Bureau d'économie théorique et appliquée (BETA)
UMR 7522

Documents de travail

« The Two Faces Of Open Innovation : Network Externalities and Learning »

Auteur

Muge OZMAN

Document de Travail n° 2008 - **24**

Décembre 2008

Faculté des sciences économiques et de gestion
Pôle européen de gestion et d'économie (PEGE)
61 avenue de la Forêt Noire
F-67085 Strasbourg Cedex

Secétariat du BETA
Géraldine Manderscheidt
Tél. : (33) 03 90 24 20 69
Fax : (33) 03 90 24 20 70
manderscheidt@cournot.u–strasbg.fr
http://cournot2.u–strasbg.fr/beta

CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
Nancy-Université Université Nancy 2
ulp UNIVERSITÉ LOUIS PASTEUR STRASBOURG

The Two Faces of Open Innovation: Network Externalities and Learning

Muge Ozman
Institut TELECOM
Telecom & Management SudParis
CEMANTIC
9, Rue Charles Fourier
91000, Evry
e-mail: Muge.Ozman@it-sudparis.eu

(Preliminary Draft)

December 1, 2008

Abstract

In this paper I differentiate between two types of benefits of open innovation. Network externalities effect happens when open innovation increases the participation of one group of users which increases the value of adoption for another group of users. Learning effect happens when economic actors increase their knowledge through access to external sources of knowledge. I investigate how each effect can be dominant depending on nature of products, by drawing upon previous research in product modularity. In addition I discuss the factors which will strengthen or weaken the effects of each dimension. The main variables which influence learning are, tacitness of knowledge, technological opportunities, appropriability of knowledge and turbulence. Network externalities effect can be strengthened by increased user innovation.

1 Introduction

Open innovation refers to the creation and development of channels through which firms access external sources of knowledge (Chesbrough, 2003). The idea that innovation is a collective process which involves many actors and their interactions is not new, and dates back to the concept of collective invention (Allen, 1983). Since then, research has developed along various lines, one of which is inter-organizational networks which act as the "locus of innovation" (Powell et al., 1996). What is relatively new in the open innovation literature is concerned with innovation in industries with indirect and direct network externalities. Open innovation in this strand of literature is mainly inspired from the successful stories of open source software, as in the case of Linux.

Multi-sided markets refer to those which serve two or more distinct user groups. There is now plenty of literature which captures the dynamics of such markets (Gawer and Cusumano, 2002; Rochet and Tirole, 2003; Evans et al., 2006; Boudrerau and Hagiu, 2008) . Some commonly cited examples are shopping malls which unite merchants and shoppers, credit card systems which serve merchants and card owners, video game consoles which supply to game developers and players, operating systems from which both end users and application developers make use of. Usually, these industries are characterized by indirect network externalities where increased adoption by one group will increase the value of adoption to the other group. [1]On the other hand, in single sided markets the producer or the service provider serves a single group of users. Examples are automobiles, airplanes, clothes. In these markets producers and consumers interact through a single market.

The main idea underlying this paper is that the effect of open innovation strategies in different market contexts are not the same and should be taken into account when evaluating the potential impacts of open innovation for the industry as a whole and for firms. In particular, it is possible to distinguish between two mechanisms through which open innovation works. One of these mechanisms is through enhancing network

[1]Direct network externalities occur when the number of adopters of a certain standard increases the value of adoption by other adopters in the same group, as in the case of two competing standards of video tapes (Arthur, 1989)

externalities. The other effect is through enhancing learning of economic actors. Both mechanisms have different implications for different industrial contexts.

I draw upon the previous research on modular systems and inter-firm networks to clarify the two dimensions of open innovation and provide a taxonomy of different industries as far as these two dimensions are concerned. Furthermore I discuss how in each of these dimensions, the benefits of open innovation can be enhanced in relation to the knowledge base regime of the industry. Knowledge base regime refers to tacitness of knowledge, technological turbulence, technological opportunities and appropriability conditions. In particular I address the question of how these factors strengthen or weaken each dimension of open innovation. Moreover, I discuss how the customized innovation process (Von Hippel, 2005) which refers to increased participation of users to the innovation process, enhances the network externality dimension of open innovation.

