LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
School of Business and Management
Industrial Engineering and Management

Global Management of Innovation and Technology

MASTER'S
THESIS

INFLUENCE OF INDUSTRY ON THE IMPLEMENTATION OF OPEN INNOVATION PRACTICES

First supervisor: D.Sc. (Tech.) Daria Podmetina
Second supervisor: M. Sc. Roman Teplov
Date: 18.12.2017, Lappeenranta, Finland

Author: Vladislav Pokusa

ABSTRACT

Author: Vladislav Pokusa

Title: Influence of industry on the implementation of open innovation practices.

Year: 2016

Place: Lappeenranta

Type: Master's Thesis. Lappeenranta University of Technology

Specification: 104 pages including 22 figures and 24 tables

First supervisor: D.Sc. (Tech.) Daria Podmetina

Second supervisor: M. Sc. Roman Teplov

Keywords: open innovation, industry differences, open innovation practices

The Open Innovation so far was studied mainly at the level of firm/organization. However, several other levels such as individual and groups, inter-organizational value networks, industry and sector, national institutions and innovation systems received much less attention. This study provides the analysis of Open Innovation at the level of industry.

The purpose of the study is to analyze interdependencies between the type of industry and implementation of Open Innovation practices and make a coherent review of industries showing differences in implementation of these practices. Results are linked with findings from literature. Study shows that firms from various industries prefer different aspects and practices of Open Innovation. In most cases it corresponds to industry features and characteristics.

Study also compares the level of Open Innovation adoption by high- and low-tech enterprises, and service and manufacture firms. Conducted analysis of variances shows significant differences between groups in implementation of several Open Innovation activities. Manufacture firms implement collaborations, participation in standardization and external technologies acquisition more intensively than service firms. High-tech firms are more active at IP in- and out-licensing and collaborations with external partners. Results also show no differences in current level of OI adoption between service and manufacture firms. Analysis also showed insignificant difference for high- and low-tech firms in current level of OI adoption.

Results may be used for further qualitative in-depth research, as well as for development of managerial guides or policy development.

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ABBREVIATIONS

ANOVA	Analysis of variance
ETC	External technology commercialization
OI	Open innovation
OMA	Open Mobile alliance
R&D	Research and development
SiW model	“Sharing is winning” model
WFGM model	“Want, Find, Get, Manage” model

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1. INTRODUCTION

1.1. Research background

Open innovation has become one of major trends in contemporary innovation management; many consulting firms now consider OI practices in their work (Chesbrough and Bogers, 2014). Chesbrough (2006) define it as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively". Later, Chesbrough and Bogers (2014, p.27) provided updated definition of open innovation in order to unify further research on the subject: "open innovation is a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model". Open innovation concept was originally associated with high-tech industries, and was considered as applicable to them (Chesbrough and Crowther, 2006), although in fact some OI activities were already presented in more mature industries (Bigliardi and Galatib, 2013). However, over time it has become adopted by wide range of industries. Now most of traditional industries implement open innovation practices (Chesbrough and Crowther, 2006). Poot et. al (2009) explored the process of open innovation adoption across industries over time and have found that all industries implement open innovation to some extent, and that the shift towards open innovation in various industries is not a simultaneous process. Poot et. al (2009) states that this process contains of "shocks" that occur in different time in different industries. Prior research already explored the issue of open innovation for various industries separately (Eidam et. al, 2014; Chiaroni et. al, 2009; Grotnes, 2009; West & Gallagher, 2006; Costa & Jongen, 2006; Bigliardia and Galatib, 2013; Ili et. al, 2010), but only few articles focused on comparison of open innovation adoption in terms of industry (Poot et. al, 2009; Van de Vrande et. al, 2009); however, these articles highlight only few single aspects of the issue. Huizingh (2011) offered to study the influence of company's external context characteristics on the adoption of particular open innovation activities. Among these context characteristics he mentioned industry, degree of competition, goods versus services and others. Only few articles exploring this topic have been found (Poot et. al, 2009; Van de Vrande et. al, 2009). Van de Vrande et. al (2009) compared the adoption of open innovation activities for service and manufacture firms and have found few differences between these categories.

1.2. Research gap, objectives and questions

Prior studies do not provide coherent review how OI is adopted in different industries. Also, despite that open innovation approach has already spread across low- and mid- tech industries, no articles that would have compared high- and low-tech industries in details have been found.

Chesbrough (2006) offered five levels of analysis for future research: individuals and groups, firm/organization, inter-organizational value networks, Industry and Sector, National Institutions and Innovation Systems. However, by summarizing research in last decade, Chesbrough and Bogers (2014) noticed that among top 20 cited articles the level of firm/organization is the most explored issue. Other levels received far less attention. Chesbrough and Bogers (2014) suggest industry as a unit of analysis and inter-industry differences as a possible research object.

Chesbrough and Vanhaverbeke (2012) state that erosion factors that has led to the shift towards open innovation should be supported by public policies. Better understanding of inter-industry differences in implementation of OI might be useful for the creation of public policies; thereby, making this topic important and relevant for research.

Thereby, the topic of Open Innovation at the level of industry is poorly developed, no comparative analysis of industries was found; however, this knowledge might be useful and find practical implications.

The **objective** of this study is to assess the influence of industry type on the way how open innovation concept is being implemented. The main question (RQ) that was raised in this thesis is *"are there differences in the implementation of particular open innovation practices by firms that are caused by the industry that firm operates in?"*.

In order to answer main research question and perform a research in a structured way the following research questions were formulated (Table 1).

Table 1 – Research objectives and questions

	Research Question	Research Objective	Research method
RQ1	Does the type of industry influence the prevalence of some OI activities?	To analyze industrial differences in terms of implementation of OI activities	Quantitative study, survey
RQ2	What is the difference in implementation of open innovation activities by firms of different technological intensity?		
RQ3	What is the difference in implementation of open innovation activities for firms in service and manufacturing sectors?		

1.3. Report structure

Report consists of six chapters and the structure aims at the representation of the report in a coherent and holistic way.

First chapter is "Introduction". Research purpose, objectives, and questions are presented at this chapter. It also briefly presents research background. The following chapter is "Literature review". It contains main theories and concepts relevant to the study, presents the concept of open innovation and basic theory, and further provides a review of articles observing open innovation issue among various industries. The final part of literature is "methodological framework and hypothesis". It briefly reviews existing theory and states hypothesis.

Next chapter is "Methodology". This chapter explains research design and used methods. Complete description of data collection and analysis is also presented within this chapter.

"Results" section includes findings acquired within analysis. "Discussion" section provides interpretation of findings from "Results" section, finds corroboration with previous research and literature, and provide possible explanation of results.

"Conclusion" chapter provides summary of the research, repeats research questions, emphasizes key findings, and suggests possible implications. Limitations of the research are presented here as well.

All cited materials, books and articles are provided within "References" section.

2. LITERATURE REVIEW

Companies have historically invested significant amount of money on research and development to pursue innovations and offer continuous growth (Chesbrough and Crowther, 2006). Ideas appeared inside companies' research labs and found their commercialization within firm's own channels. This way to innovate was mainly self-reliant and was named as "Closed innovation" by Chesbrough (2006). However, several reasons presented below (see "Reasons to adopt OI", section 2.3), made this approach not viable for many industries anymore (Herzog, 2008). The increasing need to integrate external R&D sources *"has prompted many firms to shift from a Closed Innovation model to an Open Innovation model"* (Herzog, 2008, p. 1). Companies belonging to various industries (especially high-tech industries) significantly changed their approach to innovations. The basic principles of open innovation were first realized in practice before the concept itself was introduced in academic literature (Gassman, 2006). Trott and Hartmann (2009) criticized the distinction between closed and open innovation model, arguing that companies have never followed completely closed model. However, Chesbrough and Bogers (2014) noticed that they did not imply the absence of open innovation mechanisms in previous model, but rather emphasize that due to changed conditions now these elements *"combine to form a new paradigm to manage innovation"* (p. 22).

2.1. Closed innovation model

The basic assumption that stays behind closed innovation model is that "successful innovation requires control" (Chesbrough, 2003, p. xx). Following this approach, company has internal focus given that competitor's technologies are unavailable or do not possess sufficient quality. This self-reliant approach derives from hidden rules of Closed Innovation (Herzog, 2008, p. 19):

- A firm should hire the best and smartest people

- Profiting from innovative efforts requires a firm to discover, develop, and market everything itself
- Being first to market requires that research discoveries originate within the own firm
- Being first to market also ensures that the firm will win the competition
- Leading the industry in R&D investments results in coming up with the best and most ideas and eventually in winning the competition
- Restrictive IP management must prevent other firms from profiting from the firm's ideas and technologies

Following this approach means that company does all activities from idea generation to financing and manufacturing by itself. This causes the situation when all innovation projects enter the product development cycle at the very beginning, use only internal resources and knowledge and can be commercialized only by firm's own channels of distribution. In case if ideas or projects can't be commercialized using firm's own capabilities they are stored within the company and never used (Chesbrough, 2003). Innovation process within closed innovation paradigm is presented at Figure 1.

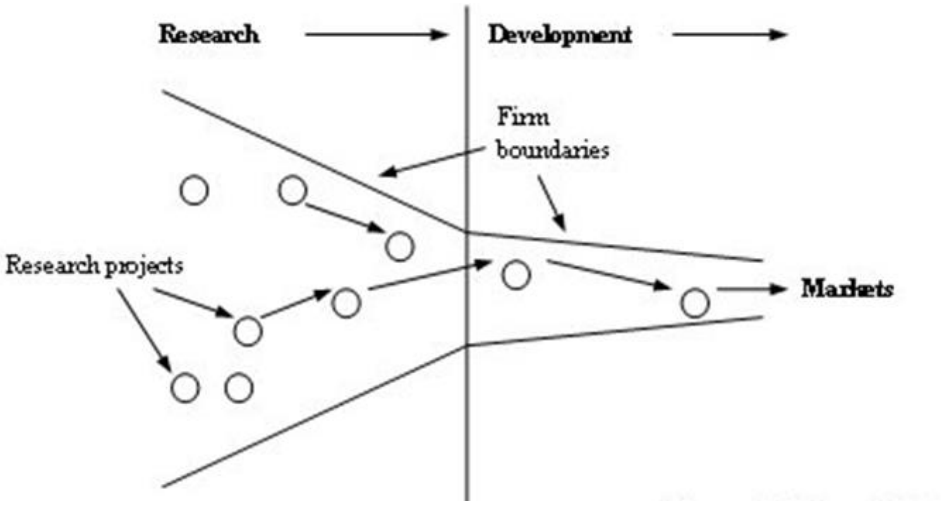

Figure 1 – Closed Innovation model (Chesbrough, 2003)

As a result of this internal focus many promising ideas remain unused (Herzog, 2008). Chesbrough (2003b) call these ideas "false negatives" – "projects that initially lack promise, but turn out to be surprisingly valuable". According to Chesbrough (2003b), this problem can be damaging to corporations that have made significant investments in projects that they could not commercialize inside the company and later revealed that those projects had high commercial value. The issue is that many of those projects might fall outside of company's existing business or need external technologies to reveal their potential.

2.2. Open Innovation model

Today firms have recognized that the importance of control that is inherent to closed innovation model have significantly decreased (Herzog, 2008). Conversely, not all good ideas and innovations are created inside the organization, as well as not all ideas created internally can or should be used by firms' own capabilities. If fact it means that by following Open Innovation model, firm not only use technologies and ideas developed internally, and not only use internal paths for commercialization. They rather should exploit external ideas and paths to the market to succeed in their innovation projects (Chesbrough, 2003).

Unlike closed innovation model, this approach makes the boundary between firm and its environment permeable. Innovation project can be launched by either external or internal technology or idea, and might enter the innovation cycle at various phases by various means. The same is right for commercialization than might use external pathways to market (Herzog, 2008).

"As such, Open Innovation therefore applies to all three phases of the innovation process (front end of innovation, idea realization and development, and commercialization)" (Herzog, 2008, p. 21). Ideas and technologies can enter the innovation process in different ways, such as venture investment or technology in-licensing. And the results of innovation projects can be commercialized in many other ways apart from using firm's own paths to the market: spin-off ventures, out-licensing and others (Chesbrough, 2003). Figure 2 depicts Open Innovation approach to the management of innovations.

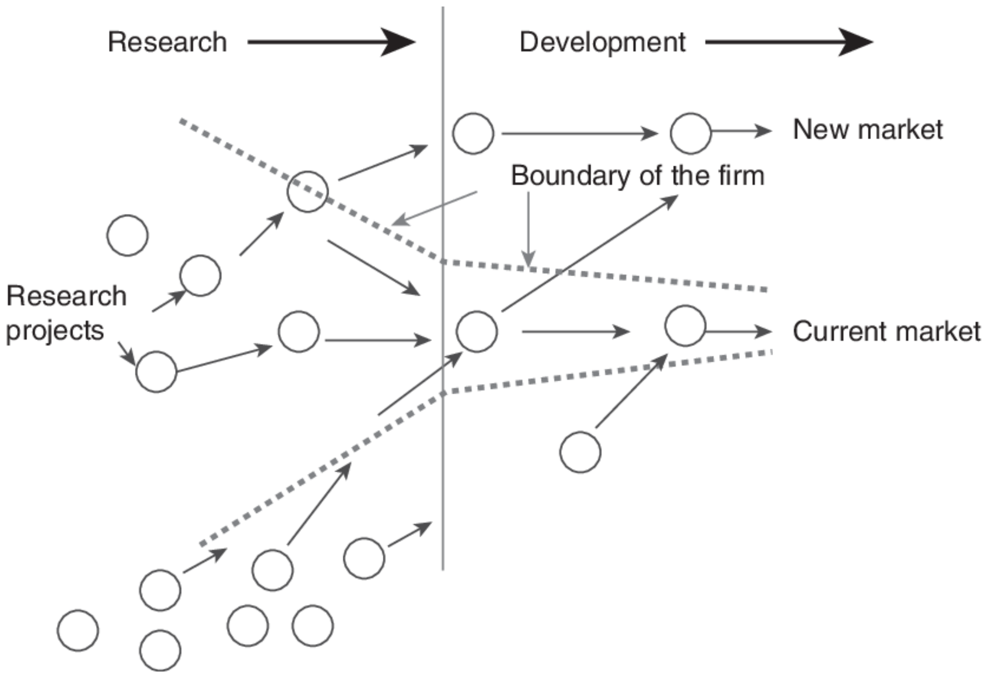

Figure 2 – Open Innovation model (Chesbrough, 2003)

The implicit rules of Open Innovation differ from Closed Innovation model. They are reflected in the following principles (Herzog, 2008, p. 22):

- A firm does not need to employ all the smart people, but rather work with them inside and outside the firm
- Internal innovation activities are needed to claim some of the significant value which
  can be created by external innovation efforts.
- In order to win the competition, it is more important to have the better business model than getting to market first.
- Winning the competition does not require coming up with the best and most ideas, but to make the best use of internal and external ideas.
- Proactive IP management allows other firms to use the firm's IP. It also considers to
  buy other firms' IP whenever it advances the own business model.

Chesbrough (2006) define Open Innovation approach *as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively"*. However, Herzog (2008) state that Open

Innovation is not only use of external ideas and technologies, but rather a holistic approach to innovation management and a change in the way to manage, create and use intellectual property. West and Gallagher (2006) have a broader definition of Open Innovation that also includes cultural changes that follow the move towards Open Innovation. They define this approach as "systematically encouraging and exploring a wide range of internal and external sources for innovation opportunities, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels". In order to unify future works in the area, Chesbrough and Bogers (2014, p.27) propose up-to-date OI definition*: "open innovation is a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model"*.

2.3. Reasons to adopt Open Innovation approach

Shortening innovation cycle and increasing customer expectations require more flexible and efficient innovation management. Companies constantly stress the need to accelerate innovation process, increase quality, and reduce costs (Eidam et al., 2014). Researchers (Gassman, 2006; Dahlander and Gann, 2010; Simard and West, 2006) mention several main factors that have led to the erosion of closed innovation model, and have broken the cycle that sustained closed innovation model presented on Figure 3.

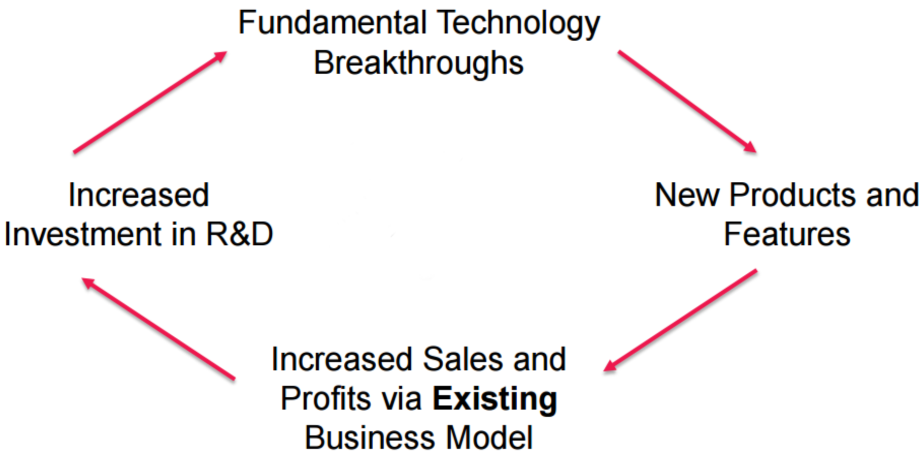

Figure 3 – Virtuous cycle of innovation (Chesbrough, 2003)

Chesbrough (2003b) mention increase in number and mobility of high skilled workers. The increase in mobility leads to knowledge spillovers and knowledge diffusion. Since it is possible for high skilled workers to move from one firm to another with the best offer, firms can simply acquire knowledge and experience by hiring the most talented people (Simard and West, 2006). Another point is that many workers nowadays work as portfolio workers and offer their service to multiple organizations at the same time. In some industries it forces companies to work as knowledge brokers, instead of hiring the best employees (Gassman, 2006). These factors diminish companies' ability to control ideas, knowledge and expertise created inside them. It also becomes more difficult for companies to control and claim the results of its R&D investments.

Technology intensity that has increased in many industries to such an extent, that it is difficult even for large companies to cope with new technology development. It is referred both to financial capability to cope with all upcoming technologies, and to ability to exploit these technologies alone (Gasman, 2006).

Gasman (2006) also mentions globalization as a trend that contributes to the shift towards Open Innovation. Global industries adopt Open Innovation practices since they help to achieve economy of scale faster that Closed Innovation approach, and also promote more powerful standards and dominant designs.

Availability of private venture capital is another factor that contributes to the shift towards Open Innovation model. Private venture capital helps to finance new firms and start-ups to commercialize new ideas. If a breakthrough occurs and company is not bringing it to the market, than engineers who made the breakthrough have an option to pursue it on their own with the help of venture capital. This is an option that they previously lacked (Chesbrough, 2003b). Furthermore, during last years university patenting activity has significantly increased. As an outcome, large amount of university researchers are trying to earn money from their research by setting up startup firms as well. Compared to established companies, these startups offer better risk-reward ratio (Herzog, 2008). Startup that benefit from the technology generally does not reinvest money in further technological breakthroughs. This destroys the virtuous cycle of innovation since the company that originally funded the innovation does not benefit from it, and the company which obtains profits does not reinvest it in further discoveries (Chesbrough, 2003b).

Dahlander and Gann (2010) also mention improved marked institutions such as intellectual property rights that allow companies to trade ideas, and new technologies that allow collaborating across geographical boundaries. Talking about technologies, Herzog (2010) also tell about innovation intermediaries that help to get access to knowledge distributed worldwide. He mentions innovation brokers that bring together technology seekers and technology providers such as InnoCentive, NineSigma, yet2.com. Innovation intermediaries also help firms to exchange information in a confidential way without revealing their motives and identities.

Another fundamental reason that forces firms to seek for external support is industry convergence that means blurring boundaries between industries and markets. Firm might need to possess knowledge from another industry in order to fill its own knowledge gap. The solution here is forming complementary partnerships, and opening firms boundaries becomes necessary (Herzog, 2010). Gassman (2006) also mention, that the more interdisciplinary research is required for new technology, the less a single company might afford it with its capabilities.

New ways of idea commercialization appears, that also forces firms to move towards Open Innovation model. Commercialization of many ideas might lie outside of current firm's boundaries. In the past, such ideas were stored inside company and rarely used. Now those ideas might be commercialized by key engineers with the help of venture capital or spill over to other firms that would benefit from it. But firm can also find external paths for commercialization, for instance, by selling IP (Chesbrough, 2003b).

2.4. Forms of Open Innovation

Following from the abovementioned, Open Innovation is based on two main aspects: technology sourcing and technology commercialization. In both of those cases, technology or knowledge flow through semi-permeable firm's boundary. Researches use various definitions for those flow patterns. Gassman and Enkel (2004) use terms outside-in for use of external knowledge and inside-out for selling IP or using external pathways to the market. Chesbrough and Crowther (2006) distinguish inbound and outbound Open Innovation for the same means. Figure 4 depicts basic forms of Open Innovation activities for inbound and outbound open innovation.

