and stage of maturity of the technology, as well as their choice of value proposition.

Researchers Joel West and Karim Lakhani were the first to study the relationship between two theories of innovation: open innovation and community theory, recognizing the role of communities outside the boundaries of companies in the creation, formation and diffusion of technological and social innovations [West, Lakhani, 2008]. By "community" is meant "a group of autonomously operating firms that agree to be bound by the limitations of a standard."

Limitations on the use of the "open innovation" paradigm in their work have been pointed out by Christian Terwiesch and Yi Xu [Terwiesch, Xu, 2008]. They described situations with a competition for the development of innovations in which one firm (seeker) faced with a problem related to innovations (for example, the technical problem of R&D) publishes this problem among many independent agents (solvers), and then provides a reward to the agent who created the best solution. Unlike internal innovations, solvers participating in open innovation contests should fear that their efforts to solve problems may not be financially rewarded. The seeker who organizes the innovation competition should be aware of this effect and develop a reward system taking into account the type of innovation problem.

Belgian researchers André Spithoven, Bart Clarysse, Mirjam Knockaert investigated the relationship between the ability to absorb information and the paradigm of "open innovation" [Spithoven et al., 2011]. For large firms intensively engaged in research and development, the concept of open innovation in terms of absorptive capacity is relatively well understood. Little attention is however paid to how small firms and companies operating in traditional sectors participate in open innovation activities. They often have a very low level of absorptive capacity or it is completely absent. SMEs and firms in traditional industries may need assistance in building up development capacity. Researchers have proposed the creation of collective research centers to build the capacity to harness innovation at the interorganizational level. The technology intermediaries are created to help firms take advantage of technology developments.

3. OPEN INNOVATION PARADIGM IN DIFFERENT INDUSTRIES

One of the first to study the application of the “open innovation” paradigm in practice was Robert Kirschbaum, vice president of Danish coal mining company DSM. Back in 2000, a special department was created in this company, which selected projects and ideas into which the company should or should not invest. These ideas come from both inside and outside – from other companies, universities or research institutes. Only some of these ideas will be of interest to DSM, and they will be explored in more detail.

Researchers Vareska Van de Vrande and coauthors, based on a survey of 605 representatives of small and medium-sized businesses in the Netherlands, examined the prevalence of the open innovation paradigm in this segment of the business [Van de Vrande et al., 2009]. The result of this study was the conclusion that small and medium-sized enterprises are involved in many practices of open innovation and are increasingly applying such practices over the past seven years. In addition, we do not see significant differences between production and the service sector, but medium-sized firms are more actively involved in open innovation than their smaller colleagues. In addition, we find that SMEs seek open innovation, primarily for market reasons, such as customer satisfaction or competitiveness [Trachuk, Linder, 2014].

Korean researchers Sungjoo Lee and coauthors studied the impact of the “open innovation” paradigm on the innovation activities of small and medium-sized enterprises [Lee et al., 2020]. The results of the study confirm the potential of open innovation for SMEs and indicate that the creation of networks is one of the effective ways to promote open innovation among SMEs. Based on the fact that commercialization after the invention is important for innovation and that SMEs are good at inventing, but do not have sufficient resources for commercialization, they suggest that one of the ways to stimulate open innovation in SMEs is to work with other firms at the commercialization stage.

Italian researchers Cristina Marullo and coauthors studied the impact of open innovation on startups. In their study they relied on a sample of 134 business plans submitted for the final round of the INTEL Global Challenge at the University of California at Berkeley [Marullo et al., 2018]. It emphasizes the relevance of teams' ability to combine and transform their initial resources through the search for open innovation.

Chinese researchers Samwell Chege and Daoping Wang in their article examined 150 agricultural enterprises and came to the conclusion that, although OI brings many advantages for agribusiness through various applications; its implementation in rural areas is a problem that limits business growth [Chege, Wang, 2019]. Therefore, government policies and support programs should promote OI in terms of infrastructure and resources to stimulate economic development and food security. In addition, public policy should be aimed at promoting various forms of technical skills and financial incentives for SMEs. This may be related to issues of training and promoting the OI process as a necessary condition for the development of internal capabilities. In addition, there is a need to strengthen the link between research institutes and SMEs.

A multifaceted approach to the integration of internal factors (internal capabilities) and external partners should be expanded as the basis for external information. There is a need for continuous

interaction, which entails interactive processes of mutual learning with feedback, which is also transmitted from the end user to partners [Trachuk, Linder, 2018]. In addition, entrepreneurs should promote the creation of new tools to measure the degree of openness of innovation through the use of knowledge and ideas of external partners. This cooperation can be enhanced through conferences, consortia, symposia and consultations from various industries and academia. This aspect of cooperation and partnerships can be useful in stimulating innovation in SMEs, especially in a growing business environment that is competitive in the global market.