In this sense, the aim of this article is to provide a comprehensive perspective for understanding various concepts in relation to open innovation. The relationship between modularity in products, modularity in organizational structure, network externalities, knowledge codification, the extent and kind of networks among firms, technological opportunities, and how these variables interact with each other have each been explored individually in various contexts in the past. Nevertheless, none of these studies provide a comprehensive overview of how these variables influence the success of open innovation strategies, and this remains to be clarified in future research. This paper is a contribution in this sense.

The first section provides the background literature on modularity. The second section investigates how modularity influences the emergence of multi-sided markets. Third section investigates the open innovation process in multi sided and single sided markets. A taxonomy of industries according to the dimensions of open innovation os presented in the fourth section. Finally the fifth section is devoted to an analysis of how each of these dimensions will be strengthened or weakened depending on knowledge base. Some concluding remarks and directions for future research follow.

2 Product modularity

Product modularity has been defined in various ways in the literature (Langlois and Robertson, 1992; Schilling, 2000; Baldwin and Clark, 2000). According to Schilling (2000: p. 312) it is a "continuum describing the degree to which a systems components can be separated and recombined...". Relatedly, Baldwin and Clark (2000) define it as the ability of the system to be decomposed into smaller parts with weak integration points between parts. Many systems today are becoming more and more modular in nature, which, according to one strand of research, may influence the organizational structures and division of labour (Brusoni and Prencipe, 2001; Schilling and Steensma, 1999; Langlois and Robertson, 1992). Moreover many scholars have pointed out that in general modular systems perform better and generate more value than architectural systems (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). This is because when there are weak interfaces between different components of a system, innovation in one part of the system will not require significant changes in other parts. It is possible to observe in most industries today that modularity in products is usually accompanied by specialization of firms and increased interactions between them. In this context Brusoni and Prencipe (2000) underline the important role of systems integrators, usually applicable in the case of complex product systems.

One of the factors which influence the relationship between organizational structure and modularity is the nature of knowledge. Knowledge can be inexpensively reproduced (expansible) and it is non-rivalrous (its use by one party does not exclude others from using it). [2] These features of knowledge influence the sources of economies of scale and scope in the industry. According to Steinmuller (2007) the expansibility and non-rivalrous properties of knowledge in the ICT sector results in the ability with which an original design can be re-used in meeting different markets, which is a source of economies of scope. In this case, the "first mover" advantage in innovation may not last for long since rapid technological change will increase the opportunities to make new and improved designs by rival firms. In other words, economies of scope in ICTs stems from the ability to "address different application needs with the same designs" (Steinmuller, 2007, p. 198). This creates important

[2] The costs of transferring knowledge depends on knowledge tacitness.

opportunities for product differentiation.

The relationship between organizational structure and modularity is restructured in the case of ICTs. Essentially this implies a change in the fundamental dilemma faced by firms on "making or buying". Various lines of research have contributed differently to the question of how firms decide to make or buy components. Transaction cost economics (Williamson, 1985) and knowledge based theories of the firm (Kogut and Zander, 1992; Grant, 1995) are notable in this sense. TCE has approached the question from an efficiency perspective, and focused on relative costs of exchange in markets and hierarchies. Knowledge base theories has focused on creation of knowledge and product characteristics in defining firm boundaries.

In the case of ICTs a different extension to this question has taken place, that is beyond the classic trade-off between "making or buying". Here, one of the decisions faced by the innovator firm has shifted to whether to produce its complementary products within the firm or create an external access to its standard and facilitate the provision of complementary products by other firms. This implies that "make or license" decision has become an additional dimension along side the "make or buy" decision. One of the distinct examples in the computer industry has been the case of IBM in the beginning of 90s. Before this period IBM was the sole producer of its hardware and software; a highly integrated firm which was largely carrying out in-house R&D and developing, distributing and providing maintenance for its systems all by itself. During the 90s, as firms like Microsoft and Intel increased their market share, and as more and more firms entered the computer market IBM faced a fundamental shift from a highly integrated organization to a central firm taking place in a dense web of other actors, as providers of software, operating systems and hardware components. Today the difference between Apple and IBM is an example to the decision between "make or buy" and "make or license" where Apple still preserves a highly integrated structure.

Based on the discussion above, modular product architectures have usually been accompanied by a modular organizational structure in the case of ICTs. The shift in the nature of the make or buy decision has implications for the extent to which the market will subdivide into different users. Because of the non rivalrous and expansibility feature of knowledge as an input, ICT industry prepares a suitable ground for the emergence of multi-sided markets, in which the innovator firm supplies to a variety of customer groups. This depends largely on the strategic decision of the standard owner which is constrained by the current state of technology, appropriability conditions and characteristics of the industry. As Schilling (2000) mentions, the ability with which the consumer can separate and reintegrate a product, the utility derived from doing so, and the complexity of the product increases the extent to which organizations will be modular, where this has been the case in ICT based industries.