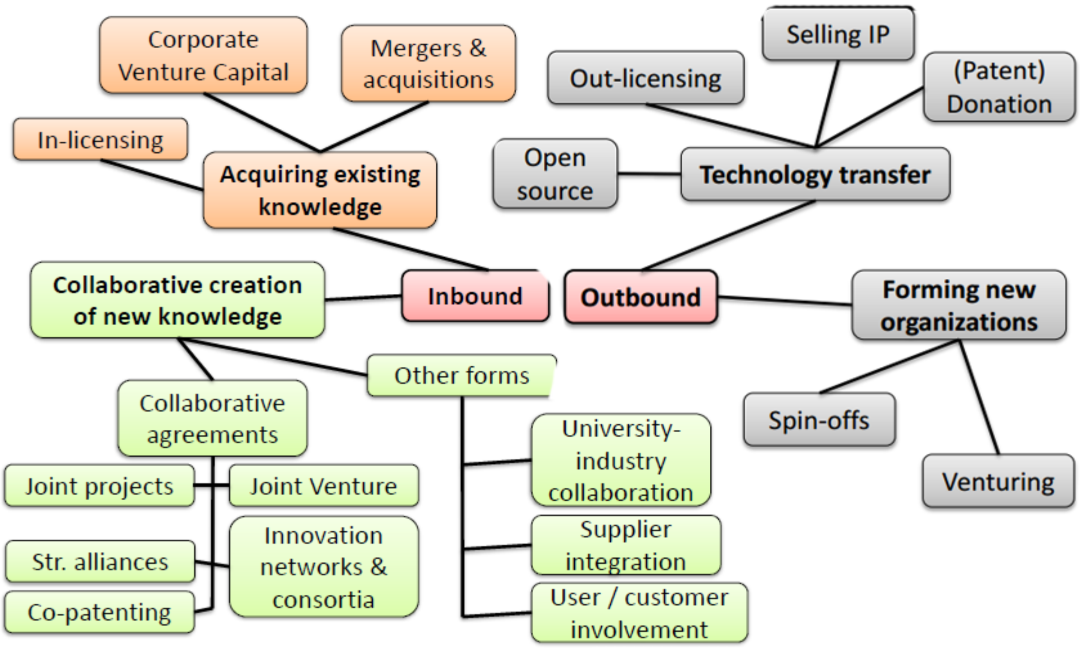

Figure 4 – Open Innovation mechanisms (Torkkeli, 2007)

Before talking about technology sourcing and inbound innovation it is important to mention the role of internal technology sourcing and R&D departments in Open Innovation paradigm. Usually, internal R&D requires high financial investment. Compared to external technology sourcing it is more time consuming and complex process. Major advantage of internal R&D process it that it is considered to be the source of competitive advantage (Herzog, 2008). However, the Burgelmann, Christensen and Wheelwright (2004) mentioned that only large firms can afford such kind of internal R&D that is able to result in new technologies.

According to Cohen and Levinthal (1990) absorptive capacity is a firm's "ability to recognize the value of new information, assimilate it and apply it to commercial ends" (p. 128). Cohen and Levinthal (1990) state that firm's prior knowledge is needed to source relevant technology outside of company's boundaries. Moreover, absorptive capacity is important for implementation of external technologies, and also for integration of these technologies with internal innovation process.

2.5. Inbound Open Innovation

According to Chesbrough and Crowther (2006), inbound Open Innovation means the practice of using external sources of innovation, and outbound innovation refers to benefiting from innovation using pathways to market lying outside of firm's boundary. This chapter will be related to brief explanation of inbound Open Innovation activities. According to Figure 4, inbound open activities can be divided into existing knowledge acquisition and collaborative creation of new knowledge.

2.5.1. Acquisition of existing knowledge

Corporate venture capital is one of inbound modes of technology sourcing. According to Dushnitsky and Lenox (2005), corporate venture capital investment refers to a situation when established firm is making investments in small innovative start-ups. The major motivation for such investments is to monitor technological developments at early stages and learn about emerging technologies as well. The investing firm obtains the possibility to learn, but also enter new market or technological field if technology or idea appears to be promising. Thereby, corporate venture investment allow firm to defer significant investments, which is important in case of emerging technologies because of high degree of uncertainty. One advantage of this Open Innovation mechanism is that in case when technology does not turn out to be successful, the minority equity stakes can be sold and the investments might be returned. This means high reversibility of such investments. Also, corporate venture investments allow firm new learning possibilities with the low level of commitments. The advantage of this mechanism over joint ventures is that corporate venture investments give the firm access to the full portfolio of technologies, while joint ventures allow access only to technologies that partnering firms bring to the venture (Herzog, 2008).

In-licensing is one of the most common ways to source technology (Ford and Saren, 2001). In-licensing means exploitation of other firm's technology within a certain timeframe. Firm that in-license technology has to pay a fixed fee plus fee based on sales. Also contract may specify markets for technology use. The major advantage of in-licensing is faster access to technology, compared to internal development and lower risks. Potential problems include search for technology and restrictive licensing conditions (Herzog, 2008).

Mergers and acquisitions in context of inbound innovation refer to complete integration of the target firm's technological portfolio. Basic motives for using mergers and acquisitions for technology sourcing are: acquiring a technological base and shortcutting the R&D process when firm is a late entrant in a technology area (Arora and Gambardella, 1990). Acquisitions usually involve high level of financial commitment and the process of acquisition is highly irreversible.

2.5.2. Collaborative creation of new knowledge

Companies might use various forms of strategic alliances for co-development new product or technology. Strategic alliance is a form of collaboration between firms when they collaborate in order to achieve common strategic goal. Basic forms of strategic alliances are joint ventures and joint R&D agreements (Herzog, 2008).

Joint venture is a new organization in which several firms own equity. Each firm brings to join venture knowledge or technology that the other firm does not have. Also, one firm might bring to joint venture its technological capabilities, and another firm – its market capabilities. Thereby, the first firm becomes able to commercialize its technology in case it is not even familiar with the market. Joint ventures might be beneficial when innovation projects involve large capital stakes and increase in size and scope. Joint ventures provide good information flows, coordination between firms and control that might be critical in the process of technology sourcing. However, the main risk of joint venturing is organizational risk: dependence on new organizations or external partners. That is why, according to Tidd, Bessant and Pavitt (2005) only 45% of all joint ventures were considered as successful, according to mutual agreement of all partners. In context of technology sourcing joint ventures are suitable for firms missing technological capabilities. However, in case those firms possess both market capabilities and required absorptive capacity to transfer the technology, they can also in-license it (Herzog, 2008).

Joint projects and collaborative R&D agreements is non-equity form for collaborative knowledge creation. In general, they are agreements between organizations to collaborate in development new knowledge, technology, product or process. They are motivated by cost and risk sharing, and getting access to partner's technology or knowledge. Typically, research-oriented collaborations involve universities and research institutions, application-oriented collaborations involve lead-users, and process-oriented collaborations involve suppliers. Also, joint R&D projects might involve even competing organizations in case they both benefit from cooperation (Herzog, 2008).

Researchers distinguish between vertical and horizontal collaboration. Horizontal collaboration implies collaboration agreements between firms from the same industry or same level of value chain (Contractor and Lorange, 2003). According to Arora and Gambardella (1990), most of R&D collaborations focuses on specific technological subfield and are oriented on in-depth research. In case of emerging technologies it is very common to collaborate between competing firms. Brandenburger and Nalebuff (1996) use term “co-opetition” for this phenomenon. They call co-opetition the situation when firm cooperate and complement each other in creating the market and compete in dividing it. However, due to remaining competition, information flows in such agreements might be limited, since each firm focuses on its goals and might be afraid of knowledge leakage (Steensma and Corley, 2000).

Vertical collaboration involves partners at different value chain levels. They might be either customers or suppliers. Company might involve supplier in order to incorporate new technology to end product. In case of R&D projects with customers firm might aim at understanding customer’s technologies and developing system solutions. This can possibly lead to increase in customer loyalty and build switching barriers, when customer is dependent on supplier’s know-hows (Herzog, 2008).

According to Tidd and Bessant (2005), research consortia consist of several organizations working together on relatively well-specified project. They play significant role in dealing with problems too big for one company.

2.6. Outbound Open Innovation

Outbound innovation is referred to profiting from technology by bringing it to the market in pathways that lie outside of firm’s boundaries. External technology commercialization (ETC) is the main part of firm’s Open Innovation strategy. By summarizing literature related to Open Innovations, ETC can be defined as “an organization’s deliberate commercializing (exploitation) of knowledge assets to another independent organization involving a contractual obligation for compensation in monetary or non-monetary terms”

(Kutvonen and Savitskaya, 2012). Firms often do not exploit full portfolio of their technologies. These technologies might be sold or out-licensed in order to generate additional revenue. Chesbrough (2003c), West and Gallagher (2006), state that spillover of technologies to external environment occurs sooner or later. Thus, in order to profit from those technologies firm might involve outbound Open Innovation mechanisms. Kutvonen (2011) also mention strategic incentives for external technology exploitation: gaining access to new knowledge, multiplication of own technologies, learning from knowledge transfer, controlling technological trajectories, external exploitation as a core business model, exerting control over the market environment. Talking about problems related to external technology commercialization researchers point at: high complexity of knowledge transactions (Arora et. al, 2001), unclear potential of technologies that firms might simply do not see (Chesbrough, 2004), high transaction costs (Brockhoff, 1992).This chapter will be related to explanation of outbound Open Innovation activities. Basically, outbound Open Innovation mechanisms can be divided in two categories: related to technology transfer and to forming new organizations (Torkkeli, 2007).

2.6.1. Technology transfer

Speaking about external technology commercialization, many researchers refer to out-licensing. Lichtenthaler (2007) refers to a substantial increase in licensing activity of firms across industries. Out-licensing activity of the firm might be driven, for instance, by motivation to generate additional revenue (Herzog, 2008). By licensing out technologies firm can more efficiently leverage their investments in R&D. However, researchers have revealed other motivations for out-licensing technologies. Figure 5 represents other motives for out-licensing, except additional revenues.

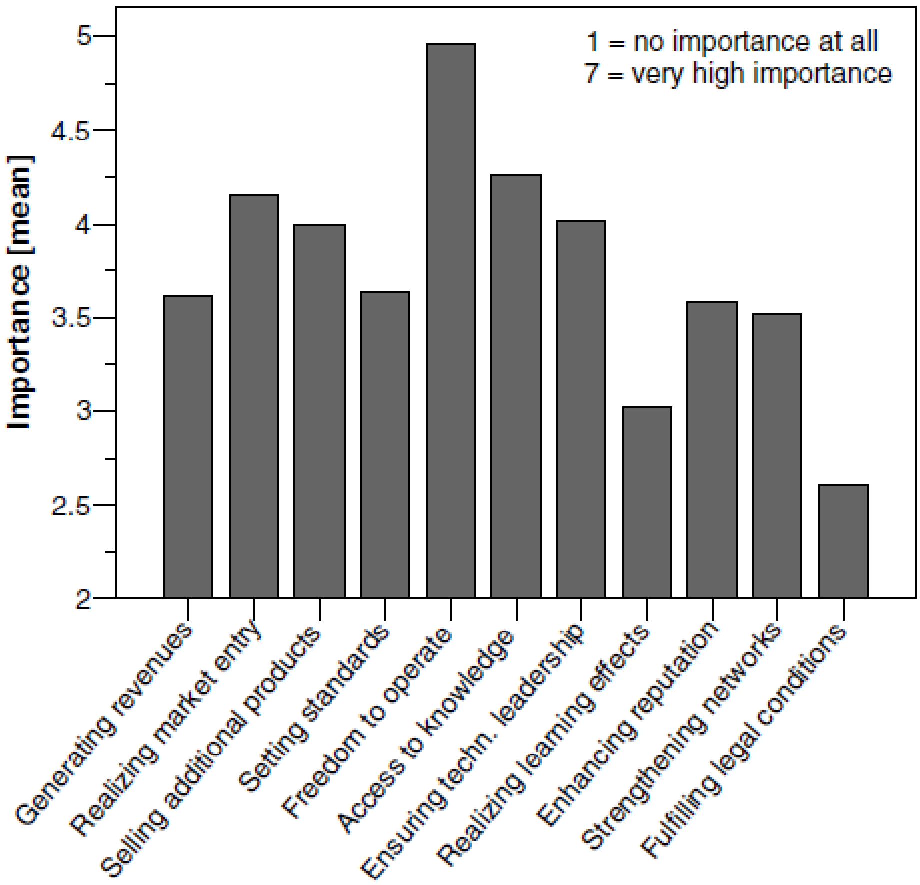

Figure 5 – Motives for out-licensing (Lichtenthaler, 2007)

According to Lichtenthaler (2007), firm position revenue generation as the seventh most important reason for out-licensing. Firms from his sample mention freedom to operate to be the most important reason. By “freedom to operate” Lichtenthaler (2007) means a type of cross-licensing agreements, in which IP rights are used in order to avoid potential lawsuits related to patent violations. Thereby, motives for out-licensing can be divided in 3 broad categories: monetary, strategic, and compulsory (Lichtenthaler, 2007). These motives are represented at Figure 6 in a structured way.

Selling IP is also referred to technology transfer to another organization in a technology sale agreement. But opposed to out-licensing it also involves transfer of technology ownership (Chiesa et. al, 2003).

Open source software is another interesting example of both outbound and inbound innovation modes. Firm might combine open source software with some proprietary components. This introduces private-collective model of innovation. Von Hippel and von Krogh (2003) mention an increase in innovation diffusion and, thereby, increase in innovation-related profits as an example of benefits referred to free revealing.

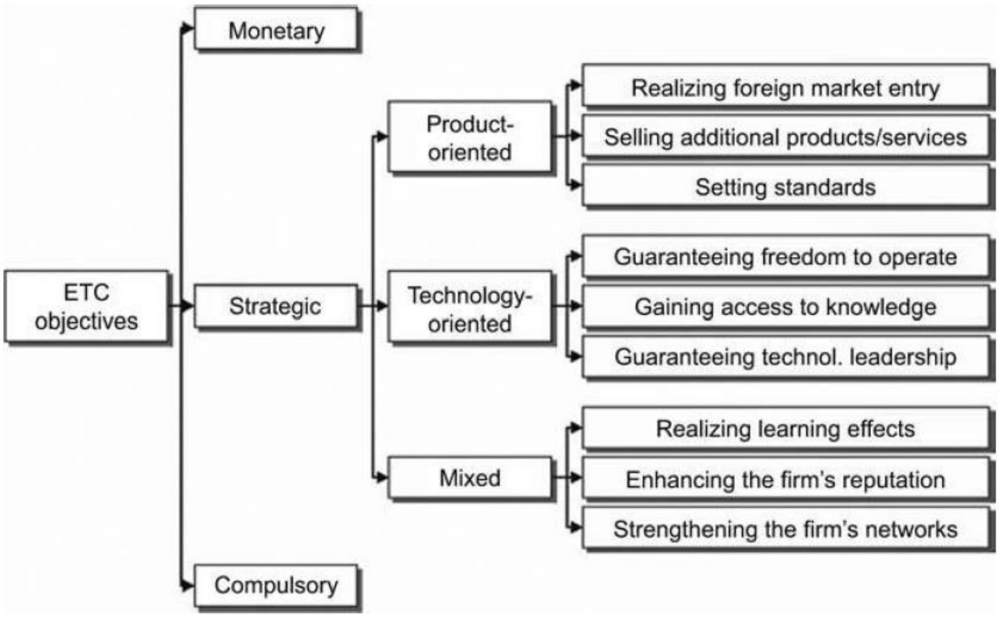

Figure 6 – Overview of the systematization of external technology commercialization objectives (Kutvonen, 2011)

2.6.2. Forming new organizations

By forming new organizations firms can also jointly commercialize a technology. Joint ventures for commercialization of new technologies involve the same logic as in case of technology sourcing: firms create a joint venture when they both possess technologies of capabilities that are complementary to each other. Joint ventures are appropriate when technology owning firm lacks market access or knowledge, or, for instance, both firms have complementary IP positions (Herzog, 2008).

Next to joint venturing, firm can also create a spin-off. Spin-offs are created by divestment of entire firm's units. Divestment of firm's units involves not only transfer of technologies, but transfer of physical assets as well. Compared to divestment of large firm units that is usually motivated by strategic reasons, a technological spin-off "is created for the purpose of commercializing one or more research discoveries outside the main business of the firm" (Chesbrough, 2003c). Typically, spin-offs are used for commercialization of research results that do not fit current company's business. This occurs for example when new technology commercialization requires different cost structure than the organization has, or a technological opportunity is too small compared to the growth objectives of organization (Christensen and Overdorf, 2000). Also technological spin-offs are suitable for commercialization of risky emerging technologies. Forming a spin-off might provide a specific environment for innovation project that protect it from resistance within main organization (Bayer, 2006).

Technology spin-offs are legally separated from main organization, and, thereby, might follow different strategies, financial and performance goals. They also can respond changing market conditions in a more flexible way. Talking about mobility of workforce, spin-offs are able to provide attractive incentive schemes such as stock options for talented employees and, thereby, motivate and retain them (Herber, Singh and Useem, 2000).

2.7. Leading Open Innovation practices and "Inbound-outbound-pecuniary-non-pecuniary" framework

Based on review of the literature and interviews with practitioners, Chesbrough and Brunswicker (2014) identified the most critical open innovation activities that can be used to cover holistic picture of open innovation implementation. The list of these activities with brief explanation is presented at Table 2.

Table 2 – Most critical Open innovation practices (Chesbrough and Brunswicker, 2014)

Inbound Practices	
Consumer and customer co-creation	Involvement of consumers or customers in the generation, evaluation, and testing of novel ideas for products, services, processes, or even business models
Information networking	Networking with other organizations without a formal contractual relationship, e.g., at conferences or events, to access external knowledge
University research grants	Funding of external research projects by researchers and scientists in universities (faculty, PhD students, or postdoctoral fellows) to access external knowledge
Publicly funded R&D consortia	Participation in R&D consortia with other public or private organizations in which R&D activities are fully or partly funded by governmental organizations (e.g., European Commission or National Science Foundation)
Contracting with	Contracting with external service providers for specialized

external R&D service providers	R&D services, including technology scouting, virtual prototyping, etc.
Idea and start-up competitions	Invitation to entrepreneurial teams and start-ups to submit business ideas via open competitive calls, with collaboration and venture support to winning teams
IP in-licensing	Licensing of external intellectual property rights (e.g., trademarks, patents, etc.) via formal licensing agreements
Supplier innovation awards	Invitation of existing suppliers to participate in innovation and submit innovative ideas
Crowdsourcing	Outsourcing innovation problem solving (including scientific problems) via an open call to external organizations and individuals to submit ideas
Specialized services from OI intermediaries	Contracting services of intermediary organizations specialized in open innovation to act as intermediary between a “searcher”-an organization with an open innovation problem-and “solvers”-a network of organizations and individuals with potential solutions
Outbound Practices	
Joint venture activities with external partners	Strategic and financial investment in independent joint ventures jointly with external partners
Selling of market-ready products	Sale of market-ready novel product idea to a third party for sale to its customers
Participation in public standardization	Participation in standardization activities via formal standardization agencies (e.g., ISO) or informal standardization consortia (e.g., OASIS)
Corporate business incubation and venturing	Corporate incubators or accelerators developing potentially profitable ideas and offering supportive environments for entrepreneurs inside the organization to identify novel paths to market
IP out-licensing and patient selling	Licensing of internal IP to external organizations via licensing agreements or selling via single payment
Donations to commons or nonprofits	Donations to commons or nonprofits (e.g., open-source communities) to support external R&D
Spinoffs	Investment in new ventures founded by firm’s employees outside organizational boundaries

These practices were also filled into “Inbound-outbound-pecuniary-non-pecuniary”, that is a matrix where main OI activities are distributed based on the direction of knowledge flow (inbound or outbound), and the presense of monetary compensation associated with the activity (pecuniary/non pecuniary). The framework was developed by Chesbrough and Brunswicker (2014) and presented at Figure 7.

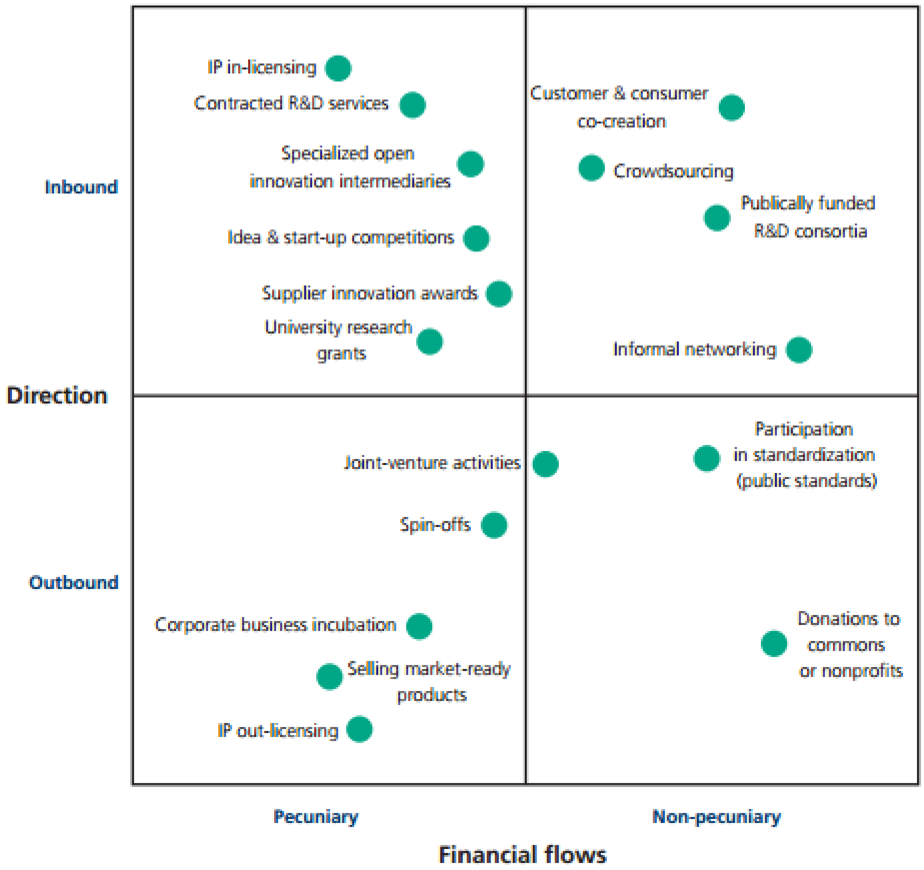

Figure 7 – Inbound-outbound-pecuniary-non-pecuniary framework (Chesbrough and Brunswicker, 2014).