The first work that defines the strategic approaches of firms to technological transactions as part of the innovation process was the one of Ulrich and Eckhard Lichtenthaler [Lichtenthaler, Lichtenthaler., 2009]. The study led to some unexpected results. Although the size of the firm has a strong positive effect on the degree of openness, the industry of the firm does not have a significant effect. Thus, the degree of openness of the innovation process is mainly determined by the individual decision of the company, and not by industry characteristics. Since only a small group of firms adhered to an extremely open approach in 2009, the data confirm the view that the trend towards open innovation is driven by innovative firms, while other companies still adhere to a relatively closed strategy.

Andrea Mina et al. measure the decisions of companies in the insufficiently studied, but developing area of open innovation – the service sector [Mina et al., 2014]. In particular, based on a survey of about 800 British firms, they examine how manufacturing and service firms differ in using 14 different approaches to open collaboration in the field of innovation, more common among high-tech manufacturers, in contrast to the collaboration of service firms focused on marketing.

Researchers from Switzerland Maria Angeles Martinez-Grau and Maria Alvim-Gaston studied the spread of open innovation strategies in a historically closed industry such as pharmaceuticals [Martinez-Grau, Alvim-Gaston 2019]. To be competitive in today's economic, regulatory and political environment, pharmaceutical companies must reduce the time and cost of product development, be able to quickly remove unpromising projects, accelerate the design process, focus on areas with high therapeutic needs and dramatically increase productivity while maintaining quality standards. In the future, only those pharmaceutical companies that have developed the ability to transform the obsolete research and development (R&D) paradigm will be successful. A closed research model is insufficient to solve emerging problems. To succeed in this new environment, large pharmaceutical companies must continue to invest in collaborative models in which many partners create innovation. To foster collaboration between industry and academia, it is especially attractive to share ideas and generate value that can strengthen research on new drugs.

Researchers have concluded that the paradigm of open innovation in drug development will continue to spread over the next decade. The search for ideas and experience from external sources is a well-established practice in the pharmaceutical industry, while about a third of all drugs in the top ten companies were initially developed elsewhere.

Large pharmaceutical companies are usually bureaucratic organizations. It takes time to determine the right partner and enter into a cooperation agreement. Universal agreements are easy to handle, but individual contracts require more discussion. Negotiations usually focus on IP ownership or financial compensation, although

other topics such as confidentiality, data exchange, and publication options must also be discussed. Effective collaboration between pharmaceutical companies and academia is easy, and the benefits are huge. Scientists are open to new ideas and points of view, and they can expand their network and professional capabilities.

4. THE INFLUENCE OF ADOPTION THE OPEN INNOVATION THEORY ON THE BUSINESS

Interestingly, the founder of this theory, Henry Chesbrough, in collaboration with various researchers, continues to study its distribution in various fields of business. For example, in 2018, his new study published the introduction of open innovation in large companies in collaboration with Brunswicker. They concluded that large firms are most often the recipients of knowledge flows, in part because they are concerned about protecting IP for outgoing knowledge.

It turned out that project teams use only a limited number of practices that involve a large pool of knowledge, such as platforms and communities, which contrasts sharply with the amount of attention that these practices receive in discussions about open innovation. Obviously, the costs and risks associated with such practices, such as the potential loss of control of intellectual property, outweigh the immediate benefits. This suggests that research in the field of open innovation should be aimed at understanding how project teams can use a wider range of knowledge without fear of losing control.

Also in collaboration with professor Christopher Lettl, an article was published on the creation of value in the framework of the open innovation paradigm [Chesbrough, Lettl, 2018]. Open innovation requires collaboration among distributed but interdependent actors that rely on each other's capabilities to create value together. This article discusses the value-based approach to open innovation, proposes consistent concepts for creating and capturing value, and outlines the potential for further research at the intersection of open innovation, value creation, and value collection. Although the ultimate goal of economic activity is value creation, the definitions of creating and capturing value have not been sufficiently explained in the literature on open innovation. However, open innovation can only be maintained over time if value is generated for all those involved either in the process of the invention or at a later point in time.