3 Multi-sided and Single-sided Markets

In the strategic management literature, a platform-based industry is one in which a central firm controls or owns a certain standard, or a platform upon which other firms produce complementary products compatible with the standard (Gawer and Cusumano, 2005).[3] The leading example is operating systems, where Linux, Unix, DOS, Windows coexist in the market as leading standards and act as platforms upon which application developers produce compatible software. Some other examples are video game consoles, hardware, smart phones, credit card systems, and even shopping malls where merchants and customers meet.

One of the characteristics of multi-sided markets is that there are both indirect direct and network externalities between different customer groups (Economides, 1996; Rochet and Tirole, 2003). An indirect network externality arises when there is a greater availability of compatible complementary products which benefits all user groups. In particular, customers benefit because there is increased variety, producers benefit because more customers are adopting the standard. In the case of ICTs there are many examples of indirect network externalities. The most straightforward example is Windows operating system and its complementary software. The more applications compatible with the Windows standard, the more is the value the customer attributes to adopting windows. Obviously, indirect network externalities are not confined to ICT based industries. The value of a shopping mall will be higher for shoppers, the more variety of shops there are in the mall. The more a card standard

[3] In the following parts of the text, standards and platforms are used interchangibly.

is adopted by merchants, the more the final consumer values that standard, and vice versa.

On the other hand in single sided markets the producer or the service provider serves a single group of users. Examples are automobiles, airplanes, clothes in which producers and consumers interact through a single market. Mostly in these industries the indirect network externalities are negligible or do not exist. To give an example, the number of airplane engine producers will not have a significant influence on the demand structure of airline companies.

Depending on the nature of the market the impact of open innovation can be analyzed in two dimensions as network externality effect and learning effect. In the next section, I explore these dimensions.

4 Open innovation: Network externalities effect and learning effect

Open innovation has increasingly occupied the agenda of researchers and managers during the last decade. In the most general sense, open innovation refers to the creation and development of channels through which firms access external sources of knowledge (Chesbrough, 2003; Chesbrough et al., 2006). The idea that innovation is not an isolated process performed by a single firm, but is a collective process in which interaction among many actors play a role is not new. Firms collaborate because of the increasing complexity in products and convergence among them, rapid technological change, and possible network effects on the consumer side. These factors have resulted in the perception of innovation as a system involving artifacts and different actors and which evolve in a complex manner.

4.1 Network Externalities Effect

One of the implications of open innovation strategies adopted by platform leaders in multi sided markets is to reduce the costs of access to the platform by different user groups. These costs stem from the complexities involved in accessing the platform and / or the license fees and royalties which accompany access. It is possible to differentiate between two types of benefits of adopting an open innovation strategy in multi-sided markets. Firstly, one of the building blocks of open innovation is that reducing the costs of access to a standard attracts more complementary producers to the standard, which will increase the value of adoption as perceived by final consumers and producers themselves. Secondly, open innovation strategies will induce more learning by all actors in the system, which may result in higher rates of innovation, which in turn will increase the value of further adoption. The first effect is quantitative in nature, the second is qualitative. Usually, these two effects will reinforce each other. The more is the number of actors involved, the more chances to recombine knowledge of various actors, and the more chances of innovation. The extent of learning does not only depend on the strategies of the standard controllers, but also the extent to which other firms participate in the learning process, which is to say the extent to which they are "open" to external channels of knowledge.

4.2 Learning Effect

The learning effect of open innovation is not new. Different terms have been adopted before and the roots of the concept dates back to Allen (1983) who developed the concept of collective invention. The various terms that were used which refer to this phenomena in the core includes distributed innovation (Kogut and Metiu, 2001), modular innovation networks (Langlois and Robertson, 1992), network forms of organization (Powell et al., 1996), regional innovation network (Saxenian, 1994). This literature coincides with the literature on inter-firm networks, which studies the mechanisms through which relationships among actors in an industrial system relates to the knowledge produced by the system.