2.8. Adoption of Open Innovation and context characteristics

Originally, shift towards Open Innovation model was associated with "high-technology" industries, such as computers, information technology and pharmaceuticals (Chesbrough 2003 and Chesbrough 2003b). However, a research by Chesbrough and Crowther (2006) revealed that Open Innovation concepts are finding application in companies outside of high technology sector. In their deliberately constructed sample that they made in order to identify early adopters of Open Innovation they have found, that despite the fact that firms from various industries adopt activities referred to Open Innovation, many of outbound-related activities have not been adopted yet. Chesbrough (2003b) state that firms from all industries will be migrating towards Open Innovation approach or have already done it. He notice that at that point all industries could have been "located on continuum from essentially closed to completely open". He provides nuclear-reactor industry as an example of completely close industry. Chesbrough explain this with the current situation in industry that is associated with low mobility of labor, little venture capital, weak startups and little amount of research carried out in universities. He also questions, whether this industry will migrate towards Open Innovation. Gassman (2006) also suggest nuclear and military industry to be examples of closed industries inclined to non-proliferation of technologies. Arguing further, he provides several trends that increase appropriateness of Open Innovation model for certain industries, corresponding to these trends. The trends he mentions were already presented in section related to reasons for adoption of Open Innovation: globalization, technology intensity, technology fusion, new business models and specifics in knowledge leveraging.

Huizingh (2011) states that effectiveness of Open Innovation activities is context dependent. Gassman (2006) offers contingency approach for studying Open Innovation concept that takes into account context characteristics determining effectiveness of this concept. Talking about context characteristics, Huizingh (2011) distinguishes internal and external context characteristics.

2.8.1. Internal context characteristics

By internal characteristics Huizingh (2011) means companies characteristics related to demographics and strategies. He includes number of employees, sales, profits, age, location, market share, and ownership type in demographic characteristics. By strategic characteristics Huizingh (2011) means strategic goals, aspects of innovation strategy, purposive acts that might influence innovation performance, organizational culture. The most studied internal context characteristic is size of the company. On the one hand, small companies can benefit a lot from open innovation because of their limited resources and market share. On the other hand, several research papers showed that most of open innovation adopters are large firms (Bianchi et al., Keupp and Gassmann, 2009; Lichtenthaler and Ernst, 2009; Van de Vrande et al., 2009). Possible reason for that is lack of resources for building collaborative networks and difficulties with protecting of IP rights that small firms face with. However, Huizingh (2011) notice that this difference is a field for further research, since it is not clear whether structural differences allow big companies to benefit from open innovation more than smaller firms do, or this difference is just a temporary phenomenon.

Strategic orientation, according to Huizingh (2011) influences the strength in the direction of outward looking focus. He states that in organizations with strong inward focus the effectiveness of open innovation concepts might be low. Other suggested aspects of strategy that might influence the effectiveness of open innovation are stage of innovation process, product lifecycle or focus on radical versus incremental innovations. The research by Lichtenthaler (2008) showed that firms with diversified product portfolio and focus on radical innovations tend to adopt more open innovation approach. Lee et al. (2010) studied adoption of open innovation in small and medium size enterprises and suggested that outbound innovation activities are more effective in latter stages of innovative process, since these practices were more common in commercialization phase.

2.8.2. External context characteristics

Huizingh (2011) mentions industry as the most obvious external characteristic. Literature on that issue is to some extent contradictive. As already mentioned, Gassman (2006) called nuclear and military industries to be completely closed. However, other studies (Van de Vrande et. al, 2009) showed no significant differences on trend towards open innovation across industries. Lichtenthaler (2008) noted that firms from semiconductors/electronics industry tend to rely less on external knowledge acquisition, as well as external commercialization. In conclusion, Lichtenthaler (2008) states that a degree of openness is determined by internal firm's characteristic and its individual strategic choice, rather than by industry. In research by Van de Vrande et. al (2009) industries were combined in two broad categories: manufacturing and services. In contrast with other studies, that study showed that manufacturing firms are more active at out-licensing of IP and outsourcing of R&D activities that service firms. Service firms appeared to implement more venturing activity. Comparison of these two broad categories showed no significant differences in other activities. Huizingh (2011) suggests studying external context characteristics in their relation to the application of particular open innovation practices. Among other external context characteristics he provides importance of patenting, market and technological turbulence, intensity of competition, goods versus services.

Poot et. al (2009) conducted a longitudinal assessment of adoption of outbound and inbound innovation activities and made a significant finding, that despite the shift towards open innovation model can be observed across all industries, the process is not continuous and is composed of shocks. The time of these shocks differs across industries.

Chesbrough and Brunswicker (2013) studied the adoption OI practices within different industries. The results presented on Figure 8. Figure shows that high-tech manufacturing firms widely adopt OI. Finance, insurance and low-tech manufacturing demonstrate low adoption rates (Chesbrough and Brunswicker, 2013). However, the sample was low and results cannot be generalized. Also, their study does not assess the implementation of particular OI practices, only whole OI adoption.

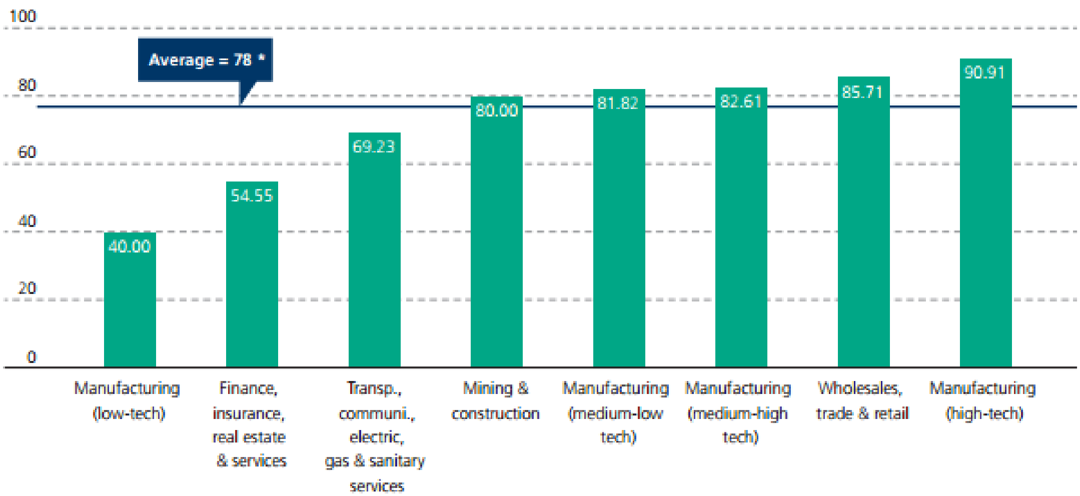

Figure 8 – Adoption of open innovation across different industries (Chesbrough and Brunswicker, 2013)

The results of previous research on the influence of context characteristics on the adoption of open innovation are to some extent contradictive: some studies state that OI strategy is more a matter of individual firm's decision (Lichtenthaler, 2008), others notice differences in OI adoption (Chesbrough and Brunswicker, 2013; Poot et. al, 2009) and implementation of particular activities across industries (Van de Vrande et. al, 2009). The aim of this Master's thesis is to study the interdependencies between the type of industry and implementation of particular open innovation practices. Further literature review describes OI implementation within the context of various industries.

2.9. Open innovation in chemical industry

Chemical industry is a process dominated industry. Majority of the products from the industry are intermediate products and many firms operate in b2b sector (Albach et. al, 1996). Eidam et. al (2014) also mention the importance of R&D intensity, that according to Gassman (2006) is one of the factors that increases relevance of open innovation paradigm for the industry.

Eidam et. al (2014) investigated the reasons for OI adoption within B2B chemical industry, as well as scale and scope of OI implementation within the industry. The research also aimed at finding patterns related to successful implementation of open innovation activities.

Among the reasons for non-adoption of OI Eidam et. al (2014) mention a high importance of process innovation within chemical industry. Process innovation is hard to protect by patents and this prevents firms from IP in- and out-licensing. Among other barriers respondents mentioned lack of resources and doubts in the relevance of OI approach for the industry.

However, 52% of respondents implemented at least some of OI activities. Respondents from the study by Eidam et. al (2014) mentioned mainly offensive motives for the implementation of open innovation such as new product development and new markets exploration. As less important, respondents mentioned defensive motives such as staying competitive and reducing R&D costs.

Respondents from the sample also stated that they see OI as a tool for searching new ideas. The research also shows that most of the firms tend to internalize external knowledge rather than exploit innovations externally. This means the prevalence of inbound innovation within the industry. Among the tools used for inbound innovation respondents mentioned: expert workshops, patent analysis, and customer visit teams. Eidam et. al (2014) also state that widespread in other industries concepts like innovation challenges for end consumers are rarely used. For outbound open innovations, companies use mainly joint projects and university collaboration. Many companies perceive collaborative research and joint projects as the most promising OI tools.

2.10. Open innovation in pharmaceuticals and biotechnology

Pharmaceuticals and biotechnology is an industry associated with high technology intensity, complex innovative processes, heterogeneity of required competences, importance of technology transfer mechanisms for the whole industry, intense cooperation between firms within industry, universities and research centers and high involvement of venture capital. These characteristics make the industry a fertile ground for the adoption of open innovation approach (Chiaroni et. al, 2009).

Chiaroni et. al (2009) investigated drivers of the adoption of open innovation, organizational modes and practices through which companies in bio-pharmaceutical industry open up their innovation processes. They used an expert panel in order to identify organizational modes related to open innovation in bio-pharmaceuticals, and also to explain their quantitative data. Their study provide typical example of discovery and development process in bio-pharmaceutical industry. Figure 9 illustrates this process.

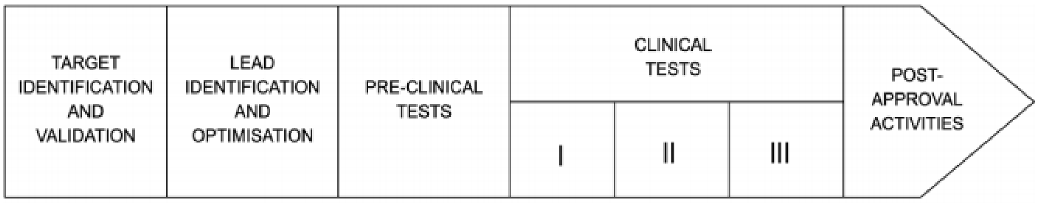

Figure 9 – Discovery and development process in bio-pharmaceutical industry (Chiaroni et. al, 2009)

Target identification and validation phase aims to identify a pathogenic gene or protein that is pathogenic for particular disease, as well as to investigate interactions between target and human organism. Lead identification phase aims at finding compound that cures selected disease. Lead optimization is the process of finding additional substances that increase stability or other properties of active component. Pre-clinical tests stage includes studying "the mechanisms of absorption, distribution, metabolism, excretion and toxicology of the new drug" and evaluation of the drug's effect on animals. Clinical tests are basically divided into three steps and involve human patients. During first stage researchers assess safety and safe dosage in a small group of people (20-80 people). Second stage involves larger groups (100-300) and aims at identification of side effects and risks. Third stage involves large groups of people (1000-3000). Third stage aims to confirm the effectiveness of the drug and its risk-benefit ratio. After third stage of clinical tests and the approval of public authorities, the drug reaches the market. Post-approval activities includes "purchasing, production, logistics, marketing and sales and post-marketing tests for the new drug" (Chiaroni et. al, 2009).

Chiaroni et. al (2009) distinguish two phases of drug discovery and development process: "generation" of innovation, and "exploitation". At first step inbound open innovation modes prevail, second step involves more outbound practices. The separating point between these two phases is a point between pre-clinical tests and clinical tests. The end of pre-clinical tests is a point at which properties of a new drug allow its commercial exploitation.

For these two steps, Chiaroni et. al (2009) describes appropriate open innovation modes. Generation of innovation stage involves collaboration in generation of innovation, purchase of scientific services and in-licensing. Collaboration in generation of innovation involves cooperation with other firms or universities with the aim to achieve a common objective. Purchase of scientific services in fact means outsourcing some part of research and development process. In-licensing in bio-pharmaceuticals involves buying a certain technology or a candidate drug from another biotech firm that might be protected by IP rights.

Exploitation of innovation stage in bio-pharmaceuticals includes collaboration for the exploitation, supply of scientific services, and out-licensing. Collaboration for the exploitation is partnering with firm that has some complementary assets that are required to benefit from the innovation. Companies from bio-pharmaceuticals out-license to other biotech company rights to use the candidate/drug it has developed (Chiaroni et. al, 2009).

Stages of new drug development and open innovation practices prevailing at each step are presented at Figure 10.

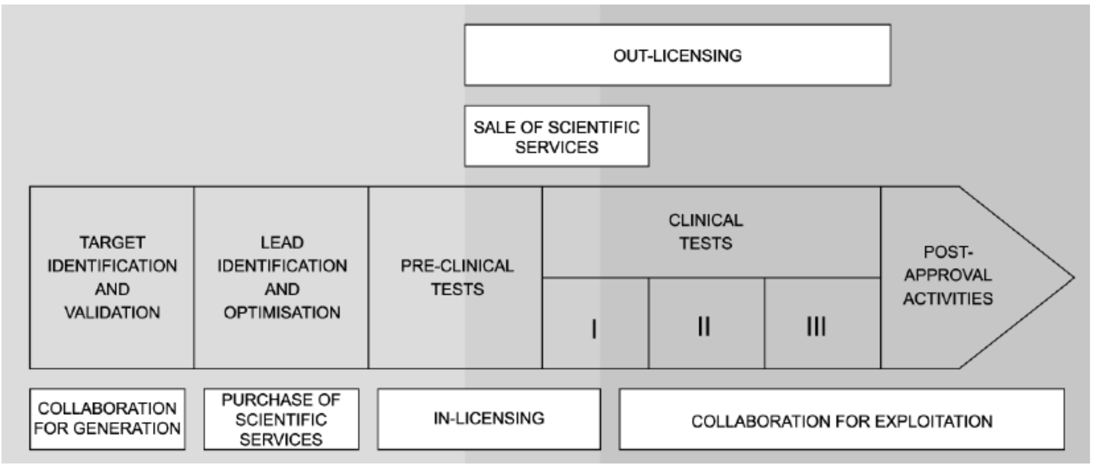

Figure 10 – Open innovation modes and their position along the phases of the drug discovery and development process (Chiaroni et. al, 2009)

Going further, Chiaroni et. al (2009) notice prevalence of open innovation modes at the stage of generation of innovation. They argue that this tendency allows top players of the market in searching for innovations and business development. They explored open innovation modes in biotech firms from 2000 to 2005 and point out at growth of inbound innovation modes. They also notice the importance of in-licensing and its tendency to increase its relative weight among other open innovation practices. It is interesting that the growth occurs mainly by substitution of collaborative innovation. Chiaroni et. al (2009) also mention that growing biotech firms that are able to use their revenues to finance their own R&D activities tend to use in-licensing more actively than collaborations. They state that although in-licensing is relatively more expensive mode than collaborative innovation, it better protects intellectual property and helps to reduce risks of technological spillovers. It also provides higher independence and management of drug discovery and development. Majority of in-licensing activities occurs in market areas with tough competition, which are focused by top players. In-licensing in latter stages of product development actively contributes to filling the product pipeline and also increases the rate of market introduction of new drugs that is important for top players in the market. It also helps to reduce risks of product development that are very high within the industry.

Chiaroni et. al (2009) observe a downtrend at the use of outbound open innovation modes from 2000 to 2005 year. However, at commercialization stage they notice growth at collaborations. They explain the need for collaborations in commercialization phase as the need to expand geographical coverage. They also observe a significant downtrend in out-licensing. Chiaroni et. al (2009) argue that in pharmaceuticals firms use out-licensing as a second best option after collaborations, when they cannot find appropriate partner, or when the product is outside of their market focus. Also, out-licensing is used in early stages of development in minor therapeutic areas in order to reduce risks and investments in further development.

2.11. Open innovation in food industry

Costa & Jongen (2006) describe food industry as mature and conservative in type of innovations, with low level of R&D investment. End consumers are cautious of radically new products and conservative in consumption patterns. This fact combined with the necessity to meet legal requirements in terms of safety makes product and process innovation in food industry complex and risky. Consumers require unique flavors, convenience in cooking, healthy diets and meeting their individual preferences. Such requirements cause the need for new business models and innovative technological solutions. Advances in related sciences and technologies offer a huge amount of opportunities to meet customer requirements (Juriaanse, 2006).

Managing innovation in food industry is complex and requires cooperation of all actors within the value chain in order to meet customer expectations, legislations and other requirements Costa & Jongen (2006). Moreover, many technologies (e.g. advances in nanotechnology) are being developed outside of the industry. This causes the need for formal collaboration with other entities and forming the innovation system.

Due to all mentioned above the food industry sector has a high potential for implementation of open innovation strategies (Sarkara and Costa, 2008).

The research by Sarkara and Costa (2008) summarized open innovation strategies employed so far in the food industry. First case is related to in-sourcing the technology and is illustrated by example of Procter & Gamble that established a network of potential sources of ideas. P&G in-sourced a technology of printing edible images on cakes originally developed by baker in Italy and used it in new type of Pringles potato chips with words and images (Huston & Sakkab, 2006; Sarkara and Costa, 2008).

Second case described International Flavors and Fragrances (IFF) that is a supplier of flavors in the food industry. They developed an internet-based toolkit that allowed customers to design and modify flavors by themselves. Thereby, the company in fact outsourced a part of their R&D activity to its customers, shifted the trial-and-error cycles on the shoulders of its customers and significantly lowered risks of product development. It also increased the level of customization and lowered expenses on market research (Thomke & von Hippel, 2002; Sarkara and Costa, 2008).

Third case is related to Calgene, a plant biotechnology R&D firm. Company created an innovation network that helped it to bring its genetically modified tomatoes to the market. Innovation network included “seed companies, farmers, packers, consumers and legislators”. Also, involvement of this network helped the company to deal with low customer acceptance of radically new technology (Vanhaverbeke & Cloodt, 2006; Sarkara and Costa, 2008).

Bigliardi and Galati (2013) summarized three models of open innovation within food industry: “sharing is winning” model (SiW), “food - machinery framework” and “Want, Find, Get, Manage” model (WFGM).

Figure 11 depicts SiW model. Model was proposed by Traitler and Saguy (2009). It is a model of collaborative innovation through strategic alliances and joint ventures that involves entire value chain and focuses on consumer-centric innovations (Bigliardi and Galati, 2013). The model includes in co-development universities and research institutes, start-ups and individual inventors and selected number of key-suppliers. The basic principle on which the model is based is sharing precise needs and requirements with potential innovation supplier. This model is used by Nestle company. By implementation of this model, the innovation provider owns a technology/solution and Nestle owns its smart applications.

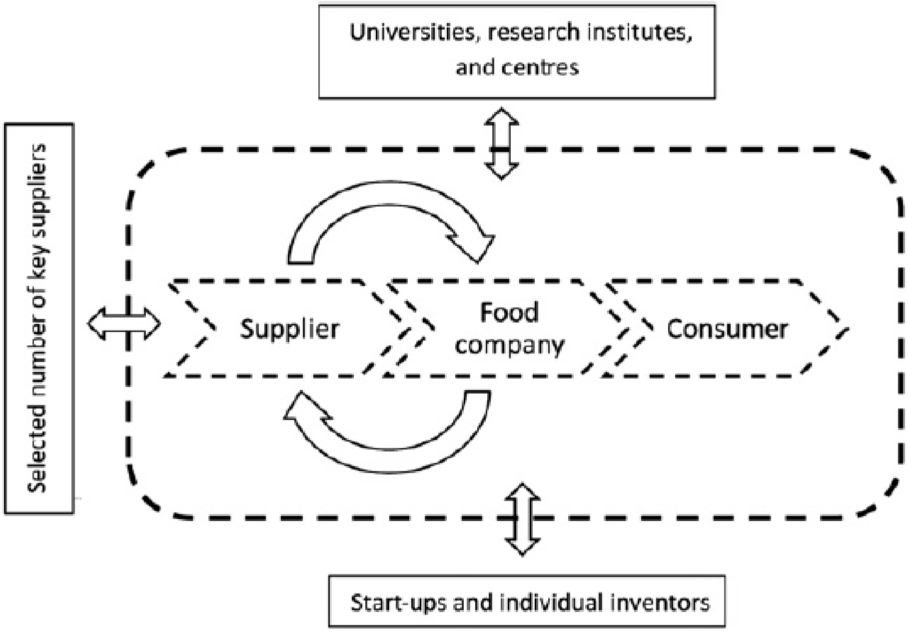

Figure 11 – The SiW model and the open food supply chain (Bigliardi and Galati, 2013)

Figure 12 depicts food - machinery framework. This model describes a particular case of supply chain and highlights an innovative role of supplier (food machinery company). The framework shows the process of customer involvement in innovation process by involving them in proactive market research, tracking modifications, and also involving them in all product development activities. Regarding IP protection, in this model food machinery company forms tacit agreements with the supplier, and more formalized agreements with customer (IP patenting).