Polish scientists Katarzyna Walecka-Jankowska and Joanna Zimmer came to the conclusion that the discovery of innovative processes for external sources is associated with many aspects of the functioning of enterprises in the environment, including the search for the necessary knowledge or partners for exchange, and the provision of know-how from leaks during cooperation or the ability to absorb knowledge [Walecka-Jankowska, Zimmer, 2019]. Absorptive capacity grows with the size of the enterprise. However, open innovation can also bring many benefits to small enterprises (reducing R&D costs, modernizing production processes, reducing the risk of innovation). Studies show that the size and age of enterprises affect their tendency to use open innovation. They chose to classify the organization's strategies according to Porter: cost leadership, differentiation,

diversification. The authors revealed that open innovation can only be implemented in companies with a differentiation strategy. Differentiation or quality leadership strategies allow enterprises to diversify a product by improving its quality, changing its appearance or use. It is extremely difficult to maintain the uniqueness and originality of a product in an era of rapidly changing market and consumer expectations (especially for small enterprises). One way to keep up with the market is to open innovation processes to external knowledge. Opening innovative processes can bring small and micro-organizations many unique advantages, for example, reducing risks and costs associated with the implementation of innovative ideas, acquiring knowledge from the best industry experts and implementing major projects in cooperation with research institutes.

American researchers Martin Garcia-Swartz and Daniel Campbell-Kelly used the case study method [Garcia-Swartz, Campbell-Kelly, 2019]. They asked a simple question: are the costs of openness covered in computing and mobile phones industry? They explored this issue, studying the history of operating systems in computer and mobile phones, and relied on four different concepts of openness: open systems, open innovation, open source software, and open control. The researchers concluded that the truly successful operating systems were those whose owner or investor was able to combine some degree of openness with a degree of control.

The first conclusion of their research is that no matter how closed or open the system is, open innovation always pays off. Even the first IBM systems, which were as closed as possible, relied on open innovation to accelerate distribution. Secondly, whether the leading system will become a high-quality, partially open system depends, among other things, on the nature of the platform (or the nature of the technology) and the nature of the competitor. Controlling the quality of the system, the opponent matters: XENIX, a partially open system, was defeated by MS-DOS, another partially open system, on a microcomputer platform, while SunOS, a partially open system, defeated Aegis (Apollo), a completely closed system and all other closed systems on a workstation platform. That is, controlling quality, a partially open system has a better chance against a completely closed system than against another partially open system. In addition, the nature of the platform (or technology) is important for quality control of the system: XENIX was probably too problematic for microcomputers, but SunOS was perfect for a more powerful workstation platform. The third historical conclusion is that forming the right alliance in support of a partially open system increases the chances of a system winning.

5. CRITICISM OF THE OPEN INNOVATION THEORY

A critical review of the concept of open innovation was also presented by Paul Trott and Dap Hartmann [Trott, Hartmann, 2009]. They expressed the opinion that the scientific community did not give enough credit to previous researchers who described, analyzed and supported most of the principles on which open innovation is based, long before the term for this new model was coined. Firms and the R&D community have so readily accepted

this concept as it is simple (it is attractive because it is simple and maintains a linear view of market science). Open and closed innovation systems are presented in the form of two alternatives that firms face. This inspires confidence in a broader argument, giving the impression that the options are mutually exclusive, although this is not the case. The sharp polarization of openness and closeness of innovative systems does not allow any middle level. Of course, Chesbrough was very successful in popularizing the concept of technology transfer and the need to share and exchange knowledge. Indeed, it seems that from the point of view of a business strategy, the concept of open innovation has reached a new audience (for example, CEOs of high-tech companies), which for so many years lacked literature on innovation and research and development. The fact that large multinational companies, such as “Procter&Gamble” and “Philips,” have introduced the principles of open innovation and facilitated conferences and publications on this subject, deserves admiration and praise. In fact, he created real laboratories (playgrounds) in which the mechanisms of open innovation can be studied in detail. What causes researchers to worry is that managers who now seem to be interested in managing innovation may be disappointed when it becomes clear that “open innovation” is not a panacea. The best way to avoid this is to consider open innovation as an incomplete line of research.

6. THE RESEARCHES STUDYING OPEN INNOVATION THEORY CONDUCTED IN RUSSIA

In Russia, the paradigm of “open innovation” is not explored in as much detail as in Western literature. There are several notable works. A study by Nataliya Linder and Andrey Kuryatnikov showed the benefits and costs of using the “open innovation” (OI) paradigm in building corporate innovation systems, while identifying relationships among types of partners and the possibility of sharing knowledge between them [Kuryatnikov, Linder, 2015]. The results showed that the depth of cooperation with various partners (universities, consultants, value chain partners, competitors and firms working in other industries) is positively associated with innovative activity, while the number of different partners has negative effects. The main result was that knowledge transfer in collaboration mitigates the negative impact of having too many different kinds of partners. An analysis of the data confirmed that the holding’s performance depends on the proportion of companies that attract internal and external stakeholders in the processes of innovation and what is the level of intensity of their interaction.