One of the distinguishing features of open innovation in the context of firm networks is its emphasis on organizational learning processes. Open innovation refers to a mechanism where firms adopt strategies which favour accessing and benefiting from research carried out in other parts of the system. One of the reasons that firms implement this strategy is exploration; in a rapidly changing environment, adopting an open strategy helps them to access new sources of knowledge lying outside the boundaries of the firm. Such strategies have usually been studied under the rich literature on inter firm networks. In this context, adopting open innovation strategies by firms means increased interactions between them, in the form of strategic alliances, R&D collaborations, joint ventures, joint product development teams and the like. Usually in network-based industries, specialization is accompanied by variety which are features of the network of firms. [4]

Regardless of whether the market is multi sided or single sided, firms do learn significantly from their connections in all contexts. For example in the case of Silicon Valley, the networks between specialized computer producers have been documented to yield significant innovation as compared to the more closed system of Route 128 (Saxenian, 1994) and the computer industry is a leading example for multi-sided markets. Iyer et al. (2006) provide a visual representation of the software industry network as a highly centralized structure with the standard controllers occupying central positions, and dense inter-firm networks among many peripheral firms.

Although the two dimensions of open innovation will usually reinforce each other depending on the nature of the industry, one effect can dominate the other. Understanding this mechanism is important to evaluate the impact of open innovation in industries and to design firm level strategies. In the next section we make a taxonomy of industries based on which effect dominates.

5 A Taxonomy of Industries: The effect of open innovation

The benefits of open innovation strategies adopted by firms are plenty. However, the type of benefits that open innovation brings are different in different market contexts. In multi-sided markets there are strong network externality effects. By adopting open innovation strategies firms have the possibility to increase their market share directly by increasing the number of participants in both sides of the market. In other cases where markets are single sided, the benefits of open innovation strategies accrue mainly through organizational learning, in which firms have access to others' knowledge, which acts as a channel through which they can increase their own innovation.

[4] Each of the firms in the network is specialized and they have increased interactions between them. In this way, the network benefits from gains through specialization. At the same time, through increased interactions they develop a common language which facilitates communication and transfer of knowledge.

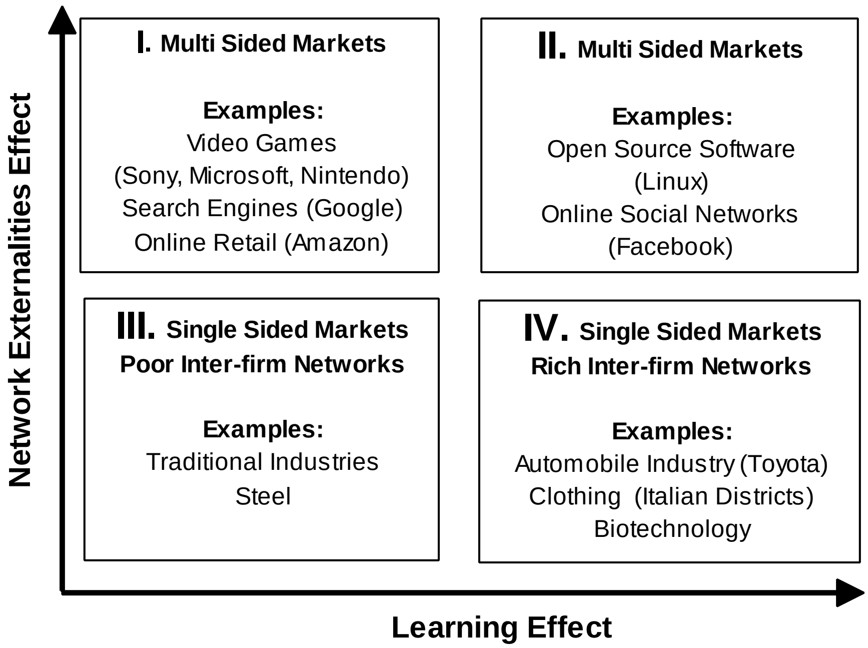

Figure 1: The two dimensions of open innovation

Figure 1 shows a taxonomy of industries based on the two dimensions of open innovation.

In Figure 1, the multi sided markets are placed in the upper boxes *I* and *II*, where network externalities effect of open innovation is dominant. Here, the extent to which learning effect accompanies the network effect depends on strategies adopted by firms in their openness. In box *II*, we place open source software and the online social networks as the extreme cases. In this box, both network externalities and learning effects are very high. These are "non-propriatery" platforms where the two dimensions strongly reinforce each other. In this case indirect network externalities exist because the number of participants in developing open source software will increase the value perceived by adopters of open source software. At the same time, open source software acts as a platform upon which the contributors solve problems jointly in developing the source code, as in the case of Linux. This results in significant learning effects from external interactions. Apart from Linux, another example is the social networking platforms as in the case of Facebook. In this case, participants have a higher likelihood of participating, the more are the number of other participants.

