

Knowledge Transfer Processes in Product Development —Theoretical Analysis in Small Technology Parks

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ABSTRACT

Large science parks and their knowledge transfer processes have been studied extensively while only a few papers on small parks exist. Characteristic to them is that the institutions and services are fewer than in the large ones. The main target of this paper is to create a framework to analyse further knowledge transfer processes in small technology parks. The framework resulting from the study has two main phases: the innovation enabler and product development process analyses. The innovation enabler analysis starts with a local innovation system and a technology park analysis, including links to other geographical levels, and links to sectoral innovation systems. It is continued with a social capital assessment and a network analysis. The product development process analysis explores the product development processes as the targets of the knowledge transfer, and transfer of different types of knowledge through and from the local innovation system.

Keywords: Knowledge Transfer; Product Development Process; Technology Park; Innovation System

1. Introduction

The first technology parks in the world were founded in the 1950's. Stanford Research Park, founded in the year 1951, is mentioned to be the first one of its kind. In January 2007, Silicon Valley employed 870,000 people [1]. In following decenniums, a large number of technology, science, and research parks were founded in the United States and in Western Europe [2]. In the 1980's and early 1990's, many technology parks started in Finland and Sweden, also in the northern most parts of the countries including Oulu in Finland and Luleå in Sweden. Also the smaller towns, e.g., Kemi in Finland and Kalix in Sweden, started their activities.

Several definitions for technology parks are available in the literature and also within the web sites of technology park associations. The International Association of Science Parks defines the term "science park" in the following way [3]: "A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R & D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes;

and provides other value-added services together with high quality space and facilities."

Even if most of the attention is paid on the large science or technology parks in large cities, they exist also in smaller towns. The aim is to renew regional economics to help the regions to survive structural changes, facilitate the local firms' access to follow the technological development, and to facilitate innovation activities. Where small towns are concerned, the services and related activities are limited when compared to large university cities. Usually the number of firms in a local cluster is small, local market is limited, and—even if there is a higher education institute—the knowledge base is limited. Various models exist. e.g., in the North of Finland there are 15 technology parks of various sizes, and a total of 17,000 jobs of which over half are in Oulu [4]. All of these 15 technology parks cooperate within the framework of the Multipolis network. The basic idea is specialisation e.g., in research and special laboratory equipment, and cooperation in tasks that would be e.g., financially difficult for one technology park to realise alone. One of the basic ideas is the knowledge transfer between the local clusters but especially from Oulu, the largest with strongest research and education resources, to the smaller centres [4].

Innovations are based on the knowledge that exists in the firms, and also on the knowledge they acquire from

various sources in the form of explicit and tacit knowledge, embedded in new skilled personnel, or subsystems. It can be expected that the technology park and the local innovation system—with their actors, services and networks—have a role in the knowledge transfer to the firms' product development processes. Personal contacts and social networks may promote or inhibit collaboration between organisations [5], and thus social capital has a role as a knowledge transfer enabler. The technology park—or the local innovation system—as a milieu, and social capital are two of the factors that enable interorganisational networking. The product development process involves various phases [6,7] where different kinds of external knowledge is needed, and transferred to.

Our study focuses on how the knowledge is transferred to the firms' product development processes in the context of small technology parks with limited resources and services, and what the influence is of the local innovation system with its limitations. The main goal is to create understanding based on existing research, in order to study the functionality of the small technology parks, and the knowledge transfer processes inside them. Based on the former, our first research question is:

RQ1 What kind of factors affect knowledge transfer to firms' product development processes from and through a local innovation system with incomplete services?

This main question will be consecutively operationalised into smaller entities to outline more accurately the factors affecting on knowledge transfer.

Industries open their innovation activities and processes and co-operate with external partners and consumers—in order to create an innovation system. This paper focuses on the management of product development process from a company perspective. However, after defining the context, we would like to present a recent approach—the context of open innovation. This recent development of knowledge regarding the user/customer/consumers involvement on innovation processes [8,9] has a similar target as an entity as our original RQ1. Therefore the idea is to compare findings of existing literature based on the framework (RQ1) to see:

RQ2 How the framework developed—RQ1—relates on concept of open innovation?