Aleksandr Kashirin and Nikolay Volobuev studied the experience of the state corporation Rostech, which had taken a clear course in 2012 on open innovation. They use various tools of open innovation and quite successfully [Kashirin, Volobuyev, 2016].

Olga Andryushkevich and Irina Denisova tried to answer the questions “Is open innovation possible in Russia?” [Andryushkevich, Denisova, 2016]. They came to the conclusion that in Russia, at least, the result of the joint efforts of the state and business in establishing business interaction between all participants in the innovation process and harmonizing their

interests, developing new forms of such interaction (collaboration, crowdsourcing, etc.), introducing an effective system is necessary management, reducing the degree of bureaucratization, etc. But this is just one small step towards the establishment of an innovative economy, in which open innovation is a promising way to exchange knowledge and technologies.

Russian researchers Mikhail Gerschman, Vitaliy Roud and Thomas Wolfgang Thurner studied the spread of open innovation in Russian state-owned companies [Gerschman et al., 2018]. In 2011, the Russian government set ambitious goals for science, technology and innovation and uses its large state-owned enterprises as channels to achieve these goals. These initiatives are aimed at cooperation between participants in innovation and the implementation of the principles of open innovation.

Table 4
Frameworks in the open innovation theory

[Lazarotti, Manzini, 2009]	
[Dahlander, Gann, 2010]	
[Fetterhoff, Voelkel, 2006]	
[Wallin, von Krogh, 2010]	
[Witzemann, 2005]	
[Schumacher et al., 2013]	
[Lee et al., 2020]	

Source: compiled by the author.

Based on a large-scale innovation survey, they compared private enterprises with state-owned companies. Our data confirms the claim that Russian state-owned enterprises stimulate demand for technology and mainly absorb the incoming activity of open innovation. Unlike private, state-owned enterprises extend their activities in the field of open innovation to knowledge producers in the country, such as research and technological organizations and leading universities. They are working on the implementation of scientific knowledge that could really be the key to globally competitive technological innovation, but also have more opportunities to attract business partners.

7. CLASSIFICATION OF FRAMEWORKS IN THE OPEN INNOVATION THEORY

A study by Italian scientists Valentina Lazarotti and Raffaella Manzini [Lazarotti, Manzini, 2009] analyzed the question of whether companies use different models to open their innovation process. They define four specific models of open innovation, which depend on the number and type of partners involved, as well as on the number and type of phases open to external participation: open innovators, specialized collaborators, integrated collaborators and closed innovators. Closed innovators avoid big obligations, but, on the other hand, cannot share risks with others. This model limits their technological capabilities, since only internal resources are used. Open innovators maximize the use of external technological capabilities, but for this, large resources and time are allocated to create the necessary organization and processes. Specialized collaborators and integrated collaborators are intermediate models that allow them to use some features that can be used externally, but at the same time limit the allocated resources.

Oliver Gassman and Ellen Enkel [Gassmann, Enkel, 2004] identify three archetypes of knowledge flows in an open innovation environment: (1) inward flows, (2) inward outward flows, and (3) bidirectional flows, and they suggest that these knowledge flows are critical to firms' innovation processes.

When considering innovation management, Teppo Felin and Todd Zenger offer a conceptual framework that expands the familiar hierarchy and demarcation of the market in two ways [Felin, Zenger, 2014]. First, they subdivide these two categories into six forms of governance, with two forms of internal hierarchy and four different categories of external sources. Secondly, they consider the management of innovation at the project level, not the firm. Based on this, they predict the choice of management form based on the nature of the knowledge sought and the nature of the problem being solved. Such research can benefit from the availability of better tools for network analysis, which show how social capital – at different levels of analysis – can generate open innovation.

Linus Dahlander and David Michael Gann [Dahlander, Gann, 2010] use measurements of inbound and outbound open innovation compared to tangible and intangible interactions. Four cells in the matrix are marked as acquiring, sourcing, selling and revealing. This model may be a good starting point for empirical research to better understand the actions that include each of the

four strategies and their effectiveness for different organizations and in different contexts. Open innovation practices can also be grouped to differentiate between process and outcome. This model links discussions in the field of innovation management with discussions in the field of IT management, where much attention has been paid to open source software. Both the process and the result of innovations can be closed or open, which leads to a 2×2 matrix. Closed innovations reflect the situation when in-house developments are developed on their own [Chesbrough, 2003a], both the process and the results are closed. In the second category of private open innovation, the result is closed (private innovation), but the process is opened either using the contribution of external partners, or by using the innovation developed internally within the company. According to the second dimension, the result of the innovation process is either private (closed) or available to others (open). Inbound open innovation refers to the internal use of external knowledge, while outbound open innovation refers to the external exploitation of internal knowledge.