In addition partners have the chance to learn about their social networks using the platform.

In box *IV*, single sided markets are placed, which are usually characterized by supply chains, with the exception of pharmaceuticals in which the relations are mostly based on market access capabilities of large firms by small biotechnology firms. In this case network externalities are limited but organizational learning effect is dominant. In these industries long term relations among firms which are based on trust is an important factor conducive to increased learning. An example in which the learning effect is more dominant than the network externalities effect is the case of Toyota network (Dyer and Nobeoka, 2000). Toyota is operating in a single sided market, where consumers buy cars. In this case network externalities are limited. [5]Moreover although cars are largely modular in nature in terms of their production processes, this is hardly the case for the final consumer, who buys the car as an integrated architecture. Although concerns for free riding and very careful evaluation of releasing company knowledge is made, Toyota network is considered to be an open system in which firms in the supply chain form problem solving teams, and are involved in various alliances with each other. In these interactions significant learning takes place as documented before (Dyer and Nobeoka, 2000).

In box *III*, traditional industries is placed in which supply chains and inter-firm relations are not as dominant as in box *IV*. Here the benefits of open innovation strategies is the least compared to other industries elsewhere in the table.

Although products in most of the boxes above can contain modularity in their architecture, the boxes in the bottom of the table are not modular products for end-users. Usually in these industries, especially in complex product systems, a systems integrator is responsible from integrating the components to produce the final product. Whereas in the upper part of the box, choices of customers play an important role and there is a greater scope for customization of the final product. Because of the nature of complementarities, the demand for one part of the market will benefit the other markets automatically.

[5]Certain degree of network externalities exist because of car maintenance services and car sellers network. Nevertheless, compared to the network externalities in ICT based industries (as given on top of the box) we take such externalities to be limited.