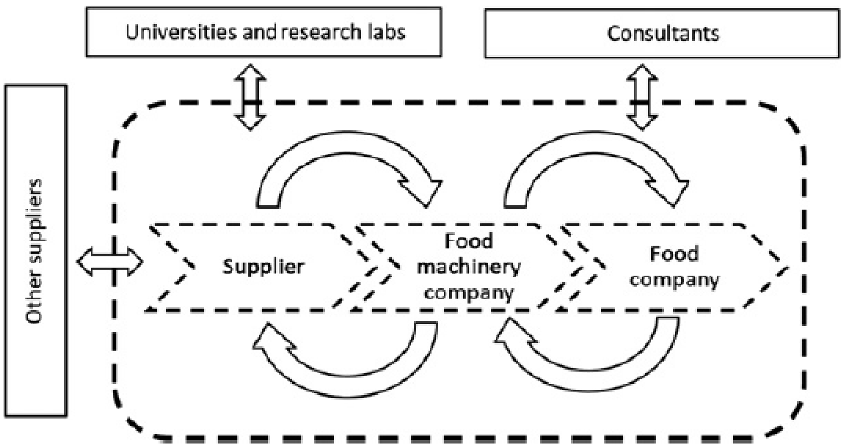

Figure 12 – The food-machinery framework and the open food supply chain (Bigliardi and Galati, 2013)

The Want, Find, Get, Manage model was developed by Slowinski (2004) and presented at Figure 13. Model determines time and way, how external knowledge should be implemented in the innovation process. The first step in this framework (Want) means that the company should determine, which knowledge it needs to acquire externally. Step "Find" is related to finding the appropriate partner. Step "Get" consists of knowledge acquisition. A successful "Get" requires setting up mutually beneficial solution with each partner. "Manage" stage means coordination of partner's resources in order to achieve common goals. It requires understanding of what information should be exchanged and way how is should be done (Bigliardi and Galati, 2013).

The WFGM framework is successfully implemented within the firm Mars. In second and first steps Mars operated within an ecosystem that looks similar with Figure 13, and has 20 defined criteria to select both the right partner and the mode of collaboration. In order to manage co-creation of knowledge Mars uses cross-functional team that systematically does open innovation activities. Team also deals with IP management and selects the right form of knowledge protection. Mars mainly uses non-disclosure agreements and other forms of collaboration based on trust and forming good relationships, instead of IP licensing. Thereby, company relies more on collaborative knowledge creation, than, simple purchasing IP (Bigliardi and Galati, 2013).

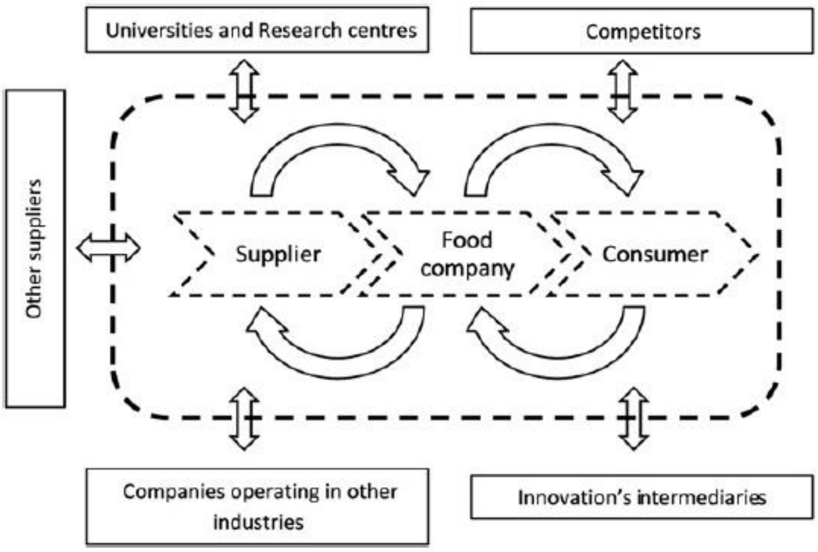

Figure 13 – The WFGM model and the open food supply chain (Bigliardi and Galati, 2013)

Table 3 provides summary of three models described and points at main actors that are involved in the OI process. WFGM model is the only one that includes interaction with the customer. Models provide different approaches to the same phenomenon. WFGM model offers highest adoption of OI within the company. It is quite difficult for implementation and requires changes in entire organizational structure, requires creation of cross-functional team to make OI activities systematic (Bigliardi and Galati, 2013).

Table 3 – Main actors involved in the OI process in OI models within food industry (Bigliardi and Galati, 2013)

Main actors involved in the OI process in the three models.								
Model	**Actors**							
	Suppliers	**Consumers**	**Customers**	**Universities and research labs**	**Competitors**	**Companies operating in other industries**	**Innovation's intermediaries**	**Others**
SiW model	**V** (large ingredient and packaging suppliers)	–	**V** (large retailers)	**V**	–	**V**	–	**V**
Food–machinery framework	**V** (medium and large companies)	–	**V** (large food company)	**V**	–	–	–	**V**
WFGM model	**V** (large companies and SMEs)	**V**	–	**V**	**V** (large companies and SMEs)	**V** (large companies and SMEs)	**V**	**V**

Bigliardi and Galati (2013) also argue that the easiest way of IP sharing within the food industry is when "the competency-providing partner owns every physical solutions (such as ingredients or technologies), while the receiving part (i.e., the food company) owns the smart applications of these solutions".

2.12. Open innovation in telecommunication services

Gassman (2006) argues that telecommunication industry is well suited for the open innovation approach. Grotnes (2009) states that telecommunication industry made a significant shift towards open innovation. Surprisingly, literature on open innovations in telecommunication industry is very limited and mainly consists of case studies.

Case study by Grotnes (2009) addresses standardization as the central issue of the paper. The process of standardization is not just a process of "recording and stabilizing existing practices or capabilities", but rather a process of co-development in the development of new products and services. Grotnes (2009) names this process "anticipatory standardization". In his research paper he provides two case studies related to standardization in telecommunication industry: Android project by Open Handset Alliance; and Open Mobile alliance.

The Android project is mainly associated with Android platform. It is a software for mobile phone that includes operating system, middleware and applications. Software development kit provides third-party developers to develop applications for the platform. Application developers can access mobile phone functionality through standardized interfaces and have access to libraries used in the development of the system. One of the goals of Open Handset Alliance is to sell more devices based on android system in order to facilitate the use of mobile services and create revenues for operators. The platform is free and the development cost for manufacturers and developers is lower than for other platforms. Regarding IP rights, Grotnes (2009) states that applications can be either open source or proprietary for developers. This combination in fact is a private-proprietary model of innovation (Von Hippel and von Krogh, 2003). Also, members of Open Handset alliance contributed parts of their IP to the project at the time of project creation (Grotnes, 2009). This process fully corresponds to the open innovation approach described by Chesbrough (2003). First, Google acquired external knowledge, and then created a developer toolkit in order to find external use of its IP. Android system is an architectural innovation. The idea is to facilitate radical innovations by providing toolkit to developers (Grotnes, 2009).

Open Mobile alliance (OMA) is the largest consortium related to standardization in the mobile industry. It has free membership. Open Mobile Alliance creates specifications and standards for new functionality and services for mobile devices. Most of specifications provide possibility to create new end-user services or better operation of mobile device. Specifications are incorporated within the architecture where connections to other enablers are shown. Enablers have interfaces towards each other, end user and underlying infrastructure. Open Mobile alliance developed OMA Service Environment for the development of new services (Grotnes, 2009). The structure of the environment is presented on Figure 14.

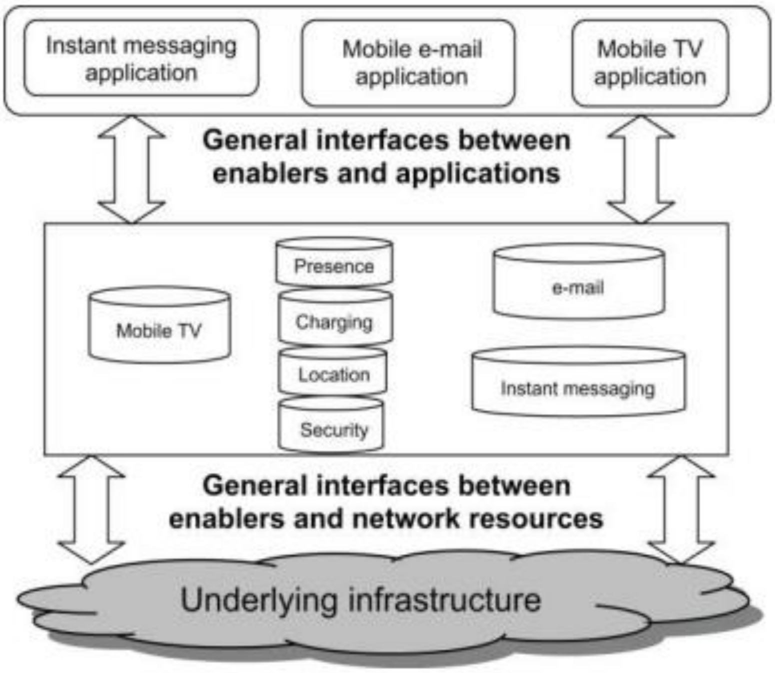

Figure 14 - The OMA service environment (Grotnes, 2009)

Specification in OMA consists of several stages that include: idea generation, development of the enabler and negotiation on "agree on the content of the requirements, architecture and the technical specifications". Companies usually try to include IPR in specifications or system architecture. Working in OMA companies provide their intellectual property and technical expertise as an input in collaborative R&D, creation of architectures, specifications and frameworks (Grotnes, 2009).

Both alliances provide a platform that might act as a foundation for further innovations. While OMA provides possibility to innovate within the architecture, Android platform provides possibility to innovate on the top of existing platform. Android project provides toolkits to third parties, while Open Mobile alliance uses collaborative efforts and resources for innovations (Grotnes, 2009).

2.13. Open innovation in software development industry

In software industry one of the most well-known examples of open innovation is open source software. Open source software requires collaboration between developers themselves, customers, suppliers, manufacturers of related products. Final product/technology is available to customers at little cost or is free. Open source software derived as an attempt to decrease the dependence on proprietary software developers (West & Gallagher, 2006).

Open source software differs from the proprietary software by the way of production and intellectual property philosophy. Open source software requires free distribution, open source code and the right to modify the software (West & Gallagher, 2006).

West and Gallagher provide four open source strategies that software development firms used in order to benefit from external innovation: pooled R&D, spinouts, selling complements, donated complements (West & Gallagher, 2006).

In case of pooled R&D firms use collaborative efforts in order to achieve common goal, and the result of pooled contributions is available to all. The role of spinouts in open source software is to spread valuable technology in order to achieve other related goals. External innovation in that case uses internally developed innovation for further development. Motivation for further innovation is free access to valuable technology. By selling complements, company is trying to use external innovation as a basis for internal development. Donation of complements is used in the following way: a company benefits from the core product and provides a platform for further development. One of the examples is game development, when a developer gives users a tool for further development. Users develop various scenarios, modify the original product. Even though it does not bring direct revenue, is extends relatively short period of demand for original product. Moreover, publisher might identify distinct customer need from the popularity of distinct product modification and create his own new product (West & Gallagher, 2006).

One of the key issues of the open source software is the attractiveness for potential contributors. Game development industry provides several solutions that are also applicable for entire open source. First solution is minimization of technical obstacles for contributors. Contributors should be provided with tools or software development platforms in order to be able to easily modify the original product or build on its basis. Second solution is creation of infrastructure that offers users a possibility to collaborate and encourages participation. Third solution is to offer contributors visibility and recognition for instance by giving awards or promotion (West & Gallagher, 2006).

West & Gallagher (2006) also states that companies are reluctant in adoption of open innovation and starting to implement it when there is no alternative option. Firms also start with open source strategies that do not strongly affect their strategy (e.g. selling complements). Also, open source software is not the only one form of open innovation in software development industry, and other forms like outsourcing R&D for complementary software are also presented.

2.14. Open innovation in automotive industry

A research by Ili et. al (2010) showed that automotive industry is appropriate for open innovation approach, however it still tends to rely on closed innovation paradigm. In their quantitative study they analyzed industry trends that according to Gassman (2006) are related to appropriateness of open innovation concept. These trends were already presented in this Master's thesis in the section related to reasons for OI adoption. Respondents were asked how these trends correspond to automotive industry, and how respondents did anticipate these trends in 10 years perspective. The results of the survey are presented at Figure 15.

Results show that open innovation paradigm is already appropriate within the industry, and will be more important in 10 years perspective. Respondents anticipated significant growth in technological intensity and relevance of new business models. It means high relevance of open innovation approach for automotive industry (Ili et. al, 2010).

Further investigating, Ili et. al (2010) analyzed to which paradigm automotive industry tends to. For this purpose Ili et. al (2010) asked respondents to choose which statement related either to close or to open innovation paradigm rather reflected their firm's attitude. Statements were developed by Chesbrough (2003) to explain differences between open and closed innovations.

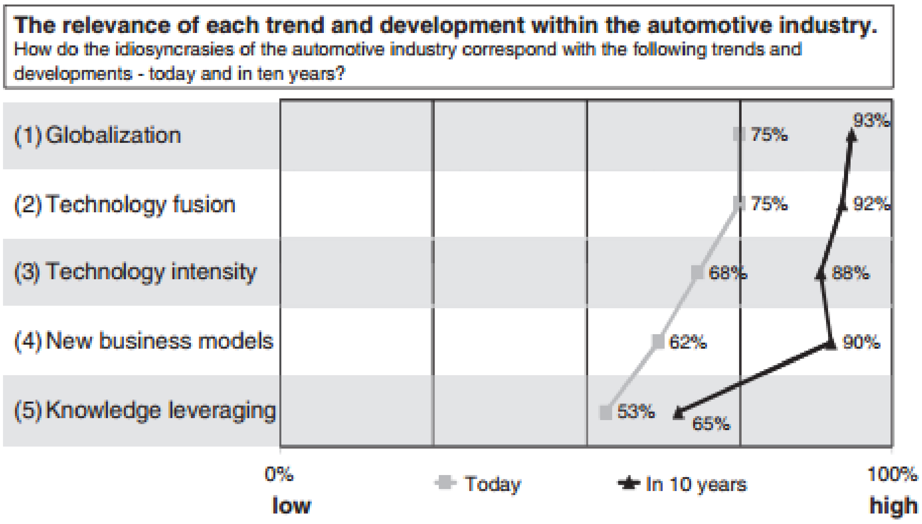

Figure 15 - The relevance of Open Innovation in the automotive industry (Ili et. al, 2010)

The results presented at Figure 16 show that currently automotive industry tends to closed innovation. However, Ili et. al (2010) notice changes in mindset regarding the origination of ideas and innovations. Majority of respondents mentioned the role of own R&D in accordance with closed innovation model. Ill et. al (2010) connect shift in attitude regarding research with increase in cost pressure within the industry.

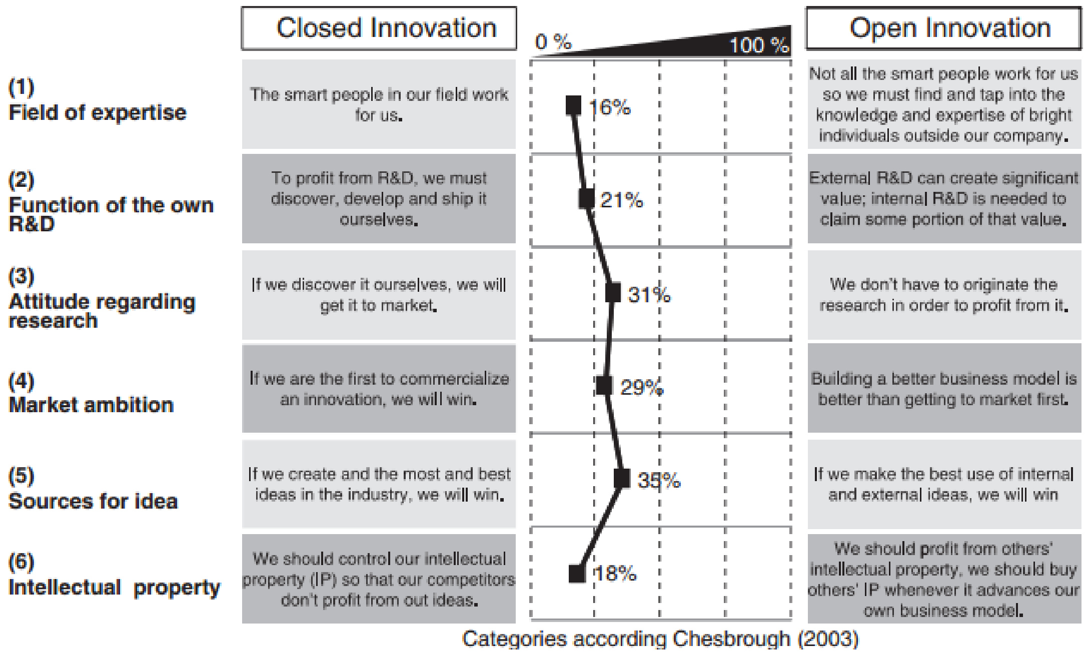

Figure 16 - The status quo of Open Innovation in the automotive industry (Ili et. al, 2010)

Exploring external sources for innovation and external paths to the market Ili et. al (2010) mention customers to be the main source for innovation, followed by competitors and suppliers. Respondents also mention governmental regulations as an additional source of innovations. Other sources show small relevance, however firms also use knowledge from other industries, provide financial support to start-ups. Regarding licensing activity Ili et. al (2010) notice defensive nature of IP protection. Most of license parties are competitors. However, during semi-structured interviews respondents told about “plenty of patent garbage” and focus of engineers only on automotive industry without attempts in finding external exploitation.

Typical methods for external technology sourcing are presented at Figure 17. Product presentations through other firms and reverse engineering are mentioned most often. Firms also use scouting for searching potential innovations and passive web-based methods. These methods allow engineers from outside the company to submit their ideas.

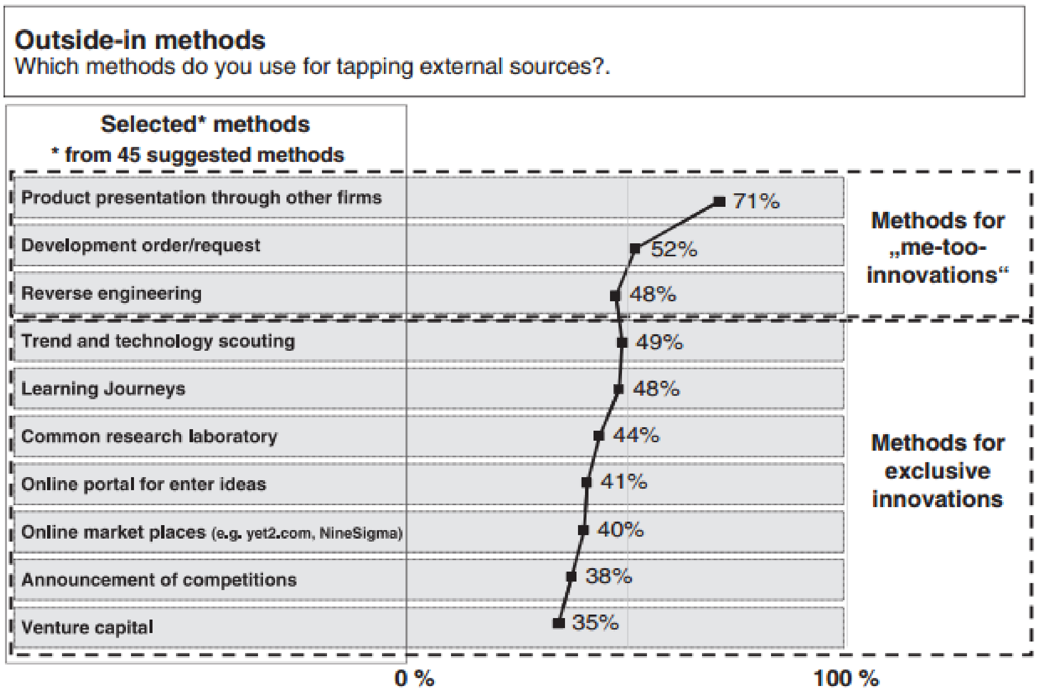

Figure 17- Outside-in methods in the automotive industry (Ili et. al, 2010)

Regarding out-licensing and knowledge exploitation Ili et. al (2010) argue that there is no mindset towards active out-licensing. Firms grant licenses mainly on request. However, only one of the respondents claimed use of active out-licensing to get additional revenue. Interestingly, this respondent also stated that their company indeed is gaining profit from this strategy, that they consider new business model. Most commonly used inside-out methods are: reciprocal licensing agreements, licensing, alliances and joint ventures. Inside-out methods are mainly used for defensive purposes also. Inside-out open innovation methods used in automotive industry are presented at Figure 18.