Terry J. Fetterhoff and Dirk Voelkel [Fetterhoff, Voelkel, 2006] propose a model that includes the following five steps: (1) finding opportunities, (2) assessing their market potential and ingenuity, (3) hiring potential development partners, (4) making profits through commercialization, and (5) expanding innovation proposals.

Another model of these researchers, the “6K Model,” is useful for evaluating the external contribution. The model distinguishes six aspects of valuation: the company (in accordance with the strategy), competition (uniqueness of opportunities), commerce (market size), capital (its value) and copyright (intellectual property). Partnership building is an important and time-consuming issue in the field of open innovation.

Martin W. Wallin and Georg Von Krogh focus on managing the integration of knowledge and determine the various five stages of the process, namely: (1) define the innovation process steps, (2) identify innovation relevant knowledge, (3) choose the appropriate integration mechanism, (4) create effective governance mechanisms; and (5) balance incentives and controls [Wallin, Von Krogh, 2010]. Stage 4 is especially related to the management of open innovation projects. Important management issues at this stage include partner selection, assessment of contributions, ownership of intellectual property, profit and loss sharing, group decision making and conflict management.

It is also worth mentioning the Van der Meer H. (2007), which divided the process of searching for external sources of innovation into four stages:

- “Want” – What external resources does the company want to access to achieve its strategic goals?
- “Find” – What mechanisms will the company use to search for these external resources?
- “Get” – What processes will the company use to plan, structure and agree on an agreement on access to resources?
- “Manage” – What tools, metrics and management methods will the company use to implement the relationship?

The German researchers Alexander Schuhmacher and others [Schuhmacher et al., 2013], based on in-depth research, identified various types of open innovators. The innovative model “knowledge creator” is defined as a company that prefers to develop innovation within its organization, while the level of

research and development acquired from outside is much lower than the industry average. “Knowledge creators” rely mainly on the internal management of innovations, and if projects are acquired from outside, they are developed mainly through internal resources and know-how. Boehringer Ingelheim (BI) and Novartis are two examples of the “knowledge creator” that still follow this more traditional R&D concept, which is based on internal R&D projects, skills and know-how and complemented by focused licensing, university collaboration and academic partnerships.

The second model, the “knowledge integrator”, describes the preference for using externally generated innovations in a model that relies primarily on internal resources and know-how. Knowledge Integrators, such as Sanofi, benefit from their internal R&D management experience, while they license or acquire the bulk of their R&D from external sources.

Thirdly, the “knowledge translator” is defined as the preference to use the resources and knowledge coming from outside the company to implement internal innovations. Knowledge translators are characterized by a portfolio of projects that has been driven primarily by internal research, and they use outsourcing, collaboration and partnerships to effectively manage their R&D projects. GSK is best described with the term “knowledge translator.”

Lastly, knowledge leverager describes the emphasis on externally generated innovations in conjunction with outside-company innovation management. This type of innovators acquires technologies and knowledge from outside and knows how to use available internal and external resources as efficiently and profitably as possible. In our analysis, Shire was the only company that qualified as a “beneficiary of knowledge.” Ideas, know-how, technologies and resources for the discovery and development of new drugs come mainly from outside. For example, Shire has an open collaboration model that functions similar to a foundation that, together with its partner venture business model, provides valuable tools for accessing external innovation.

Korean scientists Lee and others [Lee et al., 2020], in their study, consider the problem of international technological cooperation, offering a basis for developing strategies at the national level. They developed a multi-level strategic structure that helps the country develop a strategy for cooperation with another country at three different levels. The nature of cooperation is studied in terms of attractiveness at the macro level (market and technological attractiveness), proximity at the mesoscale (degree of existing relations between the two countries) and strategy at the micro level (goals of cooperation and modes). To answer these questions, this study proposes a multi-level strategic process that helps a country develop a cooperation strategy with another country at three different levels (macro, meso and micro levels); this process is called ACS (attractiveness-closeness-strategy) because it explores the nature of cooperation with a partner country in terms of attractiveness at the macro level, proximity at the mesoscale, and strategy at the micro level. This is one of the earliest attempts to emphasize the role of public policy in developing organizational strategies for open innovation and, in addition, to offer a framework for developing a strategy for international technological cooperation at the national level.