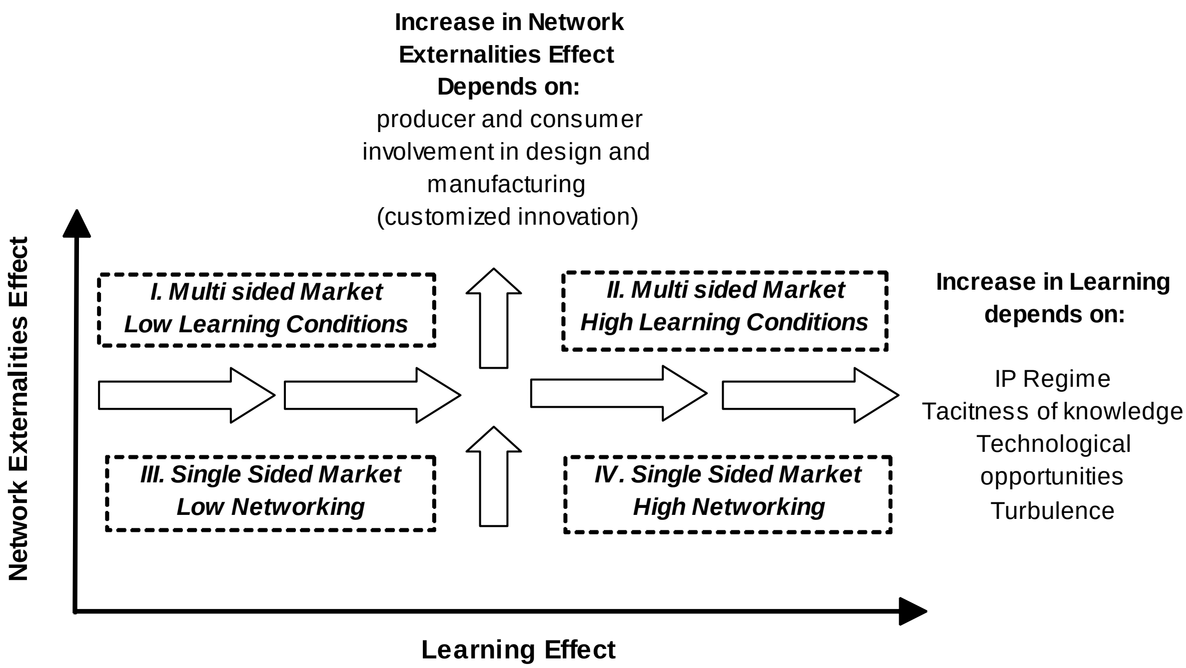

Figure 2: How change occurs in two dimensions of open innovation

6 The conditions which shape the effect of two dimensions

In the current literature a comprehensive understanding of how open innovation relates to the knowledge base regime is largely lacking. Above I differentiated between two dimensions of open innovation, as network externalities effect and learning effect. However these dimensions are not static; as industries evolve, the taxonomy of industries in this space are also changing. In addition different strategies adopted by firms influence the extent to which they derive benefit from each of these dimensions. In this section I explore how this takes place. Apart from the modularity of products, other conditions of the industry like tacitness of the knowledge base, the IP regime, turbulence, and technological opportunities will influence the extent of benefits achieved from each dimension. What are the factors which strengthen or weaken each dimension of open innovation? Figure 2 is based on Figure 1, incorporating the factors which determine the change in each dimension of open innovation.

6.1 Increasing the Learning Effect of Open Innovation

In general, the learning effect depends on the extent to which firms benefit from opening their knowledge base to external channels of knowledge. In turn, this depends on transferability of knowledge, ease of imitation, technological opportunities and the extent of turbulence . We explore each factor below.

6.1.1 Tacitness of knowledge base and appropriability

Tacit knowledge can be better transferred through repeated contacts and strong links between parties (Cowan et al., 2000). On the other hand codified knowledge can be transferred through weak links. In addition, when there is a high degree of specialization, the costs of knowledge transfer will be lower *within* specialized groups and higher *between* groups. For example, Kogut and Zander (1992), take firms as social communities in which the transfer of knowledge within the organization is facilitated, drawing upon what Arrow (1974) points out about organizations: that they facilitate communication via the development of a common language. The organization also develops capabilities by which the existing knowledge is combined with new knowledge and thereby innovation takes place as the recombination of knowledge. They explain the fundamental dilemma faced by the organization to be that when knowledge is codified, although its transfer is easier, it also renders the firm vulnerable to imitation by competitors.

Based on this knowledge-based view of organizations, where knowledge is highly tacit, its transfer among people working within a specialized group is easier than it is to transfer it between different groups. As knowledge becomes more codified, costs of communication *between* people fall but imitation becomes easier. Therefore in industries where knowledge is highly tacit, promoting the formation of *specialized teams* will increase the extent of learning within teams. Therefore to increase the benefits of open innovation in the learning dimension, firms operating in tacit knowledge regimes can promote the creation of specialized teams focusing on specific problems or areas of improvement.

In codified knowledge base regimes, it is more difficult to appropriate the returns from knowledge because of imitation risk by competitors. Therefore firms operating in codified knowledge base regimes can find it more beneficial to realize learning potential through involvement of more heterogeneous groups as customers, suppliers and buyers. Because knowledge transfer is easier, in these industries creation of online platforms for meeting of heterogenous groups will increase the extent of learning.

6.1.2 Technological Opportunities and Turbulence

The rapid innovations and increasing product complexity in knowledge intensive industries have not only raised the requirements for compatibility among product components, but have also been accompanied by richer technological opportunities. In many industries, in the face of the difficulties faced by a single firm to be self sufficient in serving a rapidly changing market, inter-firm networks have been a widespread organizational form. The role of small and flexible innovative firms in the evolution of industries has increased considerably. For example in the case of biotechnology, the network relationships are mostly dominated by arrangements between large firms and new biotechnology firms (McKelvey, 2003). In the computer industry, small firms had a significant role in the opening up of new market segments and shaping the evolution of industry (Malerba et. al. 1999).

Higher technological opportunities increases the innovative potential of the industry (Malerba, 1992). In these industries, the interactions between firms are important mechanisms to utilize the potential of these opportunities, which makes firms more likely to revert to external sources of knowledge. Therefore in industries characterized by high technological opportunities, the learning dimension of open innovation will be stronger. At the same time, technological opportunities can also facilitate the interactions between *heterogenous* groups and increase the extent of knowledge recombination by making use of diversity among different user groups. This will strengthen the network externalities dimension of open innovation.