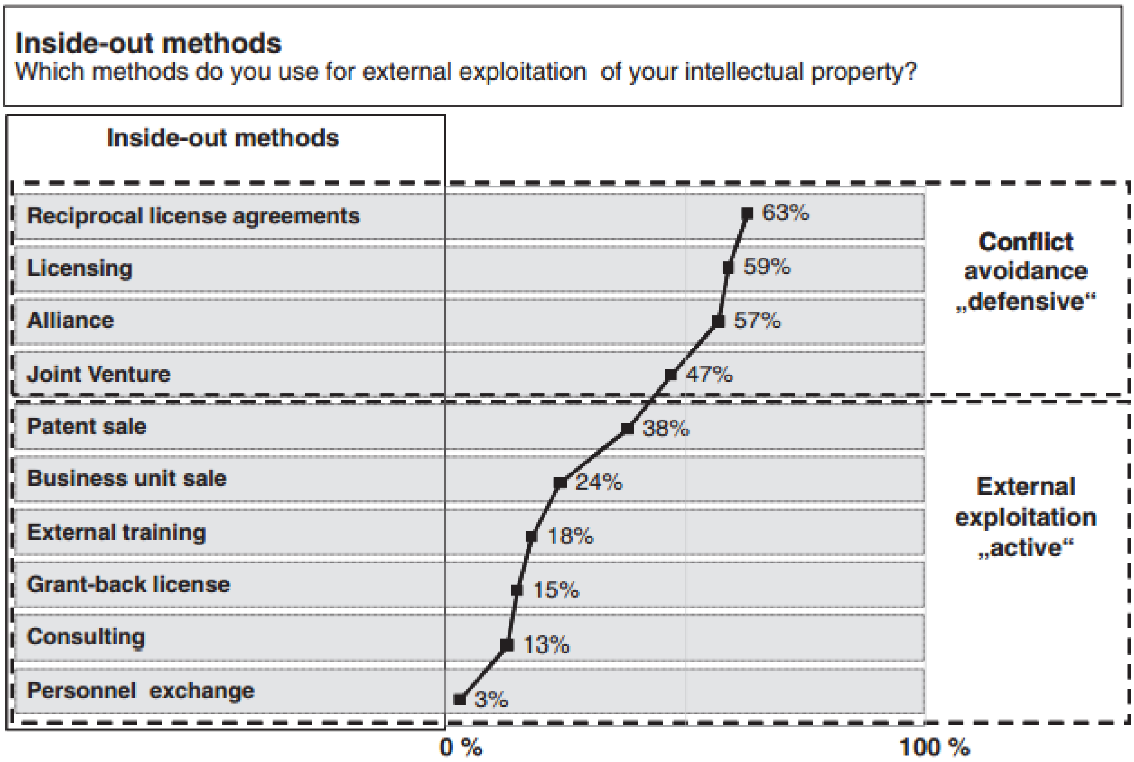

Figure 18 - Inside-out methods in the automotive industry (Ili et. al, 2010)

Ili et. al (2010) also mention barriers for OI adoption within the industry. First barrier is understanding that external technologies might influence badly the brand image. Own R&D has no time and space for adaptation of external ideas. Another barrier is the absence of top-down request for integration of OI approach. This barrier is also mentioned by several studies on open innovation theme as important. Also there is absence of incentive system, processes and methods that support active sale of IP and IP out-licensing.

2.16. Open innovation in service and manufacture enterprises

Previous studies shows that implementation of open innovation differs across industries. However, it might be useful to study differences using more broad categories such as service and manufacturing. Services differ from physical goods. (Van de Vrande et. al,

2009) argues that they differ "in terms of intangibility, inseparability, heterogeneity and perishability". Considering different offerings between these categories there is a probability in different ways of implementation of open innovation practices. Van de Vrande et. al (2009) suggested that for physical goods it seems easier to outsource R&D or to in-source new technology. The example from process-oriented chemical industry (Eidam et. al, 2014) that experiences difficulties in IP protection for process-related technologies confirms this suggestion.

Industry features described by Gassman (2006) are also more relevant for manufacturing firms: manufacturing firms are more technologically intensive, operate in large geographical industries, more influenced by globalization and require more investment in R&D (Van de Vrande et. al, 2009). Therefore, van de Vrande et. al (2009) suggested higher level of OI adoption across manufacturing firms.

A research by van de Vrande et. al (2009) included only small set of possible open innovation practices. Results showed that there are several differences between service and manufacturing firms in terms of open innovation activities. As expected, manufacturing firms appeared to be more active in technology exploration: results for R&D outsourcing and IP in-licensing were higher than for service firms. Service firms appeared to be more active in venturing activities. Customer involvement and networking appeared to be most adopted OI activities by both groups.

2.17. Open innovation in high- and low-tech enterprises

Originally, open innovation approach was associated with high-tech industries. This new paradigm was mainly applied and studied based on cases within these industries (Gassman, 2006). Chesbrough and Crowther (2006) studied early adopters of this approach and have found that it is already widespread. However, they have noticed that many of the outbound-oriented practiced have not been adopted by the time of their study, and inbound practices are dominant. They also suggest that outbound practices might already occur, but their respondents did not mentioned or detect them as open innovation.

Chiaroni et. al (2011) made a case study in order to understand the relevance of open innovation beyond high-tech industries, and to study how open innovation is being implemented in practice in low-tech industries. They have found prevalence of inbound activities; argue that the main reason for accessing to external knowledge in low-tech enterprises is to minimize risks by using and investing in technologies that have already proved by other applications.

Fine (1999) introduced a concept of "clockspeed" for industries that in fact means a speed of changes in product and process development, speed of changes in organizational structures. He also calls it "industry own evolutionary life cycle". Enkel, Gassman and Chesbrough (2009) referred electronic, IT and other high-tech industries to fast clockspeed category. They state that fast clockspeed companies actively use in-licensing, to much higher degree than out-licensing. In their sample 43% of companies had in-licensing policies, and only 36% had out-licensing. Talking about collaborative innovation and co-creation with external partners, Enkel et. al (2009) argue that the percentage of joint R&D projects differs across industries within various clockspeed categories. For companies within "electrical, electronic, IT and other high-tech industries, the number of joint R&D projects comprises almost 50% of all R&D projects within a company". For slow clockspeed industries the number of joint R&D projects comprised 20% or less. The number was especially low in leather, wood and printing industries.

Segarra-Cipres et. al (2012) studied whether the technological environment of the firm influences opening up the innovation process. Their results showed that firms related to more R&D intensive sectors explore knowledge from external sources more intensively than firms from less R&D intensive sectors. However, they found no significant differences in exploitation of these sources. In their study, Segarra-Cipres et. al (2012) also notice that despite the existence of differences between high- and low-technology sectors, significant differences within the same sector can be observed. They argue that opening up innovation process differs not only at industries level, but within the same industry as well. Regarding to open innovation practices, they studied differences related to various types of collaboration with external partners: customers, competitors, suppliers, universities. The difference in the extent to which this collaboration is being implemented by high- and low-tech firms was significant.

Hagedoorn and Duysters (2002) indicate that firm's environment plays an important role in the way how new knowledge is being created. They argue that high technology-intensive industries require flexible forms of collaboration between firms such as technological alliances. In the circumstances when knowledge quickly becomes out of date it is more efficient way for creation of new knowledge than creation within the organization. Hagedoorn and Duysters (2002) state that due to reasons mentioned above, firms from high technology-intensive sectors exploit higher number of external sources.

There is a lack of literature on adopters of open innovation in settings that differ from high-tech (Westergren, 2012). The research related to early adopters of open innovation by Chesbrough and Crowther (2006) is quite old; therefore, it would be interesting to study differences in current adoption of open innovation practices between high- and low-tech enterprises in a quantitative way.

2.18. Theoretical framework and hypothesis

The aforementioned review of academic articles on the issue of open innovation highlights how open innovation paradigm is implemented across several industries and what is special about them. Results of the review are compiled in Table 4.

Table 4 - Industries and forms of Open Innovation

Industry	Industry characteristics	What forms of OI are used
Chemical	Process-dominated, mainly b2b-oriented (Albach et. al, 1996).	Process innovations are hard to protect that prevents firms from in- and out-licensing. OI as a tool for seeking new ideas. Expert workshops, patent analysis, and customer visit teams. Collaborative research and joint projects as the most promising tools. Low use of innovation challenges and competitions for end-consumers (Eidam et. al, 2014).
Pharmaceuticals and biotechnology	High technology intensity, complex innovative processes,	High importance of in-licensing. In-licensing is used more often

	importance of technology transfer mechanisms, intense cooperation between firms within industry, universities and research centers, high involvement of venture capital. High risks of product development (Chiaroni et. al, 2009).	than collaborations. In licensing decreases risks of product development and help firms to fill product pipeline. Use of collaborations to increase geographical coverage. Out-licensing as a second best option after collaborations. Use of out-licensing at early stages of product development in order to reduce risks and further investments (Chiaroni et. al, 2009).
Telecommunication and services	Importance of creation of industry standards (Grotnes, 2009).	Strong focus on standardization. Standardization as a mean for collaborative creation of innovations (Grotnes, 2009). Use of open-source software (Von Hippel and von Krogh, 2003; Grotnes, 2009). Platforms for developers (Grotnes, 2009).
Software development	Industry has always been open	Open source software, co-development, users as a source of innovations. Companies provide users platforms for further development. More traditional forms of OI like R&D outsourcing are also presented (West & Gallagher, 2006).
Automotive	Growth in technological intensity, governmental regulations as a driver for	Reverse engineering, innovation intermediaries, ideas crowdsourcing, collaborative

	innovations (Ili et. al, 2010).	research projects, no mindset towards active out-licensing, “defensive” licensing strategy, absence of top-down request for integration of OI approach (Ili et. al, 2010).
Food	Mature and conservative in the type of innovations. End consumers are cautious of radically new products and conservative in their consumption patterns. Strong legal requirements in terms of safety make innovations risky. Demand for convenience, healthy products, meeting of individual preferences (Costa & Jongen, 2006).	Using networks of potential sources for innovations, crowdsourcing of ideas (Huston & Sakkab, 2006; Sarkara and Costa, 2008). Involvement of suppliers and customers to innovative efforts (Thomke & von Hippel, 2002; Sarkara and Costa, 2008). Co-development and tacit agreements for IP protection, non-disclosure agreements instead of IP-licensing (Bigliardia and Galatib, 2013).

The review shows that mature and traditional industries already implement open innovation; however, each industry has its own features related to implementation of particular activities. These differences in multiple cases are related to industry specifics. Consequently, the following hypothesis is proposed:

H1: Intensity on implementation of open innovation practices is associated with firm’s type of industry

Service and manufacture firms are expected to implement OI activities differently due to the nature of service and physical goods (Van de Vrande et. al, 2009). Research that involved small set of OI practices showed few differences for these categories that are presented in Table 5. Both groups show high involvement of customer in innovation activities; high use of networking.

Table 5 - Differences in used OI practices for service and manufacture firms.

Service firms	More active in venturing activities (van de Vrande et. al, 2009).
Manufacturing firms	Active in technology exploration: higher results for outsourcing and IP in-licensing (van de Vrande et. al, 2009).

For service and manufacture firms, the following hypothesis is proposed:

H2: The intensity on the implementation of open innovation practices is different for service and manufacture firms

H3: Current level of OI adoption is higher for manufacture rather that for service

Open innovation is relevant beyond high-tech industries (Chesbrough and Crowther, 2006); several studies show or suggest differences in implementation of OI activities between these categories (Chiaroni et. al, 2011; Segarra-Cipres et. al, 2012; Enkel et. al, 2009). High-tech firms are claimed to use licensing activities more actively than low-tech (Enkel et. al, 2009). Several studies (Segarra-Cipres et. al, 2012; Enkel et. al, 2009) also point at the higher level of collaborations with external partners: universities, customers; these studies mentions the higher amount of joint projects as well. In general, high-tech firms tend to be higher adopters of OI approach. For high- and low-tech industries the following hypothesis are proposed:

H4: The intensity on the implementation of open innovation practices is different for high- and low-tech firms

H5: Current level of OI adoption is higher for high-tech enterprises rather that for low-tech

In order to measure OI performance and make a holistic picture Chesbrough and Brunswicker (2014) suggested the list of OI activities derived from literature and interviews with practitioners presented at Table 6.

Table 6 - List of OI activities suggested by Chesbrough and Brunswicker (2014).

Inbound	**Outbound**
Customer and consumer co-creation	Joint venture activities with external partners
Information networking	Selling of market-ready products
University research grants	Participation in public standardization
Publicly funded R&D consortia	Corporate business incubation and venturing
Contracting with external R&D service providers	IP out-licensing and patent selling
Idea and start-up competitions	Donations to commons or non-profits
IP in-licensing	Spinoffs
Supplier innovation awards	
Crowdsourcing	
Specialized services from R&D intermediaries	

The aforementioned assumptions and findings on relationships between industry and OI practices will be tested on wider set of OI practices offered by Chesbrough and Brunswicker (2014). The modified list of practices and methods is presented in methodology section.

3. METHODOLOGY

This section is devoted to methodological approach used in the study. This section is divided into several subsections. Each subsection describes particular aspect of the research. “Research design” describes research strategy used, aligns research questions with hypothesis and objectives. “Data collection” describes the way how primary and secondary data was collected. “Data analysis” presents structure and sequence of analysis. “Methods” section describes methods used in the analysis.

3.1. Research design

This research focuses on the issue of open innovation activities and their implementation in terms of industry differences. Main research goal is to summarize industrial differences related to implementation of OI activities, make a coherent review and find possible explanations for these differences. Therefore, the following main research question is stated:

“Are there differences in the implementation of particular open innovation practices by firms that are caused by the industry that firm operates in?”

In order to achieve research goals and answer main research question, five research questions were formulated. Table 7 provides summary of research questions, research hypothesis, and objects of analysis.

Table 7 - Research design

Research objective	**Research Question**	**Hypothesis**
To analyze industrial differences in implementation of OI activities	RQ1: What are industrial differences in the prevalence of implementation of particular open innovation activities?	H1: Intensity on implementation of open innovation practices is associated with firm’s type of industry
	RQ2: What is the difference in	H2: The intensity on the implementation of open innovation

	implementation of open innovation activities for firms in service and manufacturing sectors?	practices is different for service and manufacture firms H3: Current level of OI adoption is higher for manufacture rather that for service
	RQ3: What is the difference in implementation of particular open innovation activities by firms of different technological intensity?	H4: The intensity on the implementation of open innovation practices is different for high- and low-tech firms H5: Current level of OI adoption is higher for high-tech enterprises rather that for low-tech

Research strategy of this study is survey. Following from main research question and research goals this research is a quantitative descriptive and explanatory study. The main research objective of the study is to analyze industrial differences in implementation of OI activities. Therefore, quantitative research appears to be the most appropriate methodology.

The research includes analysis of quantitative data received from the survey. It aims at answering RQ1-RQ5 and as a result will provide structured analysis of how OI is implemented in various industries.

Prior literature provides theories related to open innovation, and also a review of several industries in terms of implementation of OI practices. However, these studies do not summarize and compare implementation of OI practices depending on the type of industry. The amount of cross-industrial studies on OI with the focus on analysis of the difference in OI adoption between industries is low. For several industries no quantitative research on the topic has been found, and most of research was based on case studies and interviews. **Research purpose** is to find interdependencies between the type of industry and implementation of OI practices and make a coherent review of industries showing differences in implementation of these practices.

3.2. Data collection

The research involves quantitative data collection and analysis. Within current research primary data was collected using survey. Data from academic articles related to research questions was also used as secondary data.

Data for the purposes of the research was collected for European project OI-net which aim is to integrate OI in higher education in Europe and improve standards in innovation education across Europe (oi-net.eu, 2013). Data collection included two steps: development of a questionnaire for survey, and data collection itself.
For the purpose of questionnaire development OI activities from academic literature sources were analyzed. Existing questionnaires and consultant reports were also used. Questionnaire was assesses by experts, improved and piloted in 15 firms. Results from pilot study also proved that developed measures are adequate. Feedback from pilot study was collected and implemented in final version of survey, and a large-scale survey was launched. Main language of survey was English, but it was also available in 12 other languages.

During data collection stratified sampling was used, by criteria of economic significance of top 5-10 industries in countries. Geographical area covered by survey includes all major European regions. Countries at different stages of development based on Global Competitiveness report were included. Survey was launched in September 2014 and finished in June 2015. Key respondents of the survey were managers, directors and vice-directors in companies. Response rate is on average 10%.

Total amount of responses is 525. 38 countries were included in the analysis. For the purposes of the research, only private companies were included in analysis; therefore, 461 companies remained for the analysis.

3.3. Data measures

For the purpose of this master's thesis several variables from original dataset were used. Main variables used in the analysis are adoption of various open innovation activities. Each variable corresponded to particular activity associated with open innovation. Survey included 13 activities that derived from Chesbrough and Bruswicker (2013), were evaluated by OI experts and modified during the process of survey development. In the survey companies were asked to assess the level of adoption of each particular open innovation activity with 8-point Likert scale from zero to seven, where zero responded to non-adoption and eight corresponded to very intense use. List of variables corresponding to OI activities is presented in Table 8.

Table 8 – Variables responding to adoption of OI activities

№	Variable	Label
1	RDConsumCocreation	Customer and consumer co-creation in R&D projects
2	Crowdsourcing	Crowdsourcing
3	ExtIdeasScan	Scanning for external ideas
4	CollabInnov	Collaborative innovation with external partners (i.e. suppliers, universities, competitors…)
5	RDSubcontr	Subcontracting R&D
6	IdeaStartUpComp	Idea & start up competitions
7	ExtNetwork	Using external networks (e.g. associations, intermediaries, knowledge brokers)
8	Standardization	Participation in standardization (public standards) / influencing industry standards
9	FreeReveal	Free Revealing (e.g. Ideas, IP) to external parties
10	IPinlicense	IP in-licensing
11	IPoutlicense	IP out-licensing
12	ExtTechAcquis	External technologies acquisition
13	SellingUnusedTech	Selling unutilized / unused technologies
14	OI_status	Overall open innovation adoption level

To analyze industrial differences the type of industry was used as another variable. Respondents were offered with 28 options of industries. List of offered industries (Table 7) derived from Industry Classification Benchmark (Industry Classification Benchmark, 2016). Table 9 represents the list of industries that were offered in the survey.

Table 9 – List of industries included in the survey

Industry ID	Industry
1	Energy
2	Materials
3	Capital goods
4	Commercial and professional services
5	Transportation
6	Chemicals, petroleum and coal products
7	Automobiles and components
8	Consumer durables and apparel
9	Hotels, restaurants and leisure
10	Media
11	Retailing
12	Food and staples retailing
13	Food, beverages and tobacco
14	Household and personal products
15	Healthcare equipment and services
16	Pharmaceuticals and biotechnology
17	Banks
18	Diversified financials
19	Insurance
20	Real estate
21	Software and services
22	Technology, hardware and equipment
23	Semiconductors and semiconductor equipment
24	Telecommunication services

25	Utilities
26	Other
27	Consulting

One more variable used in the analysis is OI status – a nominal variable responding for self-evaluation on the level of OI adoption. Variable include 5 alternatives corresponding to 5 alternatives which ranged from Stage 1 “We are not adopting and not planning to adopt open innovation” to Stage 5 “We are experienced adopters of OI (processes, procedures, and best practices are in place)”.

For making the comparison between groups of service and manufacture firms variable “Manufacture” was used. Meaning “0” was used for service firms and “1” for manufacture. The distribution of cases between groups is presented at Table 10.

Table 10 – Distribution of industries between groups: service and manufacture, and distribution of respondents

Service	Amount of respondents	Manufacture	Amount of respondents
Commercial and professional services	54	Energy	30
Transportation	18	Materials	26
Hotels, restaurant and leisure	8	Capital goods	6
Media	3	Chemicals, petroleum and coal products	11
Retailing	13	Automobiles and components	26
Food and staples retailing	5	Consumer durables and apparel	4
Banks	12	Food, beverages and tobacco	20
Diversified financials	4	Household and personal	12

		products	
Insurance	5	Pharmaceuticals and biotechnology	13
Real estate	7	Technology hardware and equipment	20
Software and services	48	Semiconductors and semiconductor equipment	4
Telecommunication services	11		
Utilities	3		
Consulting	9		
Total:	200	Total:	172

For making the comparison between groups of low- and high-tech firms variable “Hightech” was used. Meaning “0” was used for low-tech firms and “1” for high-tech. The distribution of cases between groups is presented at Table 11.

Table 11 – Distribution of respondents between groups: high- and low-tech, and distribution of respondents

Low- and mid-tech industries	**Amount of respondents**	**High-tech industries**	**Amount of respondents**
Energy	30	Pharmaceuticals and biotechnology	13
Materials	26	Telecommunication services	11
Capital goods	6	Semiconductors and semiconductor equipment	4
Retailing	12	Healthcare equipment and services	3
Healthcare equipment and services	2	Software and services	48
Technology hardware	3	Technology hardware and	10

and equipment		equipment	
Commercial and professional services	54		
Transportation	18		
Chemicals, petroleum and coal products	11		
Automobiles and components	26		
Consumer durables and apparel	4		
Hotels, restaurants and leisure	8		
Media	3		
Retailing	12		
Food and staples retailing	5		
Food, beverages and tobacco	20		
Household and personal products	12		
Banks	12		
Diversified financials	4		
Insurance	5		
Real estate	7		
Utilities	3		
Consulting	9		
Total	292	Total	89

High-tech industry classification was based on Kile and Phillips (2009). Classification is presented at Table 12. Some firms were related to opposite category by analyzing their websites. For firms related to capital goods, retailing, healthcare and equipment, software and services, and technology hardware and equipment the decision to classify it as high- or low-tech was made individually for each case.