An article by Italian researchers Antonello Cammarano, Francesca Michelino and Mauro Caputo [Cammarano et al., 2019] seemed very interesting and insightful. The impact of open innovation (OI) on innovation outcomes has been widely studied in the literature. To assess the impact of OI and each specific source of OI, the authors examined which technological strategies could be supported and what type of innovative products were achieved. Thus, this document contributes to a deeper understanding of the role of OI from the point of view of gaining knowledge, emphasizing how different practices of OI support different technological strategies and allow achieving different innovation results.

Consistently with literature, the novelty level is assessed through backward citations and the impact on the linkages between components is evaluated considering the novelty of the combination of technological fields disclosed in patent documents. Each document in the current innovation effort is thus defined as:

- incremental, if backward citations are present and no new combination of components is found;
- architectural, when there is a new combination of technological components and references to prior art were discovered;
- modular, if it does not refer to prior knowledge but no new combination is detected;
- radical, when it is featured by technological originality and generates a new combination of technological components.

Two classifications of technological strategies were identified: exploitation and exploration. Exploitation is the use of existing capabilities through activities such as standardization and refinement, while research relates to access to new areas of knowledge through basic research and experimentation. The second classification of technological strategies relates to different levels of exploitation of existing knowledge, which leads to different levels of familiarity with knowledge. With the help of specialization strategies, companies focus on a narrow field of knowledge or activity, while diversification can be continued to expand business activities in disparate areas, accumulating knowledge with potential application in multiple product-market domains complementary to the core business or far from familiar technical areas.

This work focuses on four sources of open innovation: R&D outsourcing, joint development, the acquisition of external technologies and incorporation of knowledge in the focal company through mergers and acquisitions (M&As). Firms outsource R&D to develop new technology, when the outsourcer is primarily interested in gaining access to external knowledge or solutions [Van de Vrande et al., 2009] and there is a one-way transfer of external knowledge within the company. Collaborative development, on the other hand, is based on an intentional two-way knowledge sharing between the main company and the other party. Firms can collaborate with third parties for many reasons, such as reducing uncertainty, sharing costs, and accessing additional expertise.

The purchase of technology consists of the acquisition of IP, know-how and other types of knowledge from other organizations in order to quickly integrate external know-how. In fact, firms adopt a strategy when (1) they need quick access to a specific technology already available, (2) a technology developed from

the outside offers the best option, or (3) they do not have enough knowledge to develop it internally [Lee et al., 2020]. Finally, the practice of incorporation (the introduction of knowledge in the main company) is useful for expanding the resources of firms by combining or acquiring new knowledge from the target company, when technologies either deviate from the main technical capabilities of the firm – and thus it is difficult for members of firms to understand and apply them, or they remain in silent form, and therefore impede the transmission and codification of knowledge as soon as it is identified. This practice allows for superior innovative performance by combining technological knowledge, disseminating know-how and redistributing technology in a united organization.

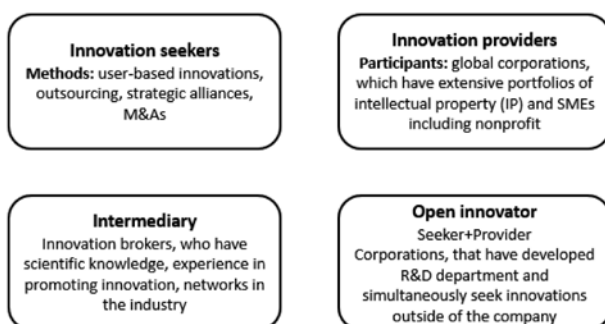
The purpose of their article is to distinguish the influence of each practice of OI on technological strategies and the type of innovative products. The authors performed a comparative study among practitioners, analyzing a sample of 243 high-tech companies from three sectors with intensive research and development. From an analysis of the results, we found differences between the practices of OI in terms of their relationship with technological strategies and the type of innovation.

Thus, those companies that have adopted intelligence and diversification strategies are turning to open innovation. The propensity for exploration is higher in joint development than in outsourcing R&D. In addition, the purchase of external technology improves intelligence strategies. Higher levels of diversification can be achieved through collaborative development, technology acquisition, and incorporation. Technology purchases and mergers and acquisitions expand access to radical innovation, and joint development allows partners to combine their capabilities and establish new product configurations. In addition, in outsourcing R&D, third parties provide only a limited contribution, which usually leads to gradual innovation. Thus, our findings prove that R&D outsourcing is an intermediate way between OI practices and internal development.

Open innovation is mainly used for exploration and diversification and mainly leads to modular and radical innovation. Incremental innovations are mainly achieved through outsourcing of R&D, joint development leads to architectural innovations, while the acquisition and implementation of external technologies provide access to modular and radical innovations.