2. Frame for Theoretical Construct

Our theoretical frame of this study is based on five areas: innovation systems; social capital; product development process; networking; and the knowledge transfer process as a compilation “**Figure 1**”. The local innovation system including the technology park, and the local social capital are enablers determining the basic conditions and milieu that enable the knowledge transfer processes. The knowledge is transferred in the product development process which determines what knowledge is needed in each of

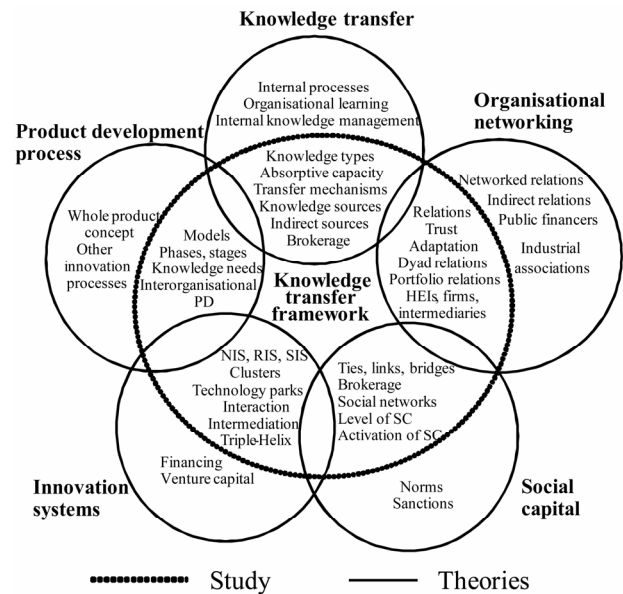


Figure 1. The elements affecting knowledge transfer from and through a local innovation system to firms' product development processes.

the phases. Interorganisational networking makes the knowledge transfer possible, and firms develop networks according to the needs and the enablers: the innovation system; and social capital. The knowledge transfer process, as a consequence, is the result of the enablers, needs, and networking.

The structure in itself consists of several theories that are included or excluded in our analysis. The use of different theoretical fields in the study is limited to the level that is directly useful in the analysis in chapter 4.

3. Enablers and Processes for Knowledge Transfer

3.1. Innovation Systems

Through innovation systems we search for the role of the innovation system in enabling knowledge transfer to firms' product development processes in small technology parks. The innovation system in which a firm operates is an enabler for its innovative processes.

The first feature to be studied is the spatial scale of the focal technology park, or the local innovation system it is part of. In the reviewed literature, the technology park definition varies from one building to a whole city or town and from a park area to a whole county like the Silicon Valley. In most of the technology parks neither all the local actors participating in the firms' product development processes nor all the local firms involved are located in the science park [10]. The spatial scale is the first step to be defined when a technology park is analysed as an innovation system.

The chosen strategy of the focal technology park has a

major effect on the operations. Ylinenpää [11] defines two main strategies: the incubation strategy, aiming for favourable conditions to create new start-up firms; and the attraction strategy trying to attract established and larger firms to locate knowledge-intensive divisions or units with the expertise and recruitment base that the local HEI (Higher Educational Institute) forms. The latter strategy may lead to a vertically oriented “firm constellation” instead of horizontal “network” structure [11], and thus the strategy choice may influence the product development processes. Also to understand the recent functionality of a technology park, its earlier history and development has to be known: every park has been founded in its own time and has same features in its development path as the others, even though not simultaneously [12]. A short analysis of the parks history and the development path of focal technology are an essential part of the frame.

According to the literature, other actors, e.g., supportive services, have an important role in the product development processes of a firm in providing services related on business infrastructure. In a technology park there are some specific actors that are founded to operate some specific activities. In some cases, the technology park itself takes care of several tasks: building and maintaining the premises; operating business hotel services; running the incubating services etc. There is anyhow a large variation between science parks [4]. To enable a proper analysis of the functions, activities and actors should be analysed in detail, but limited to knowledge-related matters. The role of KIBS (Knowledge intensive business services) and other intermediaries in an innovation system is to intermediate knowledge and information as well as to influence the structures and dynamics of the system [13-15]. Many organisations or parts of them may have the intermediating role even unconsciously [13]. The incubators’ role is to assist start-up firms and transfer or intermediate them the knowledge they need [16-18]. To identify the intermediaries and their roles, their activities are analysed by applying some of the functions that Howells [14] has defined.

According to a number of studies, organisations operating in interface are the most important partners for firms in their innovative activities [19-21]. The other firms include several different types of groups having different characteristics from the focal firm point of view. Customers are of the highest importance according to surveys amongst firms [20-25]. Local customers inside the “local innovation system” are of highest importance [26,27] followed by equipment, material, component, and subsystem suppliers [19-23]. The existence of local competitors allows both mutual knowledge transfer, joint knowledge transfer from third parties, and knowledge creation through joint participation in research programmes [19,28]. An anchor tenant with a heavy investment

in R & D may have a major effect on local smaller firms [29]. Strategic and tactical alliances, and subcontracting in product development processes have become more and more usual in the globalising market with multi-technological products [30]. Alliances, partnerships, and outsourcing as forms of co-operation of individual tasks or projects are of high importance [25,29-36], and they should be considered as an essential part of the enabling factors in the local innovation system on the entity level.