Rapidly changing market conditions and turbulence in the environment will increase the motivation of firms to be involved in more interactions with each other for the purpose of *exploring* new knowledge residing outside the firm boundaries, and to be informed about new developments. Therefore, in many industries, uncertainty and turbulence increases the extent of openness. Therefore, the learning dimension of open innovation will be higher in industries characterized by high uncertainty.

6.2 Increasing the Network Externalities Effect of Open Innovation

In general the network externalities effect depends on the extent to which the market is divided into different user groups. In multi-sided markets, there are stronger network externalities than in single-sided markets, as discussed above. However regardless of the market in which the firm operates, the network externality benefits can be increased by creating platforms on which various heterogenous groups can interact. In fact, during the recent years the use of ICTs has enabled creation of special platforms through which users of products and services participate in solving particular problems and sharing their experience about products. In this process, which is termed to be customized innovation, different groups of users are indirectly involved in the production process with their feedback (Von Hippel, 2005; Baldwin et al., 2007; Prahalad and Krishnan, 2008). Therefore, even if the industry is not characterized by strong network externalities, the use of communication technologies can create a medium through which network externalities can be created even in single sided markets. By making use of communication technologies, firms can "artificially" create sides in a market, by creating platforms in which different groups of users interact. Figure 3 summarizes the arguments that we have outlined above.

7 Concluding Remarks

In this paper we decomposed the benefits of open innovation into two dimensions depending on the nature of products in the markets. These dimensions are network externalities effect and learning effect. Network externalities effect occurs when adopting open innovation strategies benefits one customer group which indirectly increases the value perceived by the other consumer group.

By the very nature of the ICT industry, increased modularity in product architectures is usually accompanied by increased organizational modularity. In particular, ICT industries prepare a more suitable environment for the emergence of multi sided markets, although multi sided markets are not confined to ICTs only. We argued that

	Network Externalities	Learning
Tacit Knowledge	Higher degree of modularity will increase communication *between* specialized groups	Specialized teams having strong ties among team members
Codified Knowledge	Facilitates communication among heterogeneous groups like consumers, suppliers, buyers	Learning can take place through weak links between actors
Technological opportunities	Strengthens the benefits of interactions among heterogeneous groups like consumers, suppliers, buyers	Increases learning potential
Turbulence	Increases the willingness of actors to be involved in various heterogeneous groups	Increases the motivation of actors to be involved in external interactions

Figure 3: Open innovation dimensions and conditions of the knowledge base

in multi sided markets network externality effect can dominate the learning effect.

Quite contrarily, modularity of final products is limited in single sided markets. In single-sided markets the learning effect is likely to dominate network externality effect depending on the industry, i.e. whether it is characterized by increased inter firm networking or not.

Finally, we argued that the positive impact of open innovation can be increased in each dimension. This will depend on characteristics of the knowledge base (tacitness, technological opportunities, appropriability of knowledge, turbulence) and firm strategies.

Strategies which will enhance communication platforms between and within heterogenous customer groups will in general increase the network externality effect of open innovation, in both single sided and multi sided markets. Examples to this are customized innovation which is seen in many industries today. Customized innovation refers to increased involvement of customers in the innovation process, mainly made easier by increased availability of communication media.

Strategies which enhance learning depends directly on knowledge base regime. Where knowledge is highly tacit specialized problem solving teams will enhance learning. When there are limited imitation possibilities learning dimension of open innovation will be enhanced. When there are increased technological opportunities, there will be more returns from external interactions in the form of learning. When there is high turbulence, actors will be more motivated to be involved in external interactions which will enhance the learning effect.

References

[1] Allen, R. (1983) “Collective Invention”, Journal of Economic Behavior and Organization, 4, 1-24.

[2] Arrow, K.(1974) The Limits of Organization, 1974.

[3] Arthur, W. B. (1989), "Competing Technologies, Increasing Returns, and Lock-In by Historical Events". Economic Journal, Vol. 99, No. 394, pp. 116-131.

[4] Baldwin, C. Y. and Clark, K. B. (2000) Design Rules: the Power of Modularity Volume 1. MIT Press.

[5] Baldwin, C. , Hienerth, C. and von Hippel, E. (2006) "How user innovations become commercial products: A theoretical investigation and case study" Research Policy, Volume 35, Issue 9, November 2006, Pages 1291-1313.

[6] Boudreau, K. and Hagiu, A. (2008) Platform Rules: Multi-Sided Platforms as Regulators,

accesible from: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1269966 in October 2008.