However, the most common and comprehensive classification of open innovation strategies is as follows. It was described by researchers Peter Gianiodis, Scott Ellis and Enrico Secchi [Gianiodis et al., 2010].

Fig. 1. Open innovation strategies



They identified four distinctive strategies based on intercompany exchanges included in various transactions in the industry's value chain: innovation seeker, innovation provider, intermediary, and open innovator (see Figure 1).

In the value chain, the “innovation seeker” is a firm that seeks innovative solutions outside its borders. Firms acquire technological solutions in innovation markets to complement existing technology portfolios [Teece, 2000]. There are plenty of examples for innovation seekers: software companies participate in open source communities to gain access to critical innovation solutions. Similarly, pharmaceutical companies acquire solutions by jointly developing technology with strategic partners or by acquiring smaller companies that developed it [Dahlander, Wallin, 2006; Higgins, Rodriguez, 2006].

Researchers have identified three main sharing mechanisms used by innovation seekers: using innovation, using information from users, outsourcing innovation, and strategic alliances or mergers and acquisitions [Cassiman, Veugelers, 2006; Higgins, Rodriguez, 2006]. As a rule, the external search for innovation seekers begins with their existing network: they attract suppliers, strategic partners and other network members who are familiar with the company's technology portfolio and innovative systems. Not surprisingly, the adoption of open innovation is usually enhanced when a firm has an extensive network of partnerships. Firms leverage users to help them improve existing offers or develop new extensions to products or services. Although not a completely new phenomenon, the use of user-based innovation has grown significantly over the past decade [Von Hippel, 2005]. User forums, such as online communities, clubs, or blogs, are new repositories of potential ideas that complement traditional ways of interacting with clients [Dahlander et al., 2008]. Significant maintenance costs for large R&D departments force firms to seek more effective means of innovation in products and services.

Outsourcing can take the form of an initial application in the open market, taking into account all possible sources, or firms can limit their search to existing partners and suppliers. Despite the risks, outsourcing innovation outside the circle of existing relationships can lead to new solutions that may not be available to competitors. There are three main methods for outsourcing innovation: (1) direct contact with the specified provider of innovation; (2) organization of a tender or auction in the open market; or (3) use of an intermediary. Firms apply the paradigm of open innovation through strategic alliances and mergers and acquisitions. Strategic alliances give firms the opportunity to use additional technologies, opportunities, and assets that can improve both early activities in the value chain (for example, R&D) and the offer of products and services [Markman et al., 2009a].

Many “innovation seekers,” use strategic partnerships to gain access to intellectual property, which can increase R&D performance or products offered by the seeker. In addition, alliance partners ensure complementarity of assets, which increases the efficiency of R&D. Mergers and acquisitions expand the scope of application of products and the market, and also allow firms to gain efficiency through combined interaction. In the context of OI, the preferred method is the acquisition of small and medium-sized enterprises, which were the first to develop promising technology, but do not have sufficient resources to fully exploit their discoveries. In general, SMEs

do not have the financial capital or adequate infrastructure to independently commercialize many of their discoveries, which makes selling to innovation seekers an effective way to capitalize on their inventions [Oliveira et al., 2003].

As mentioned above, “innovation providers” become the partner of “innovation seekers”: an organization that distributes innovative solutions. These organizations do not use their technological discoveries to create commercial solutions, but to sell them as “products” to partners, who then reconfigure the technologies to package them as final products [Markman et al., 2009b]. Such organizations use their technology to gain access to additional assets and improve market access [Christensen et al., 2005]. In addition, partnerships with larger firms provide access to innovative networks that can play a fundamental role in the success of small and medium-sized enterprises (SMEs).

“Innovation providers” is one of two types of organizations: large global firms and small and medium-sized enterprises, including non-profit organizations. The first group consists of global corporations such as Xerox and IBM, which have extensive portfolios of intellectual property (IP) that contain underused technologies. These intellectual property portfolios are the result of extensive investments in R&D; nevertheless, for a number of reasons, these investments led to the emergence of technologies that firms could not commercialize on their own. These firms are currently viewing their large R&D portfolios as potential milk cows and are looking for partners either to sell IP directly or to develop commercially viable products.

The second group includes small and medium-sized enterprises (SMEs) with strong technological positions in niche markets. As noted, SMEs do not have sufficient financial capital and infrastructure assets to launch extensive product lines and must rely on external financing to expand their business. These also include non-profit organizations with extensive research missions. For example, research universities are the main source of technological discoveries because of their vast research infrastructure – teachers, laboratories, graduate students, etc. – allowing them to conduct research activities. However, like SMEs, they lack the necessary organizational structure, mission and culture to successfully commercialize their discoveries.