The type and existence of higher education and research institutes varies between technology parks and local innovation systems. HEIs form the central source of qualified personnel. The knowledge base can be focused to fit better on the needs of local firms with the help of project-based learning, and these are focused on firms’ needs [20,37-39]. The local degree and other education programmes are analysed to find out their roles. Local research has a significant value to the firms. [20,40-42]. The different models the institutions utilise for contract research, publicly funded research, study projects, licensing etc. are of importance to understand their enabling roles.

A local innovation system does not work without connecting links to broader geographic context: the regional, and national innovation systems. When defining the spatial boundaries of a regional innovation system, the main criterion is the high “coherence” or “inward orientation” with regard to product development processes instead of e.g., administrative boundaries [43]. In practice this can be interpreted so that a science park or a local innovation system can be part of a larger regional system, or have links to one or several regional systems [44]. The national innovation system forms the boundary conditions in which the local actors operate. The national system should not be seen as a question of resource allocation but the dynamic features including learning, knowledge flows and relationships [45]. The maturity and functionality of the “local innovation system” can be reflected to the knowledge space (creation of a regional innovation environment), the consensus space (a “triple helix” of linkages generate ideas and strategies), and the innovation space (realising goals, experiments, public venture capital). [46] The sectoral innovation system approach focuses on knowledge and technology domain, actors and networks, and institutions [47,48]—the same types of elements as the spatially defined innovation systems but focusing on one sector. The sectoral system can be local, national, or global, or it can have all these dimensions combined [48].

3.2. Social Capital

Connections and links between people form the base for networking among firms and other organisations. Even if the cooperation between firms is built on tight contracts,

the negotiations and connections are dependent on interaction between people working in those firms. Strong ties are important for social support. A weak tie is the opposite—a friend of a friend type of interaction—that is valuable as a source of novel information. [49,50] Therefore we search for the role of social capital in enabling knowledge transfer to firms' product development processes in small technology parks. Structural holes are potential connections that can be used to broker gaps in the network [50,51]. Brokerage across the structural holes provides a vision of options otherwise unseen [51]. Direct ties serve as sources of resources and information, indirect ties as sources of information, and structural holes between partners expand the diversity of information. Direct and indirect ties influence the innovation output positively, but an increasing number of structural holes decrease innovation output [52].

Social capital consists of social networks, norms, and sanctions that govern their characteristics. It has three basic components: a network; a cluster of norms, values and expectations shared by group members; and sanctions that help to maintain the norms and network. The sub-types of social capital are defined as bonding, bridging and linking. Bonding can be referred to strong ties and bridging to weak ties while linking is an even weaker connection including, e.g., norms like mutual respect [53]. Strong ties, high level of social capital, and proximity foster innovation and learning processes as total [54-60] while weak ties foster radical innovations [61]. Key persons are important to make networks efficient [56,62].

3.3. Product Development Process

Our main focus is on knowledge transfer to the product development processes of the firms in small technology parks. The product development process itself is not a primary object, but because of the type and sources of knowledge needed, the different parts of the product development process varies [63] and renders it necessary to analyse the product development process to some degree. Therefore, we need to understand what kind of knowledge is needed in various phases of product development processes in firms in small technology parks. There are several models to describe the product development process. The number and definition of stages varies to some degree. The fuzzy front end consists of the identification of the opportunity, idea generation and refinement, and idea evaluation [64]. Some involve the concept development in it, while others involve even the idea evaluation in the main product development process [6]. The concept development is followed by the technical design stages. The technical development is then followed by functional testing, validation and refinement, as well as production ramp-up and launch [6,7,64].

Firms rarely innovate alone [65] but seek collaboration

to share risks [66], and find complementary resources [66-69]. Users are a major source of knowledge [63, 69-72] as well as suppliers [73-75]. In addition to the mediating role, intermediaries may also have a role in tailoring new technologies [76]. The role of higher education and research institutes is emphasised [41,77-79] although in surveys they do not reside at the top of list [20,22,23]. The role of co-operation as outsourcing, alliances, and partnerships is rising [80-82] especially when incremental innovations are concerned. The attention should be first paid on the process and its stages. Secondly, the knowledge needs in various stages should be analysed according to the knowledge type, source, and importance.