Table 12 - High-tech industries according to Kile and Phillips (2009)

SIC Code	Industry Name	N (Percent)	Percent Matching	Percent Not Matching (Type II Errors)
283	Drugs	157 (5.0)	94.9	5.1
357	Computer and Office Equipment	82 (2.6)	96.3	3.7
366	Communication Equipment	77 (2.4)	88.3	11.7
367	Electronic Components and Accessories	83 (2.7)	98.8	1.2
382	Laboratory, Optic, Measure, Control Instruments.	56 (1.8)	73.2	26.8
384	Surgical, Medical, Dental Instruments	100 (3.2)	84.0	16.0
481	Telephone Communications	94 (3.0)	90.4	9.6
482	Miscellaneous Communication Services	8 (0.3)	100.0	0.0
489	Communication Services, NEC	19 (0.6)	94.7	5.3
737	Computer Programming, Data Processing, etc.	652 (20.8)	97.5	2.5
873	Research, Development, Testing Services	33 (1.0)	97.0	3.0
Combined sample of all of the above SIC codes		1,361 (43.4)	94.2	5.8

3.4. Data analysis

In order to compare adoption of particular open innovation practices means for each of open innovation activities were calculated. Industries that got less than 10 cases in the survey are not presented in results. Each industry was fitted into the "Inbound-outbound-pecuniary-non-pecuniary" framework applied by Chesbrough and Brunswicker (2014).

Going further, industries were divided in two groups: service and manufacture; and adoption of open innovation activities between these two groups were compared. I also conducted analysis of variances in order to test significance of differences between groups. Descriptive statistics and graph related to self-perception of OI adoption was built for both categories.

Same analysis was implemented for high- and low-tech firms: industries were divided in two groups: service and manufacture; and adoption of open innovation activities between these two groups were compared. Analysis of variances in to test significance of differences between groups was conducted. Descriptive statistics and graph related to self-perception of OI adoption was built for both categories. In order to test significance Chi-Squared test was implemented.

3.5. Methods

Analysis of variance was used to test differences in implementation of OI by industries. Analysis of variance was also used to test groups of service of manufacture firms, and high- and low-tech firms for significance in their implementation of OI activities. Despite the intensity of adoption of OI activities was assessed with 7-point Likert scale, the distance between each item is equivalent and parametric statistics can be used (Norman, 2010). Likert scale can be viewed as an interval scale, and the use of ANOVA is possible.

For comparison between service and manufacture firms an, and high- and low-tech firms for significance in adoption of Open Innovation Chi-Squared analysis was used. Variable responding for adoption of OI is OI_status. It is a categorical variable; therefore, the use of non-parametrical statistical test was required.

4. RESULTS

Appendix A provides descriptive statistics for implementation of open innovation activities among various industries. Columns are related to particular open innovation activities. The numeration of these activities is presented in Table 6. Appendix B provides ANOVA and LSD test for industries and OI practices. LSD test includes only pairs with significance level $p<0.05$.

Results show that open innovation is being implemented in most of industries to certain extent. The most adopted activities for all of the industries are: scanning for external ideas, collaborative innovation with external partners, the use of external networks, and external technologies acquisition. However, for several distinct activities some industries demonstrate significantly higher results than other. ANOVA showed statistical significance for only two activities: out-licensing ($p<0,05$) and participation in standardization ($p<0,05$).

For chemicals, petroleum and coal products mean value for customer and consumer co-creation is higher than for other industries (Mean value 5,091 for chemical industry, and 3,551 for all respondents). This industry also shows very low result for IP out-licensing and selling unused technologies and high result for scanning for external ideas.

Crowdsourcing finds higher implementation in food, beverages and tobacco (Mean 2,300), household and personal products (Mean 2,167), and software and services (Mean 2,271). Mean value of variable related to implementation of crowdsourcing for all respondents is 1,770.

Materials, pharmaceuticals and biotechnology, banks, and hardware and equipment show higher results for subcontracting R&D (3,654, 3,615, 3,750, 3,600 respectively, versus 2,831 total mean value).Food, beverages and tobacco industry implements idea and startup competitions significantly more often than other industries (3,150 for food, beverages and tobacco versus 2,265 total). Other highly-implemented activities for this industry are: customer and consumer co-creation, crowdsourcing, and free revealing. Other activities are close to mean values for all respondents.

Energy industry shows significantly higher result ($p<0,05$) for participation in standardization (4,567 for energy industry versus 3,154 total).

Automotive industry mostly implements scanning for external ideas (4,000), collaborative innovations (4,346), and external technology acquisition (3,192).

Pharmaceuticals and biotechnology show highest values for IP in- and out-licensing (3,231 versus 1,714 total for in-licensing; 3,538 versus 1,315 total). This industry is also quite active in collaborative innovation with external partners and subcontracting R&D. The difference for IP out-licensing is statistically significant ($p<0,05$).

One more industry that shows deviations from other industries is telecommunication and services. This industry is most active in selling unused technologies than all other industries included in the analysis (3,909 versus 1,516 total). It also shows quite high result for external technology acquisition and significantly differs at participation in standardization ($p<0,05$).

For deeper analysis of OI implementation by certain industries, data variable responding for the intensity of OI adoption was recoded. OI activities with adoption intensity higher than 4 were coded as high coded as high intensity (H), from 2 to 4 is medium intensity (M), and below 2 is low intensity (L).

The "Inbound-outbound-pecuniary-non-pecuniary" framework applied by Chesbrough and Brunswicker (2014) was filled with OI activities and they were colored according to the level of adoption by certain industry. Industries included in the analysis are numerated in Table 13. This numeration is applied in Tables 14 and 15.

Table 13 – Industries numeration

№	Industry
1	Energy
2	Materials
3	Commercial and professional services
4	Transportation
5	Chemicals, petroleum and coal products
6	Automobiles and components

7	Retailing
8	Food, beverages and tobacco
9	Household and personal products
10	Pharmaceuticals and biotechnology
11	Banks
12	Software and services
13	Technology hardware
14	Telecommunication services

Table 14 provides “Inbound-outbound-pecuniary-non-pecuniary” framework for industries numbered from 1 to 7. Table 15 provides same framework for industries numbered from 8 to 14. Sample average was put at column “A”.

Table 14 Open Innovation Strategies Matrix - High (H), Medium (M), Low (L) for industries 1 to 7

	Pecuniary	*Industry №*								*Non Pecuniary*	*Industry №*							
		A	*1*	*2*	*3*	*4*	*5*	*6*	*7*		*A*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Inbound	5. Subcontracting R&D	M	M	M	M	M	M	M	M	1. Customer co-creation in R&D	M	M	H	M	M	H	M	M
										2.Crowdsourcing	L	L	L	L	L	L	L	L
										3. Scanning for external ideas	H	M	H	H	H	H	M	M
	6. Idea & start-up competitions	M	L	M	M	L	M	M	M	4. Collaborative innovation with external partners	H	M	H	M	M	H	H	M
	10. IP in-licensing	L	M	M	L	L	L	L	L	7. Using external networks	M	M	M	M	M	M	M	M
	12. External technology acquisition	M	M	M	M	M	M	M	M									
Outbound	11. IP out-licensing	L	L	L	L	L	L	L	L	9. Free Revealing	L	L	M	L	L	L	L	L
	13. Selling unused technologies	L	L	L	L	L	L	M	L	8 Participation in standardisation	M	H	M	M	M	M	M	M

Table 15 - Open Innovation Strategies Matrix - High (H), Medium (M), Low (L) for industries 8 to 14

	Pecuniary	*Industry №*								*Non Pecuniary*	*Industry №*							
		A	*8*	*9*	*10*	*11*	*12*	*13*	*14*		*A*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Inbound	5. Subcontracting R&D	M	L	M	M	M	M	M	M	1. Customer co-creation in R&D	M	M	H	M	M	H	M	M
										2.Crowdsourcing	L	M	M	L	L	M	L	L
										3. Scanning for external ideas	H	M	H	H	H	H	M	H
	6. Idea & start-up competitions	M	M	M	L	M	M	M	M	4. Collaborative innovation with external partners	H	H	H	H	H	H	H	H
	10. IP in-licensing	L	L	M	M	L	M	M	M	7. Using external networks	M	M	M	M	M	M	M	M
	12. External technology acquisition	M	M	M	H	H	M	H	H									
Outbound	11. IP out-licensing	L	L	L	M	L	L	L	L	9. Free Revealing	L	M	M	L	M	L	L	M
	13. Selling unused technologies	L	L	L	L	L	L	L	M	8 Participation in standardisation	M	M	M	M	H	M	M	H

Following from Tables 14 and 15 we can clearly see the prevalence of outbound and non-pecuniary open innovation activities for majority of industries.

Most of industries demonstrate low adoption of outbound pecuniary activities. The sample average is low as well. The only exceptions are pharmaceuticals that exhibit moderate adoption of out-licensing, and automobiles and telecommunications that exhibit moderate adoption of selling unused technologies.

All industries show high or moderate adoption of collaborative innovation and scanning for external ideas. Sample average is also high. Moreover, all inbound non-pecuniary activities except crowdsourcing are highly or moderately implemented. Three industries show moderate use of crowdsourcing: food, household products, and software and services.

Regarding outbound non-pecuniary part of matrix it can be concluded that free revealing don't find wide implementation, however, several industries moderately implement it: food, household products, technology hardware, banks, telecommunications, and materials. Sample average is low. Several industries show high rate of implementation of participation in standardization: banks, telecommunication and services and energy. Sample average for standardization is "Moderate".

Inbound pecuniary activities are mostly low or moderately-implemented. However, several industries show high rate of implementation for external technology acquisition that differ from "Moderate" average value: pharmaceuticals, banks, technology hardware and telecommunications. Despite relatively low adoption rate of in-licensing activities in average, several industries such as energy, materials, household and personal products, pharmaceuticals, software and services, technology hardware, and telecommunications moderately use this activity. All industries show moderate use of subcontracting R&D except food, beverages and tobacco.

Interestingly, most industries moderately use idea and start-up competitions, and sample average is "moderate" but energy, pharmaceuticals, and transportation show low level of adoption.

Table 16 provides descriptive statistics on OI activities for service and manufacture enterprises. Numeration of variables responding for implementation of each OI activity is presented in Table 8. I also applied analysis of variances to analyze significant differences in the level of adoption of various OI activities between these two groups. For these two groups current OI status was also analyzed. Results are presented in Table 17 and Figure 25.

To summarize, industries show different patterns in implementation of OI activities, and different industries prefer one OI practices to others. ANOVA show significant differences in implementation of IP out-licensing and participation in standardization. Consequently, H1 is confirmed.

Table 16 - Mean values of open innovation activities for service and manufacture enterprises.

Manufacture/Service		1	2	3	4	5	6	7	8	9	10	11	12	13
Service	Mean	3,415	1,875	4,350	4,035	2,705	2,475	3,380	2,900	1,995	1,585	1,335	3,035	1,450
	N	200	200	200	200	200	200	200	200	200	200	200	200	200
	Std. Deviation	2,4108	2,2572	2,2701	2,2155	2,3399	2,5871	2,3608	2,4679	2,2225	2,2468	2,1226	2,5090	2,1682
Manufacture	Mean	3,628	1,541	4,192	4,715	2,977	2,099	3,070	3,488	1,843	1,942	1,442	3,674	1,634
	N	172	172	172	172	172	172	172	172	172	172	172	172	172
	Std. Deviation	2,6003	2,1036	2,1960	2,1013	2,2684	2,2049	2,1264	2,6034	2,1037	2,2729	1,8863	2,2785	2,0858
Total	Mean	3,513	1,720	4,277	4,349	2,831	2,301	3,237	3,172	1,925	1,750	1,384	3,331	1,535
	N	372	372	372	372	372	372	372	372	372	372	372	372	372
	Std. Deviation	2,4990	2,1910	2,2345	2,1871	2,3080	2,4220	2,2578	2,5450	2,1668	2,2629	2,0148	2,4231	2,1296

Table 17 - OI status descriptive statistics for service and manufacture firms

	OI_status											
	1,0		2,0		3,0		4,0		5,0		Total	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Service	46	23,5%	34	17,3%	51	26,0%	41	20,9%	24	12,2%	196	100,0%
Manufacture	37	21,8%	25	14,7%	53	31,2%	30	17,6%	25	14,7%	170	100,0%

Figure 19 represents data from Table 16. Collaborative innovation with external partners, scanning for external ideas, customer and consumer co-creation appear to be the most adopted open innovation activities for both categories. However, analysis of variances (Table 18) showed few significant differences in mean values for collaborative innovation with external partners ($p<0,05$), participation in standardization ($p<0,05$), and external technologies acquisition ($p<0,05$). Manufacturing enterprises are more inclined to implement collaborative innovation with external partners (4,715 for manufacturing firms and 4,035 for service industry) and participate in standardization (3,488 for manufacturing and 2,9 for service). External technology acquisition also appears to be more widespread across manufacturing firms (3,674 for manufacturing and 3,035 for service industry). Consequently, H2 is rejected; however, for several OI practices the difference is statistically significant.

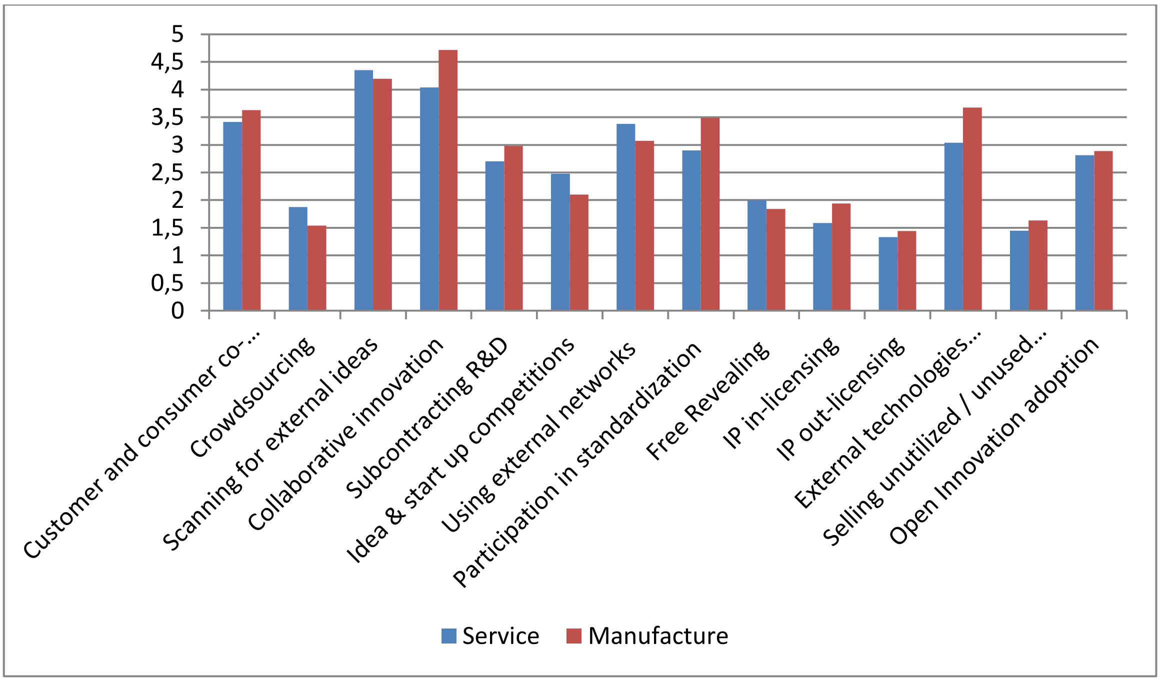

Figure 19 – Open innovation adoption in service and manufacture firms

Table 18 - Analysis of variances for service and manufacturing firms

			Sum of Squares	df	Mean Square	F	Sig.
Customer and consumer co-creation in R&D projects * Manufacture/Service	Between Groups	(Combined)	4,192	1	4,192	,671	,413
Crowdsourcing * Manufacture/Service	Between Groups	(Combined)	10,335	1	10,335	2,160	,143
Scanning for external ideas * Manufacture/Service	Between Groups	(Combined)	2,313	1	2,313	,462	,497
Collaborative innovation with external partners (i.e. suppliers, universities, competitors…) * Manufacture/Service	Between Groups	(Combined)	42,774	1	42,774	9,139	,003
Subcontracting R&D * Manufacture/Service	Between Groups	(Combined)	6,829	1	6,829	1,283	,258
Idea & start up competitions * Manufacture/Service	Between Groups	(Combined)	13,085	1	13,085	2,238	,136
Using external networks (e.g. associations, intermediaries, knowledge brokers) * Manufacture/Service	Between Groups	(Combined)	8,900	1	8,900	1,749	,187
Participation in standardization (public standards) / influencing industry standards * Manufacture/Service	Between Groups	(Combined)	32,013	1	32,013	4,996	,026
Free Revealing (e.g. Ideas, IP) to external parties * Manufacture/Service	Between Groups	(Combined)	2,136	1	2,136	,454	,501
IP in-licensing * Manufacture/Service	Between Groups	(Combined)	11,776	1	11,776	2,308	,130
IP out-licensing * Manufacture/Service	Between Groups	(Combined)	1,056	1	1,056	,260	,611
External technologies acquisition * Manufacture/Service	Between Groups	(Combined)	37,808	1	37,808	6,535	,011
Selling unutilized / unused technologies * Manufacture/Service	Between Groups	(Combined)	3,121	1	3,121	,688	,407

Figure 20 presents results for self-perception of current open innovation status of the company and represents data from Table 17. For service and manufacture categories no significant pattern can be observed corresponding to self-perception of open innovation.

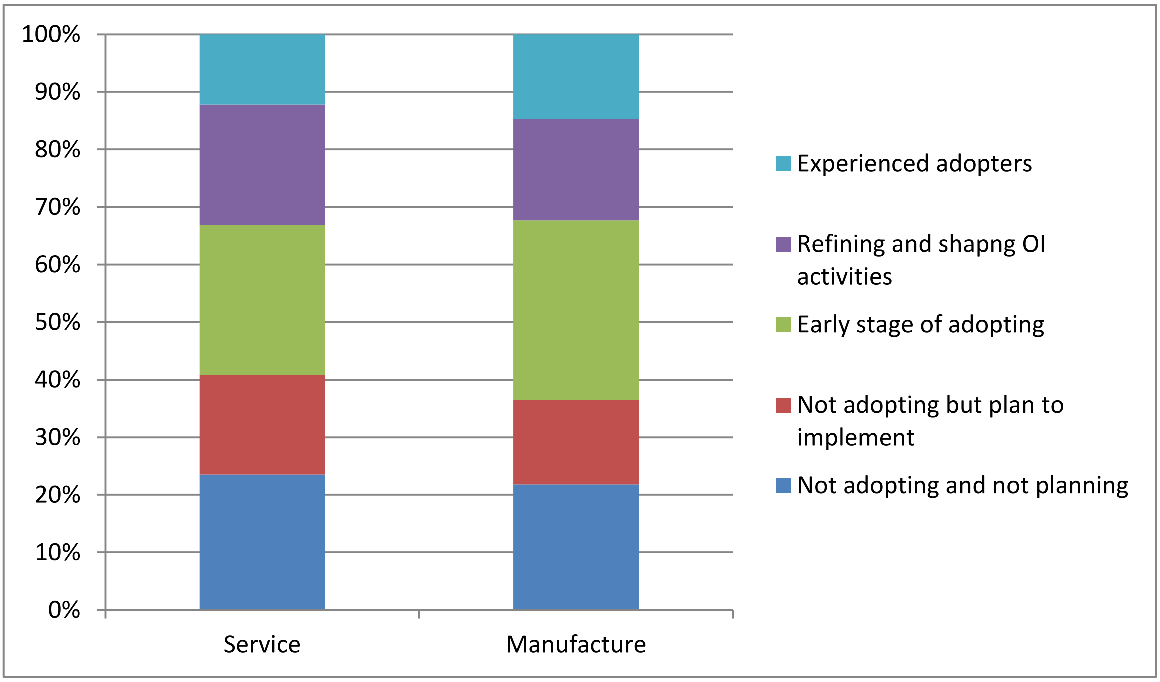

Figure 20 – Self-perception of open innovation in service and manufacture firms

In order to test significance, Chi-Squared test was used.

Table 19 - Chi-Square test for service/manufacture firms

	Manufacture/Service	OI_status
Chi-Square	2,108[a]	31,991[b]
df	1	4
Asymp. Sig.	,147	,000

a. 0 cells (0,0%) have expected frequencies less than 5. The minimum expected cell frequency is 186,0.

b. 0 cells (0,0%) have expected frequencies less than 5. The minimum expected cell frequency is 90,8.

The results of chi-square test show that the difference not enough to be statistically significant (p=0,147).Therefore, H3 is rejected.

In Table 20 mean values of each open innovation activity are compared for high-technology and low-technology enterprises. Numeration of variables responding for implementation of each OI activity is presented in Table 8. For these two groups current OI status was also analyzed. Results are presented in Table 21 and Figure 26.

Table 20 - Mean values of open innovation activities for high- and low-tech enterprises.