[7] Brusoni, S. and Prencipe, A. (2001) "Unpacking the Black Box of Modularity: Technologies, Products and Organizations," Industrial and Corporate Change, vol. 10(1), pages 179-205.

[8] Chesbrough, H. (2003) Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Cambridge, MA.

[9] Cowan, R., David, P.A., Foray, D., 2000. The explicit economics of knowledge codification and tacitness. Industrial and Corporate Change 9 2., 211–253.

[10] Dyer, J.H. and Nobeoka, K. (2000) "Creating and Managing a High Performance Knowledge Sharing Network: The Toyota Case", Strategic Management Journal, 21: 345-67.

[11] Evans, D., Hagiu, A. and Schmalensee, R.(2006) Invisible Engines: How Software Platforms Drive Innovation and Transform Industries, MIT Press

[12] Gawer, A. and M. A. Cusumano (2002) "Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation," Harvard Business School: Boston, MA.

[13] Goyal, S., (2005) Learning in Networks: A Survey, in Group Formation in Economics: Networks, Clubs and Coalitions, Demange and Wooders (eds.), Cambridge: Cambridge University Press.

[14] Grant, R.M. "Toward a Knowledge-Based Theory of the Firm," Strategic Management Journal (17), Winter Special Issue, 1996, pp. 109-122.

[15] Iyer, B., Lee C.H. and Venkatraman, N. (2006) Managing in a "Small World Ecosystem": Some Lessons from the Software Sector, California Management Review; 48(3): p28-47.

[16] Kogut, B. and Zander, U. 1992 'Knowledge of the firm, combinative capabilities, and the replication of technology', Organization Science 3: 383-397.

[17] Kogut, B. and Metiu A. (2001) Open-Source Software Development and Distributed Innovation, Oxf RevIew of Economic Policy, 17:248-264

[18] Langlois, R. N. and Robertson, P.L (1992) Networks and innovation in a modular system: lessons from the microcomputer and stereo component industries, Research Policy 21(4), pp. 297–313.

[19] Lavie, D. and Rosenkopf, L. (2006) Balancing Exploration and Exploitation in Alliance Formation, The Academy of Management Journal, 49(4): 797-818.

[20] Malerba, F. (1992) "Learning by Firms and Incremental Technical Change", The Economic Journal, 102: 845-859.

[21] Malerba, F., Nelson, R., Orsenigo, L. and S.Winter (1999) "History Friendly Models of Industry Evolution: the Case of the Computer Industry", Industrial and Corporate Change, 8(1): 3-40.

[22] Powell, W.W., Koput, K.W. and Smith-Doerr, L. (1996) Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology, Administrative Science Quarterly, 41:116-145.

[23] Prahalad, H. and Krishnan, M. S. (2008) The New Age of Innovation. Mc Graw Hill.

[24] Rochet, J. and Tirole, J. (2006) Two-sided markets: a progress report, RAND Journal of Economics, 37(3): p. 645-667.

[25] Rochet, J. and Tirole, J. (2003) Platform Competition in Two-Sided Markets, Journal of the European Economic Association, 1(4): p.990-1029.

[26] Rothaermel, F.T. and Deeds, D.L. (2004) Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development, Strategic Management Journal, 25: 201-221.

[27] Sanchez and J.T. Mahoney (1996), Modularity, flexibility, and knowledge management in product and organizational design, Strategic Management Journal 17, pp. 63–76 (Winter special issue) .

[28] Saxenian, A.L., (1994) Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Harvard University Press, Cambridge

[29] Schilling, M. and Phelps, C. C. (2007) "Interfirm Collaboration Networks: The Impact of Large-Scale Network Structure on Firm Innovation"? Management Science, 53(7): 1113-1126.

[30] Schilling, M. A.(2000) Toward a General Modular Systems Theory and Its Application to Inter-firm Product Modularity, Academy of Management Review, 25 (2), p.312-334.

[31] Steinmuller, E. (2007) The Economics of ICTs: Building Blocks and Implications in eds. R. Mansell, C. Avgerou and D. Quah, The Oxford Handbook of Information and Communication Technologies, Oxford University Press.

[32] Von Hippel, E. (2005) Democratizing Innovation, MIT Press.

[33] Williamson, 1985. Williamson, O.E., 1985. The Economic Institutions of Capitalism. The Free Press, New York.