At the center of many innovation search exchanges and innovation providers is an “intermediary”: a firm that acts as an innovation broker [Terwiesch, Xu, 2008]. The presence of intermediaries helps explain the explosive growth of OI by firms from different industries and economic regions; they act as catalysts for market exchange and have influenced the transition of many companies from the traditional closed innovation model. Although some intermediary firms have gained strong market positions – Innocentive, Yet².com, Nine Sigma.

The largest number of studies can be found with regards to the effectiveness of intermediaries in the paradigm of open innovation.

Innovative intermediaries, which are usually regarded as independent third parties, can be defined as agents or brokers “helping to provide information about potential partners; conclusion of a transaction between two or more parties; Act as an intermediary or intermediary in bodies or organizations that are already cooperating; and assistance in seeking advice, funding and supporting the innovative results of such cooperation.”

To perform these diverse roles as intermediaries in open innovation, they can use web platforms that facilitate interaction and simplify networking between various sites around the world, turning this traditional form of one-way communication into a constant global dialogue.

The paradigm of open innovation, the rapid development of which has contributed to the proliferation of the Internet, has provided firms with beneficial access to a wide range of external sources of innovative ideas. The explosive growth of open innovation intermediary networks, such as InnoCentive or Linked-in, allows you to quickly combine knowledge-seeking firms to solve a wide range of business tasks (seekers) with other firms or individuals who already have relevant knowledge (solvers or innovative intermediaries)) These intermediary networks allow purchasing departments to obtain coded and uncoded knowledge from firms or individuals outside their traditional supplier networks using a one-time transactional relationship.

One striking example of an intermediary site that focuses primarily on codified knowledge is InnoCentive, created in 2001 by Eli Lilly [Billington, Jager, 2008]. Seekers set tasks on the InnoCentive platform, and solvers provide solutions that can be anonymously captured, codified, and passed on to the seeker. Companies or individuals who respond to challenges are called “solvers” in the sense that they have a solution to a published problem that they are willing to document. Applicants, who are almost always corporations or nonprofits, pay an annual fee of \$100,000 for access to the network, and then offer remuneration to decision makers. InnoCentive also receives a percentage of this award. A rapidly growing network of solvers was approaching 170,000 by mid-2010. Over time, InnoCentive expanded its service offering and domain coverage from initial core life science offerings to include other areas such as mathematics and statistics, entrepreneurship, and engineering design.

Another example is Gerson Lehrman, an expert network of more than 200,000 professionals, including scientists, doctors, researchers, and former company specialists. Research managers at Gerson Lehrman help seekers find experts through this network and facilitate contact with experts through phone calls, round tables, written reports, surveys and visits. These simplified networks are growing rapidly in both size and number of domains served.

The last separate OI strategy, which the authors call the “open innovator,” is actually a combination of two other innovative strategies. Firms, especially multicomponent conglomerates, try to maintain a balance between internal and external knowledge creation activities, which contributes to cases when they act as innovators (for example, to “fill” technological gaps) and innovation providers (that is, to assign non-core technologies or abandon a certain technological trajectory). These firms use their extensive partnerships to constantly share knowledge as part of their expansion efforts [Teece, 2000].

They have both access to technology (i.e., an IP portfolio) and the necessary capabilities (i.e., absorptive capacity), as well as gaps in their innovative systems that make them buyers and sellers of innovations. Open innovators are usually large global firms that have specialized research and development units, and at the same time are looking for external technologies for inclusion. Xerox, which is the subject of much of Chesbrough’s first book, is a good example of a firm using this strategy

(Chesbrough, 2003a). Given that such companies are often large corporations, they tend to finance by-products to market some of their innovations, relying on mergers and acquisitions to acquire interesting innovations.

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ABOUT THE AUTHOR

Lidiya S. Orlova

Graduate student, Management Department Assistant
Financial University under the Government of the Russian Federation.

Research interests: strategy of innovative development of the industrial companies, tools of open innovations, innovative activity of strategic alliances.

E-mail: lsorlova@fa.ru

ИНФОРМАЦИЯ ОБ АВТОРЕ

Лидия Сергеевна Орлова

Аспирант, ассистент Департамента менеджмента Финансового университета при Правительстве Российской Федерации.

Область научных интересов: стратегия инновационного развития промышленных компаний, инструменты открытых инноваций, инновационная деятельность стратегических альянсов.

E-mail: lsorlova@fa.ru