High-tech		1	2	3	4	5	6	7	8	9	10	11	12	13
0	Mean	3,421	1,693	4,200	4,204	2,768	2,275	3,311	3,168	1,936	1,546	1,196	3,207	1,479
	N	280	280	280	280	280	280	280	280	280	280	280	280	280
	Std. Deviation	2,5090	2,1533	2,1824	2,2171	2,2828	2,3705	2,2078	2,5038	2,1241	2,1094	1,8532	2,3917	2,0669
1	Mean	3,944	1,753	4,562	4,944	3,034	2,404	3,045	3,236	1,910	2,404	1,910	3,640	1,618
	N	89	89	89	89	89	89	89	89	89	89	89	89	89
	Std. Deviation	2,4650	2,2678	2,3353	1,9792	2,4095	2,5793	2,4304	2,6757	2,3435	2,6273	2,3676	2,5192	2,2538
Total	Mean	3,547	1,707	4,287	4,382	2,832	2,306	3,247	3,184	1,930	1,753	1,369	3,312	1,512
	N	369	369	369	369	369	369	369	369	369	369	369	369	369
	Std. Deviation	2,5051	2,1784	2,2224	2,1826	2,3135	2,4196	2,2630	2,5428	2,1758	2,2714	2,0094	2,4267	2,1112

Table 21 - OI status descriptive statistics for high- and low-tech enterprises

		OI_status											
		1,0		2,0		3,0		4,0		5,0		Total	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Low-tech	0	79	22,1%	62	17,3%	109	30,4%	65	18,2%	43	12,0%	358	100,0%
High-tech	1	20	23,5%	11	12,9%	17	20,0%	21	24,7%	16	18,8%	85	100,0%

Figure 21 is a graphic representation of results from Table 20. Analysis of variances (Table 22) shows few significant differences in patterns of high-tech and low-tech industries. High-tech enterprises are more inclined to collaborative innovation (Mean value 4,944 for high-tech industries and 4,204 for low-tech; p=0,005). The analysis also revealed significant differences for both IP in- and out-licensing. High-tech enterprises tend to leverage IP licensing more actively than low-tech (IP in-licensing mean value for high-tech enterprises is 2,404, and 1,546 for low-tech, p=0,003; IP out-licensing mean value high-tech enterprises is 1,910, and 1,196 for low-tech, p=0,002). Consequently, H4 is rejected; however, for several OI practices the difference is significant.

However, the level of implementation of IP licensing for both categories is low. Differences for other open innovation activities are not significant. Most adopted open innovation activities for both categories are scanning for external ideas, collaborative innovation and customer and consumer co-creation.

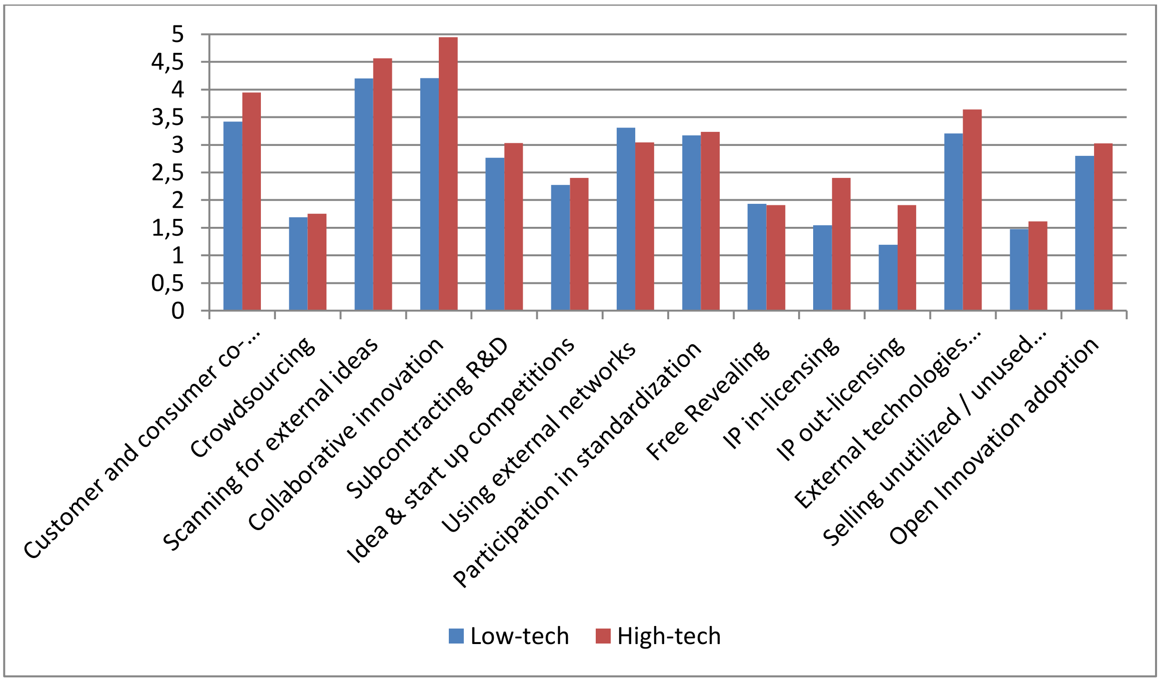

Figure 21 – Open innovation adoption in high-tech and low-tech industries

Table 22 - Analysis of variances for high- and low-tech firms

			Sum of Squares	df	Mean Square	F	Sig.
Customer and consumer co-creation in R&D projects * High-tech	Between Groups	(Combined)	18,430	1	18,430	2,952	,087
Crowdsourcing * High-tech	Between Groups	(Combined)	,243	1	,243	,051	,821
Scanning for external ideas * High-tech	Between Groups	(Combined)	8,840	1	8,840	1,794	,181
Collaborative innovation with external partners (i.e. suppliers, universities, competitors…) * High-tech	Between Groups	(Combined)	37,006	1	37,006	7,914	,005
Subcontracting R&D * High-tech	Between Groups	(Combined)	4,773	1	4,773	,892	,346
Idea & start up competitions * High-tech	Between Groups	(Combined)	1,132	1	1,132	,193	,661
Using external networks (e.g. associations, intermediaries, knowledge brokers) * High-tech	Between Groups	(Combined)	4,770	1	4,770	,931	,335
Participation in standardization (public standards) / influencing industry standards * High-tech	Between Groups	(Combined)	,313	1	,313	,048	,826
Free Revealing (e.g. Ideas, IP) to external parties * High-tech	Between Groups	(Combined)	,044	1	,044	,009	,923
IP in-licensing * High-tech	Between Groups	(Combined)	49,724	1	49,724	9,870	,002
IP out-licensing * High-tech	Between Groups	(Combined)	34,398	1	34,398	8,697	,003
External technologies acquisition * High-tech	Between Groups	(Combined)	12,680	1	12,680	2,160	,143
Selling unutilized / unused technologies * High-tech	Between Groups	(Combined)	1,312	1	1,312	,294	,588

Figure 22 presents results for self-perception of current open innovation status of the company and graphically represents data from Table 21. High-tech firms show much higher amount of experienced OI adopters and companies which are already refining and shaping OI activities. Both categories have quite similar amount of respondents at first two stages of OI adoption. Low-tech firms show high amount of companies that are currently at early stages of OI adoption.

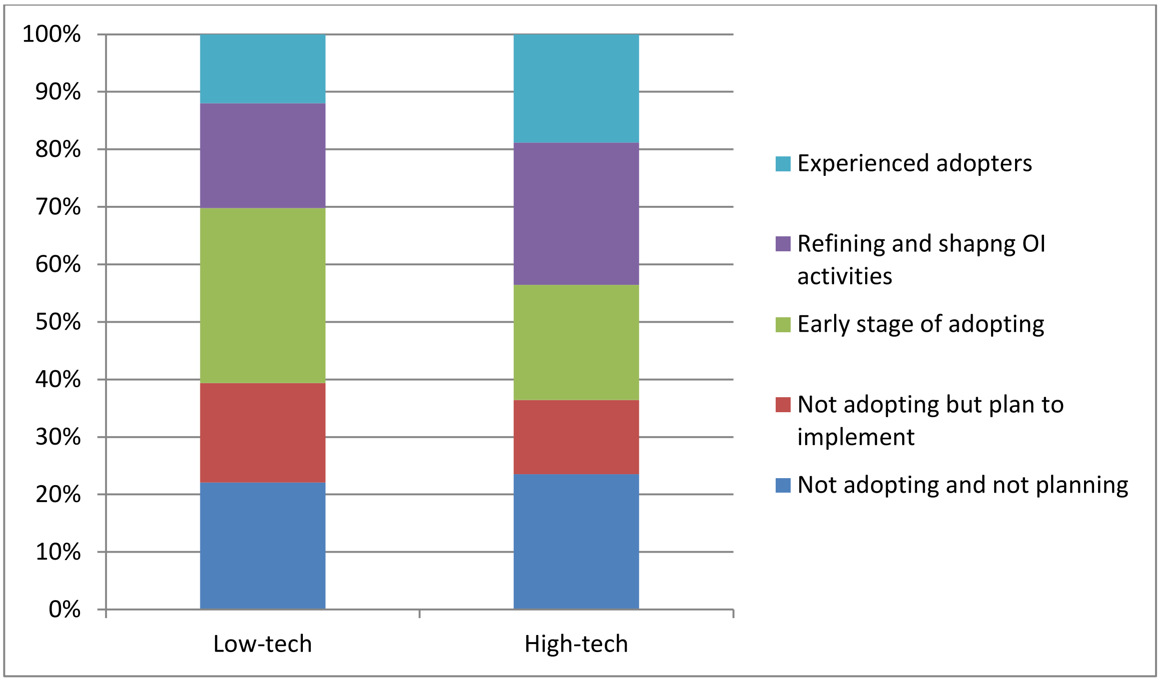

Figure 22 – Self-perception of open innovation in service and manufacture firms

In order to test significance, Chi-Squared test was used (Table 23).

Table 23 - Chi square test for high- and low-tech firms

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7,412[a]	4	,116
Likelihood Ratio	7,399	4	,116
Linear-by-Linear Association	1,819	1	,177
N of Valid Cases	443		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 11,32.

The results of chi-square test show that the difference not enough to be statistically significant (p=0,116). Therefore, H5 is rejected.

5. DISCUSSION

Results show that all industries implement open innovation. That is consistent with findings of Chesbrough and Crowther (2006), who revealed that industries beyond high-tech also use this approach. That finding is also in line with Trott and Hartmann (2009) who argued that all industries have always been open to certain extent.

Analysis shows that industry has an influence on the prevalence of different open innovation practices. Despite most adopted activities (scanning for external ideas, collaborative innovation with external partners, the use of external networks, and external technologies acquisition) for all of the industries are to certain extent common, distinct industries demonstrate significant prevalence of particular open innovation practices that is connected with industry specifics.

For each particular OI practice most of industries have the level of adoption in the same range as sample average; but several industries exhibit different results.

Pharmaceuticals and biotechnology demonstrate very high result for collaborative innovation, IP in- and out-licensing. In fact, this industry demonstrates the highest result for IP licensing activities among all industries included in the research. That is consistent with findings of Chiaroni et. al (2009) who pointed out at high and increasing relevance of licensing activities for this industry. Chiaroni et. al (2009) explained this with specific of product development within pharmaceutical industry, where few steps of product development provide highly unpredictable results and actually consist of trial-and-error approach, and other few steps might be highly expensive. In-licensing mitigates risks of early product development that are especially high for the industry. The use of crowdsourcing, and idea and startup competitions is low and lower that “moderate” average level of adoption across sample. Links with previous literature regarding this have not been found; however, these activities seem to be not appropriate for this industry in general.

Chemical industry show highest results in customer and consumer co-creation, high result in scanning for external ideas, moderately low in IP in-licensing and very low in IP out-licensing and selling unused technologies. These findings are completely in line with study by Eidam et. al (2014). They describe chemical industry as mostly B2B-oriented and mention customer visit teams among the most used open innovation practices. Eidam et. al (2014) also mention that most of the respondents from the industry consider open innovation mainly as an approach to finding new external ideas. Regarding IP licensing they notice that chemical industry is mainly process-dominated and it is quite hard to protect intellectual property related to processes within the industry. It explains very low results in IP licensing and selling unused technologies.

Energy industry show high importance of participation in standardization. However, I could not find research on open innovation for this and related industries. As already mentioned above, this industry might be the area for future research.

Telecommunication industry exhibits high results for participation in standardization, free revealing, IP in-licensing and selling unutilized technologies. Literature on telecommunication industry and open innovation is quite limited; however, study by Grotnes (2009) addresses standardization as a central issue of open innovation within telecommunication industry. The study highlights the importance of standardization activities within the industry. Described standardization activities to some extent include free revealing activities (contributions to open source software, contributions in standardization activities). High result for selling unused technologies might be the issue for further research.

Food industry demonstrates high results for customer and consumer co-creation, collaborative innovation, and idea, crowdsourcing and start-up competitions. It also demonstrate low adoption rate for subcontracting R&D and licensing activities. That finding is in line with Bigliardia and Galatib (2013) who noticed that firms in food industry mostly use collaborative innovations rather than R&D subcontracting or in-licensing. Literature on the food industry does not provide any quantitative assessment of adoption of open innovation practices; however, it provides several case studies and models that are used within the industry. Customer and consumer co-creation within food industry is observed both in B2B sector (Sarkara and Costa, 2008) and in B2C (Bigliardi and Galati, 2013). Several case studies also provide examples of sourcing external ideas using network of potential sources of ideas and technologies (Sarkara and Costa, 2008). Research does not allow do find out what model from presented in literature review is dominant in the industry. Low level of adoption for R&D subcontracting as well as low level of licensing activities might also be a sign that the use of innovation intermediaries and companies operating in other industries is also low. Therefore, at this point SiW model (Traitler and Saguy, 2009) appears to be more relevant or adopted within food industry, rather that WFGM model (Slowinski, 2004). Findings confirm statements of Bigliardi and Galati (2013) who noticed that WFGM model is quite difficult for implementation and requires changes in entire organizational structure, and requires systematic approach to OI. Therefore, the industry now is more inclined to more easy SiW model. Further quantitative research on bigger sample is needed in order to assess the adoption of other OI activities and explain it in industry context.

Automotive industry show results very close to sample average and nothing special specific for the industry can be selected. Results show that in contrast to Ili et. al (2010) companies do not actively use crowdsourcing and in-licensing in their operations. Low level of out-licensing is in line with Ili et. al (2010) who noticed that there is no mindset towards active out-licensing within the industry.

Regarding Chesbrowgh and Brunswicker framework – on average all industries show high adoption of non-pecuniary inbound activities; moderate adoption of inbound pecuniary and outbound non-pecuniary activities; low adoption of outbound pecuniary activities.

These findings confirms hypothesis 1, and show that firms from different industries use different aspects of open innovation according to needs within the industry, its features and characteristics. Therefore it can be concluded that adoption of particular OI practices is associated with the type of industry and associated industry characteristics.

Manufacture and service firms show few differences in adoption of OI practices. ANOVA shows that manufacture firms appear to be significantly more active in collaboration with external partners, participation in standardization, and external technologies acquisition. Findings related to collaborative innovation and external technologies acquisition are in line with van de Vrande et. al (2009): activities related to technology exploration appeared to be more actively implemented by manufacturing firms. In contrast to van de Vrande et. al (2009), manufacturing firms are significantly more active in collaboration with external partners than service firms. Participation in standardization seems to be more related to manufacturing firms, than service. It cannot be concluded that these categories of firms differ in implementation of all or most of OI activities; therefore, hypothesis 2 is rejected. However, the statement is correct for several aforementioned activities.

The distribution of service and manufacture firms related to the level of OI adoption shows no significant differences between categories. Hypothesis 3 is rejected.

High-tech enterprises' demonstrate higher percentage of experienced OI adopters (18,8% in high tech versus 12,0% in low-tech) and firms that are currently refining their OI activities (24,7% in high-tech versus 18,2% in low tech). The percentage of firms at first two stages of adoption that are currently not implementing OI activities is the same for both high- and low-tech enterprises. However, low tech industries demonstrate high percentage of companies that are at early stages of OI adoption (30,4% for low-tech firms and 20% for high-tech). However, chi-square test showed that the difference is not statistically significant ($p=0.166$). Therefore, hypothesis 4 is rejected.

Analysis of variances showed that high-tech firms use collaboration with external partners and IP in- and out-licensing significantly more often than low-tech firms. Enkel et. al (2009) and Segarra-Cipres et. al (2012) provide evidence that high-tech firms are more inclined to use collaborative agreements and collaborative R&D. In study of Enkel et. al (2009) it is also stated that high-tech firms actively use IP in-licensing. They did not provide the comparison with low tech industries in terms of IP licensing, and this study shows that high-tech firms are rather more active in IP licensing. Results also show prevalence of in-licensing upon out-licensing for both high- and low-tech firms. Hypothesis 5 is rejected; however, for several OI activities the difference between groups is significant.

Going back to Lichtenthaler (2008) who argued that a degree of openness is determined by internal firm's characteristic and its individual strategic choice, rather than by industry it can be concluded, that despite strategy of the firm defines its degree of openness, there also are differences at industry level that can be explained by industry-specific factors: competitiveness, clockspeed, IP regime and others.

6. CONCLUSIONS

Chesbough and Brunswicker (2014) pointed at the importance of understanding of industry differences for future research on the issue of open innovation. Previous literature did not provide a comprehensive review of industries and their adoption of OI. Only several studies were devoted to quantitative assessment of distinct industries in terms of open innovation implementation (e.g. Ili et. al (2010) for automotive industry, Eidam et. al (2014) for chemical industry, van de Vrande et. al (2009) for service and manufacture enterprises, and Segarra-Cipres et. al (2012) for high- and low-technology firms). Other researches are mostly qualitative, based on interviews and case studies and do not allow generalizations. There is lack of evidence of the level of adoption of OI paradigm across industries. This study addressed this gap and provided comprehensive review of open innovation implementation across industries, analyzes current situation across industries, and also assesses industry features related to implementation of particular open innovation activities.

The main research question of the study was: *"are there differences in the implementation of particular open innovation practices by firms that are caused by the industry that firm operates in"*. The research goal of the study was to summarize industrial differences related to implementation of OI activities, make a coherent review and find possible explanations for these differences. Following research objectives, three research questions were formulated:

- *RQ1: Does the type of industry influence the prevalence of some OI activities?*
- *RQ2: What is the difference in implementation of open innovation activities by firms of different technological intensity?*
- *RQ3: What is the difference in implementation of open innovation activities for firms in service and manufacturing sectors?*

The analysis of academic literature was performed in order to answer stated research questions as well as to triangulate the results of further analysis and find corroborations with previous findings. Empirical research included the analysis of survey data. The study is quantitative and survey was selected as a research method for the study. The main research objective of the study was to analyze how Open Innovation is implemented in different industries.

In order to answer research questions, the following hypothesis were proposed and tested:

H1: Intensity on implementation of open innovation practices is associated with firm's type of industry
H2: The intensity on the implementation of open innovation practices is different for service and manufacture firms
H3: Current level of OI adoption is higher for manufacture rather that for service
H4: The intensity on the implementation of open innovation practices is different for high- and low-tech firms
H5: Current level of OI adoption is higher for high-tech enterprises rather that for low-tech

Hypothesis 1 was confirmed. As suggested, firms from different industries prefer different aspects of Open Innovation approach, that are associated with industry features. That also answers research question 1. Differences and industries with their features are presented in discussion section in details.

Hypothesis 2 was rejected; however, the following OI activities appeared to be used with different intensity between groups: collaboration with external partners, participation in standardization, and external technologies acquisition.
Hypothesis 3 was rejected and no significant difference in open innovation adoption status was observed.
These findings provide answer to research question 2, highlighting activities that are implemented differently between categories.

Hypothesis 4 was rejected; however, the following OI activities appeared to be used with different intensity: IP in licensing, IP out-licensing and collaboration with external partners.
Hypothesis 5 was rejected: data and chart showed differences between categories and higher amount of experienced OI adopters within high-tech firms; however, difference was not statistically significant. These findings provide answer to research question 3, highlighting activities that are implemented differently between high- and low-tech firms.

It can be concluded that there are differences in implementation of OI practices that are caused by the industry the firm operates in. These differences are confirmed by statistical analysis.

Limitations of the study include relatively small sample, especially for particular industries, that to some extent restricts generalizations and reliability of the study. Industry classification should be more precise and detailed in order to get more precise industry categories. It is also important to mention that despite particular industries demonstrate distinct patterns of OI implementation, it is not only an industry-level phenomenon and there also are differences within industry sectors. These differences might be related to various factors, e.g. strategy, firm size, etc. The sample included a set of European companies; therefore, results should be generalized to other regions or conditions considering this issue.

This Master's thesis provides structured review and quantitative analysis that might be useful for future in-depth research, for development of managerial guides on open innovation, and governmental policies related to OI that will consider industry specifics. Huizingh (2011) also stated that in order to study OI effectiveness, it is important to find out the reasons why firms in particular industries open up and how do they implement open innovation approach.

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APPENDICES

Appendix A

Descriptive statistics for industries and the implementation of open innovation practices

		Open innovation activity ID												
Industry		1	2	3	4	5	6	7	8	9	10	11	12	13
Energy	Mean	3,000	1,400	3,933	3,867	2,633	1,600	3,167	4,567	1,667	2,167	1,133	3,600	1,533
	N	30	30	30	30	30	30	30	30	30	30	30	30	30
	Std. Deviation	2,7916	2,0443	2,4344	2,3450	2,1891	1,9046	2,3057	2,5955	2,0899	2,6403	1,7760	2,4579	2,1613
Materials	Mean	4,192	1,577	4,308	4,923	3,654	2,154	2,923	3,231	2,192	2,000	1,654	3,846	1,846
	N	26	26	26	26	26	26	26	26	26	26	26	26	26
	Std. Deviation	2,4003	2,0035	2,2763	1,9783	2,2440	1,9119	2,0576	2,6579	2,3327	2,3324	1,9988	2,2216	2,0725
Capital goods	Mean	3,500	1,667	2,833	5,167	2,500	2,167	2,167	4,333	1,500	2,000	1,667	4,000	1,667
	N	6	6	6	6	6	6	6	6	6	6	6	6	6
	Std. Deviation	2,9496	2,4221	2,4833	2,1370	2,5884	1,4720	2,2286	2,4221	2,3452	1,7889	2,7325	2,3664	2,7325
Commercial and professional services	Mean	3,389	1,648	4,315	3,815	2,593	2,333	3,611	2,074	1,889	1,278	1,056	2,463	1,185
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
	Std. Deviation	2,4680	2,2667	2,4327	2,1638	2,3912	2,6777	2,3182	2,2558	2,0250	2,0227	1,8876	2,4084	1,9336
Transportation	Mean	2,444	1,111	4,222	3,667	2,389	1,944	3,500	3,667	1,889	,778	1,167	2,722	1,889
	N	18	18	18	18	18	18	18	18	18	18	18	18	18
	Std. Deviation	2,0643	1,6047	1,8647	2,2752	1,9445	1,8934	2,2029	2,3009	2,0832	1,6997	2,2557	2,4925	2,5870
Chemicals, petroleum and coal products	Mean	5,091	1,182	5,091	4,818	2,909	2,091	3,455	3,364	1,727	1,273	,636	3,273	,545
	N	11	11	11	11	11	11	11	11	11	11	11	11	11
	Std. Deviation	2,3856	1,5374	1,4460	2,0889	2,2563	2,5867	2,2962	2,5406	1,9540	1,6181	,9244	2,1019	,8202

Automobiles and components	Mean	3,077	1,154	4,000	4,346	3,077	2,000	2,500	2,962	1,346	1,308	1,038	3,192	2,115
	N	26	26	26	26	26	26	26	26	26	26	26	26	26
	Std. Deviation	2,3820	1,4884	1,9799	2,1715	2,5911	2,2091	2,0640	2,4573	1,8535	1,9135	1,4827	2,2807	2,3720
Consumer durables and apparel	Mean	5,500	2,250	6,250	5,500	2,750	2,750	3,500	4,500	1,750	2,250	2,000	5,250	1,750
	N	4	4	4	4	4	4	4	4	4	4	4	4	4
	Std. Deviation	1,9149	3,3040	,9574	1,0000	2,5000	2,7538	1,7321	2,3805	1,7078	2,2174	1,8257	2,0616	2,2174
Hotels, Restaurants and leisure	Mean	3,125	3,750	3,625	3,375	2,625	2,125	3,250	1,500	2,750	1,375	1,625	2,125	1,250
	N	8	8	8	8	8	8	8	8	8	8	8	8	8
	Std. Deviation	3,1368	2,6049	2,0659	2,7223	2,9731	3,0909	2,4928	2,1381	3,3274	2,5600	3,0208	2,9001	2,0529
Media	Mean	3,333	2,000	5,333	5,667	3,667	1,333	2,667	2,667	1,333	2,000	2,000	3,667	,333
	N	3	3	3	3	3	3	3	3	3	3	3	3	3
	Std. Deviation	2,0817	1,7321	,5774	1,1547	1,1547	1,5275	2,3094	2,0817	1,5275	1,0000	1,0000	2,3094	,5774
Retailing	Mean	2,154	1,692	3,769	3,615	2,308	2,154	3,692	3,692	1,692	1,154	,462	3,308	1,462
	N	13	13	13	13	13	13	13	13	13	13	13	13	13
	Std. Deviation	1,9513	1,7505	2,2418	2,5344	2,0970	2,7642	2,1364	2,5293	1,6013	2,0350	,7763	2,8102	2,3315
Food and staples retailing	Mean	2,800	3,200	5,200	3,800	3,000	4,000	2,200	5,200	2,600	2,200	2,200	4,200	,400
	N	5	5	5	5	5	5	5	5	5	5	5	5	5
	Std. Deviation	2,7749	2,5884	1,9235	2,1679	2,7386	2,5495	2,9496	1,9235	3,2094	3,0332	3,0332	3,0332	,5477
Food, beverages and tobacco	Mean	3,600	2,300	4,000	4,900	1,600	3,150	2,950	2,400	2,400	1,400	1,250	3,150	1,200
	N	20	20	20	20	20	20	20	20	20	20	20	20	20
	Std. Deviation	2,6833	2,7549	1,9735	2,1250	1,5355	2,8335	1,9595	2,7222	2,3486	2,1619	1,8317	2,1343	1,8238
Household and personal products	Mean	4,083	2,167	4,583	4,583	2,917	2,083	3,917	2,750	2,083	2,000	,917	4,000	1,667
	N	12	12	12	12	12	12	12	12	12	12	12	12	12
	Std. Deviation	2,1933	2,4058	1,9752	2,6097	2,3143	2,3916	2,1933	2,3789	2,1933	2,0000	,9003	2,6285	2,1034
Healthcare equipment and	Mean	4,000	2,250	4,625	6,000	3,750	2,875	4,250	3,750	2,250	2,375	,375	3,000	1,000
	N	8	8	8	8	8	8	8	8	8	8	8	8	8

services	Std. Deviation	2,8284	2,4349	1,9955	1,7728	2,6592	2,5319	2,6049	2,5495	2,2520	2,7223	1,0607	2,7775	1,6036
Pharmaceuticals and biotechnology	Mean	2,385	1,538	4,231	5,538	3,615	1,615	2,846	3,385	1,692	3,231	3,538	4,308	1,846
	N	13	13	13	13	13	13	13	13	13	13	13	13	13
	Std. Deviation	2,9308	2,5038	2,8034	1,3914	2,4337	2,1809	2,3038	2,7850	2,5944	2,9764	2,6651	2,6890	2,2303
Banks	Mean	3,250	1,167	4,417	4,333	3,750	2,917	3,667	4,250	2,000	1,750	1,083	4,250	1,583
	N	12	12	12	12	12	12	12	12	12	12	12	12	12
	Std. Deviation	2,1373	2,0817	2,3916	2,2293	2,1373	2,6097	2,3484	2,1794	2,5226	2,3789	1,7299	1,7123	2,3916
Diversified financials	Mean	2,250	1,250	3,000	4,250	1,500	3,750	5,000	3,500	1,250	1,500	,500	,750	1,750
	N	4	4	4	4	4	4	4	4	4	4	4	4	4
	Std. Deviation	2,6300	1,5000	2,1602	1,7078	2,3805	2,8723	1,1547	2,3805	,9574	1,9149	1,0000	,9574	2,8723
Insurance	Mean	2,400	,600	5,200	3,600	2,800	2,800	2,600	3,400	1,200	1,000	1,600	2,200	,600
	N	5	5	5	5	5	5	5	5	5	5	5	5	5
	Std. Deviation	2,1909	1,3416	1,3038	2,3022	2,9496	2,6833	1,9494	2,3022	1,3038	1,4142	2,6077	1,4832	,8944
Real estate	Mean	3,000	3,000	3,143	2,714	1,286	1,571	3,286	3,714	2,000	,429	,286	2,429	,857
	N	7	7	7	7	7	7	7	7	7	7	7	7	7
	Std. Deviation	2,7689	3,4641	2,7946	1,8898	1,6036	1,9024	2,0587	2,4300	2,7689	,7868	,7559	2,8785	1,5736
Software and services	Mean	4,292	2,271	4,604	4,563	2,750	2,625	2,646	2,521	1,875	2,208	1,833	3,354	1,208
	N	48	48	48	48	48	48	48	48	48	48	48	48	48
	Std. Deviation	2,2021	2,4472	2,4034	2,1919	2,5222	2,6548	2,4451	2,5264	2,3304	2,5926	2,3640	2,7327	2,0931
Technology hardware and equipment	Mean	3,800	1,100	3,950	5,150	3,600	2,350	3,100	3,850	1,850	2,100	1,550	4,050	1,900
	N	20	20	20	20	20	20	20	20	20	20	20	20	20
	Std. Deviation	2,5912	1,9211	2,2275	1,8516	2,2339	2,1712	2,0000	2,5298	1,6705	2,0366	1,7498	1,9869	2,2499
Semiconductors and semiconductor equipment	Mean	4,500	1,500	5,000	5,000	3,500	,500	5,500	4,750	2,000	3,000	1,500	3,000	,750
	N	4	4	4	4	4	4	4	4	4	4	4	4	4
	Std. Deviation	2,3805	1,7321	2,7080	2,1602	1,9149	,5774	1,2910	2,5000	2,8284	2,9439	1,7321	2,1602	,9574

Telecommunicaion services	Mean	3,545	1,273	4,909	5,000	2,909	2,818	3,727	4,364	2,455	2,455	1,182	4,545	3,909
	N	11	11	11	11	11	11	11	11	11	11	11	11	11
	Std. Deviation	2,4643	1,8488	2,1192	1,9494	2,5477	3,2502	2,9695	2,8381	2,8413	2,9449	2,3160	1,8091	2,4271
Utilities	Mean	3,667	1,000	3,000	3,333	3,667	2,667	3,333	3,000	2,667	1,000	1,000	4,333	,000
	N	3	3	3	3	3	3	3	3	3	3	3	3	3
	Std. Deviation	3,2146	1,0000	2,6458	1,5275	1,5275	2,3094	2,3094	1,7321	1,5275	1,7321	1,7321	2,0817	,0000
Other	Mean	3,679	1,951	4,395	4,765	2,741	2,037	3,457	3,000	1,654	1,481	1,086	3,247	1,481
	N	81	81	81	81	81	81	81	81	81	81	81	81	81
	Std. Deviation	2,6402	2,2798	2,1891	2,3036	2,6400	2,2663	2,4852	2,4495	2,0197	2,1102	1,7335	2,4926	2,0378
Consulting	Mean	4,667	2,556	4,889	3,889	3,556	2,778	5,222	2,444	3,111	2,222	2,667	3,000	2,667
	N	9	9	9	9	9	9	9	9	9	9	9	9	9
	Std. Deviation	2,6926	2,1279	2,0883	2,6667	2,1858	2,7739	1,8559	2,4552	2,2608	2,3863	2,7839	2,1794	2,3452
Total	Mean	3,551	1,770	4,304	4,451	2,831	2,265	3,293	3,152	1,883	1,714	1,315	3,310	1,516
	N	461	461	461	461	461	461	461	461	461	461	461	461	461
	Std. Deviation	2,5255	2,2085	2,2192	2,2127	2,3732	2,3955	2,3048	2,5253	2,1416	2,2439	1,9601	2,4364	2,1034

Appendix B

ANOVA and post hoc analysis for industries and OI practices

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
IP out-licensing	Between Groups	152,996	26	5,884	1,582	,036
	Within Groups	1614,396	434	3,720		
	Total	1767,393	460			
Customer and consumer co-creation in R&D projects	Between Groups	203,288	26	7,819	1,243	,193
	Within Groups	2730,764	434	6,292		
	Total	2934,052	460			
Crowdsourcing	Between Groups	137,115	26	5,274	1,087	,353
	Within Groups	2106,512	434	4,854		
	Total	2243,627	460			
Scanning for external ideas	Between Groups	101,919	26	3,920	,786	,766
	Within Groups	2163,565	434	4,985		
	Total	2265,484	460			
Collaborative innovation with external partners (i.e. suppliers, universities, competitors…)	Between Groups	176,464	26	6,787	1,419	,085
	Within Groups	2075,688	434	4,783		
	Total	2252,152	460			
Subcontracting R&D	Between Groups	134,395	26	5,169	,913	,590
	Within Groups	2456,408	434	5,660		
	Total	2590,803	460			
Idea & start up competitions	Between Groups	109,311	26	4,204	,721	,842

	Within Groups	2530,402	434	5,830		
	Total	2639,714	460			
Using external networks (e.g. associations, intermediaries, knowledge brokers)	Between Groups	154,688	26	5,950	1,128	,304
	Within Groups	2288,779	434	5,274		
	Total	2443,466	460			
Participation in standardization (public standards) / influencing industry standards	Between Groups	288,057	26	11,079	1,818	,009
	Within Groups	2645,314	434	6,095		
	Total	2933,371	460			
Free Revealing (e.g. Ideas, IP) to external parties	Between Groups	57,466	26	2,210	,467	,989
	Within Groups	2052,208	434	4,729		
	Total	2109,675	460			
IP in-licensing	Between Groups	135,087	26	5,196	1,034	,420
	Within Groups	2181,117	434	5,026		
	Total	2316,204	460			
External technologies acquisition	Between Groups	189,721	26	7,297	1,246	,190
	Within Groups	2540,921	434	5,855		
	Total	2730,642	460			
Selling unutilized / unused technologies	Between Groups	147,408	26	5,670	1,303	,147
	Within Groups	1887,720	434	4,350		
	Total	2035,128	460			

Multiple Comparisons

LSD

Dependent Variable	(I) Industry	(J) Industry	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
IP out-licensing	1,0						
		16,0	-2,4051*	,6404	,000	-3,664	-1,146
		27,0	-1,5333*	,7330	,037	-2,974	-,093
	2,0						
		16,0	-1,8846*	,6551	,004	-3,172	-,597
	3,0						
		16,0	-1,8718*	,9519	,050	-3,743	-,001
	4,0						
		16,0	-2,4829*	,5958	,000	-3,654	-1,312
		21,0	-,7778*	,3826	,043	-1,530	-,026
		27,0	-1,6111*	,6944	,021	-2,976	-,246
	5,0						
		16,0	-2,3718*	,7020	,001	-3,752	-,992
	6,0						
		16,0	-2,9021*	,7901	,000	-4,455	-1,349
		27,0	-2,0303*	,8669	,020	-3,734	-,327
	7,0						
		16,0	-2,5000*	,6551	,000	-3,788	-1,212
		27,0	-1,6282*	,7459	,030	-3,094	-,162
	9,0						
		16,0	-1,9135*	,8667	,028	-3,617	-,210

	11,0						
		16,0	-3,0769*	,7565	,000	-4,564	-1,590
		21,0	-1,3718*	,6030	,023	-2,557	-,187
		27,0	-2,2051*	,8363	,009	-3,849	-,561
	13,0						
		16,0	-2,2885*	,6871	,001	-3,639	-,938
	14,0						
		16,0	-2,6218*	,7721	,001	-4,139	-1,104
		27,0	-1,7500*	,8505	,040	-3,422	-,078
	15,0						
		16,0	-3,1635*	,8667	,000	-4,867	-1,460
		21,0	-1,4583*	,7365	,048	-2,906	-,011
		27,0	-2,2917*	,9372	,015	-4,134	-,450
	16,0	1,0	2,4051*	,6404	,000	1,146	3,664
		2,0	1,8846*	,6551	,004	,597	3,172
		3,0	1,8718*	,9519	,050	,001	3,743
		4,0	2,4829*	,5958	,000	1,312	3,654
		5,0	2,3718*	,7020	,001	,992	3,752
		6,0	2,9021*	,7901	,000	1,349	4,455
		7,0	2,5000*	,6551	,000	1,212	3,788
		9,0	1,9135*	,8667	,028	,210	3,617
		11,0	3,0769*	,7565	,000	1,590	4,564
		13,0	2,2885*	,6871	,001	,938	3,639
		14,0	2,6218*	,7721	,001	1,104	4,139

	15,0	3,1635*	,8667	,000	1,460	4,867
	17,0	2,4551*	,7721	,002	,938	3,973
	18,0	3,0385*	1,1028	,006	,871	5,206
	20,0	3,2527*	,9042	,000	1,476	5,030
	21,0	1,7051*	,6030	,005	,520	2,890
	22,0	1,9885*	,6871	,004	,638	3,339
	24,0	2,3566*	,7901	,003	,804	3,910
	25,0	2,5385*	1,2353	,040	,110	4,966
	26,0	2,4520*	,5762	,000	1,319	3,585
17,0						
	16,0	-2,4551*	,7721	,002	-3,973	-,938
18,0						
	16,0	-3,0385*	1,1028	,006	-5,206	-,871
20,0						
	16,0	-3,2527*	,9042	,000	-5,030	-1,476
	21,0	-1,5476*	,7803	,048	-3,081	-,014
	27,0	-2,3810*	,9720	,015	-4,291	-,471
21,0						
	4,0	,7778*	,3826	,043	,026	1,530
	11,0	1,3718*	,6030	,023	,187	2,557
	15,0	1,4583*	,7365	,048	,011	2,906
	16,0	-1,7051*	,6030	,005	-2,890	-,520
	20,0	1,5476*	,7803	,048	,014	3,081
	26,0	,7469*	,3513	,034	,056	1,437

	22,0						
		16,0	-1,9885*	,6871	,004	-3,339	-,638
	24,0						
		16,0	-2,3566*	,7901	,003	-3,910	-,804
	25,0						
		16,0	-2,5385*	1,2353	,040	-4,966	-,110
	26,0						
		16,0	-2,4520*	,5762	,000	-3,585	-1,319
		27,0	-1,5802*	,6777	,020	-2,912	-,248
	27,0						
		4,0	1,6111*	,6944	,021	,246	2,976
		6,0	2,0303*	,8669	,020	,327	3,734
		7,0	1,6282*	,7459	,030	,162	3,094
		11,0	2,2051*	,8363	,009	,561	3,849
		14,0	1,7500*	,8505	,040	,078	3,422
		15,0	2,2917*	,9372	,015	,450	4,134
		20,0	2,3810*	,9720	,015	,471	4,291
		26,0	1,5802*	,6777	,020	,248	2,912
Participation in standardization (public standards) / influencing industry standards	1,0	2,0	1,3359*	,6615	,044	,036	2,636
		4,0	2,4926*	,5622	,000	1,388	3,598
		7,0	1,6051*	,6615	,016	,305	2,905
		9,0	3,0667*	,9824	,002	1,136	4,997
		13,0	2,1667*	,7127	,003	,766	3,567
		14,0	1,8167*	,8433	,032	,159	3,474

		21,0	2,0458*	,5746	,000	,917	3,175
		26,0	1,5667*	,5277	,003	,530	2,604
		27,0	2,1222*	,9383	,024	,278	3,966
	2,0	1,0	-1,3359*	,6615	,044	-2,636	-,036
	3,0						
		4,0	2,2593*	1,0624	,034	,171	4,347
		9,0	2,8333*	1,3333	,034	,213	5,454
	4,0	1,0	-2,4926*	,5622	,000	-3,598	-1,388
		3,0	-2,2593*	1,0624	,034	-4,347	-,171
		5,0	-1,5926*	,6719	,018	-2,913	-,272
		11,0	-1,6182*	,7627	,034	-3,117	-,119
		12,0	-3,1259*	1,1541	,007	-5,394	-,858
		17,0	-2,1759*	,7879	,006	-3,725	-,627
		22,0	-1,7759*	,6462	,006	-3,046	-,506
		23,0	-2,6759*	1,2793	,037	-5,190	-,161
		24,0	-2,2896*	,8167	,005	-3,895	-,684
		26,0	-,9259*	,4337	,033	-1,778	-,073
	5,0						
		4,0	1,5926*	,6719	,018	,272	2,913
		9,0	2,1667*	1,0491	,039	,105	4,229
	6,0						
	7,0	1,0	-1,6051*	,6615	,016	-2,905	-,305
	8,0						
		9,0	3,0000*	1,5119	,048	,029	5,971

9,0	1,0	-3,0667*	,9824	,002	-4,997	-1,136
	3,0	-2,8333*	1,3333	,034	-5,454	-,213
	5,0	-2,1667*	1,0491	,039	-4,229	-,105
	8,0	-3,0000*	1,5119	,048	-5,971	-,029
	11,0	-2,1923*	1,1094	,049	-4,373	-,012
	12,0	-3,7000*	1,4075	,009	-6,466	-,934
	17,0	-2,7500*	1,1269	,015	-4,965	-,535
	22,0	-2,3500*	1,0328	,023	-4,380	-,320
	23,0	-3,2500*	1,5119	,032	-6,221	-,279
	24,0	-2,8636*	1,1472	,013	-5,118	-,609
11,0						
	4,0	1,6182*	,7627	,034	,119	3,117
	9,0	2,1923*	1,1094	,049	,012	4,373
12,0						
	4,0	3,1259*	1,1541	,007	,858	5,394
	9,0	3,7000*	1,4075	,009	,934	6,466
	13,0	2,8000*	1,2344	,024	,374	5,226
	21,0	2,6792*	1,1602	,021	,399	4,959
	27,0	2,7556*	1,3771	,046	,049	5,462
13,0	1,0	-2,1667*	,7127	,003	-3,567	-,766
	12,0	-2,8000*	1,2344	,024	-5,226	-,374
	17,0	-1,8500*	,9015	,041	-3,622	-,078
	24,0	-1,9636*	,9268	,035	-3,785	-,142
14,0	1,0	-1,8167*	,8433	,032	-3,474	-,159

	17,0						
		4,0	2,1759*	,7879	,006	,627	3,725
		9,0	2,7500*	1,1269	,015	,535	4,965
		13,0	1,8500*	,9015	,041	,078	3,622
		21,0	1,7292*	,7968	,031	,163	3,295
	21,0	1,0	-2,0458*	,5746	,000	-3,175	-,917
		12,0	-2,6792*	1,1602	,021	-4,959	-,399
		17,0	-1,7292*	,7968	,031	-3,295	-,163
		22,0	-1,3292*	,6571	,044	-2,621	-,038
		24,0	-1,8428*	,8253	,026	-3,465	-,221
	22,0						
		21,0	1,3292*	,6571	,044	,038	2,621
	23,0						
		4,0	2,6759*	1,2793	,037	,161	5,190
		9,0	3,2500*	1,5119	,032	,279	6,221
	24,0						
		4,0	2,2896*	,8167	,005	,684	3,895
		9,0	2,8636*	1,1472	,013	,609	5,118
		13,0	1,9636*	,9268	,035	,142	3,785
		21,0	1,8428*	,8253	,026	,221	3,465
	26,0	1,0	-1,5667*	,5277	,003	-2,604	-,530
		4,0	,9259*	,4337	,033	,073	1,778
	27,0	1,0	-2,1222*	,9383	,024	-3,966	-,278
		12,0	-2,7556*	1,3771	,046	-5,462	-,049