3.4. Interorganisational Networking

In current economy, no organisation is an island, and therefore we need to outline, how does interorganisational networking function in knowledge transfer to firms' product development processes in small technology parks? The basic level in an interorganisational relationship is a dyad one-to-one relation, where personal contacts and social capital are in an essential role [5]. Personal contacts may either promote or inhibit exchange of information, assessment, negotiations and adaptation, and service production and transfer. Because of various factors, firms use managerial practices and processes to foster trust-building. The trust itself has three dimensions: competence; goodwill; and behaviour [83]. Reputation of treating counterparts fairly [84], cultural values, and norms are of importance [85]. A shared identity helps in developing mutual trust that assists in developing transparency, intent to mutual learning, and understanding each other better than formal agreements. On the other hand, too strong trust is argued to destroy creativity. Mutual trust and commitment; power dependencies; mutual intent; shared identity; and previous outcomes define the relationship atmosphere. Processes needed in for interaction are exchange; adaptation; and coordination. The support structure should cover the rewarding system; operational structure; and infrastructure [86].

In practice most firms operate simultaneously with several other firms and organisations. This is called the portfolio of relationships [87]. If the system is open, the members are connected to each other through other members in structural holes controlling knowledge flows among actors. In a closed system all actors have connections to all others. An open system favours capture of new knowledge but not so much the creation of it. A closed system supports more both moving and doing of knowledge, but supports incremental development and innovation [84]. If the market is turbulent, the actors are forced to constant strategising, partnerships are decided fast, many of them are short, and the networks are con-

stantly changing [81]. The whole network can be managed by using e.g., methods used in supply chain management, including business process integration etc [88,89].

Lambert [88] defines four types of business process links according to the importance of each actor to the firm: managed links; monitored links; non-managed links; and non-member links. In some cases also connected relations are managed [87], which in practice means that the specified part of the relationship chain is closed [84]. In a full network mode, all the members are connected to each other in several different ways [87]. The ARA (Activities, Resources, Actors) model introduces the concept of the function of third parties that takes into consideration the influence of a relationship to third parties, or how the firm is affected by a relationship between third parties [90,91]. The ARA model is argued to be a useful framework for understanding information exchange, where trust is a major transfer enabler [84-86,92-94].

3.5. Knowledge Transfer and Management

Several knowledge transfer and management theories are available in the literature. They deal mainly with knowledge management on the organisational level [95,96]. We need to study: how is knowledge transferred in and through the local innovation system to companies' product development processes in small technology parks? Our interest is on the knowledge related processes in small technology parks including the transfer inside the local innovation system, and the knowledge transfer through the local innovation system to the product development processes of the firms. The amount in which a firm is capable to capture knowledge is dependent on its absorptive capacity which is not just a sum of the absorptive capacities of the individual persons, but includes the knowledge transfer functions. Difficulties may be caused, e.g., by centralised gatekeeper roles, the expertise of the individuals receiving the knowledge, the narrowness of expertise, or even by the "not-invented-here" syndrome [97]. The absorptive capacity is determined by mutual trust and power dependencies within the relationship, the mutual intent, receiver's ability to capitalise on the transferred knowledge, the organisational receptivity [98], the similarity of the knowledge bases of the firms, the organisational support structures, and the compensation policies [99].

The knowledge needed to enhance the absorptive capacity does not include just the substantive knowledge itself but also awareness of where the useful complementary knowledge resides within and outside the organisation: knowledge of who knows what; who can help with what problem; or who can exploit new information [97]. It has been found that age as well as educational and size effects influence the SME acquisition and assimilation of knowledge [100].

Knowledge transfer into a firm leads to organisational learning processes—that can be described with learning curves [101,102]—including the individual learning of the employees, coordination of work, incremental innovation of the process, and the effect of new tools [102]. Research and development expenditure influence in the slope of the learning curve [103]. Knowledge can be transferred by moving people, technology, or a structure to an organisation, or by modifying people (e.g. training), technology, and the structure of the recipient organisation. If the knowledge is embedded in individuals, the extent of labour turnover may cause organisational forgetting [101].

There are two basic types of knowledge: tacit and explicit. The tacit knowledge is the most difficult to transfer, but succeeds with the help of various types of collaboration forms [95,104,105]. Lubit [104] lists solutions to accomplish it without transforming the knowledge to explicit form: working together with experts making observations and learning from coaching; working in groups and networks including brainstorming etc.; recording learning histories by writing narratives of critical events such as a change initiative, a product launch, or an innovation including mistakes; and developing routines for dealing with various situations and spreading the routines throughout the organisation. The explicit knowledge, e.g., in form of data, specifications, manuals, scientific formulae, or product can readily be transmitted formally and systematically [97,105].

3.6. Factors Affecting Knowledge Transfer to Firms' Product Development Processes

The first enabler is the local innovation system (**Figure 2**) including the technology park, actors and structures, regional and national links, and connections to sectoral innovation systems. 1) The second enabler is the local social capital with its links and bridges to other locations; 2) The enablers will create the foundation for knowledge transfer, and they are analysed on the innovation system level. Then the product development processes determine what type of knowledge is needed in each of the project phases; 3) The knowledge needed in the process phases is transferred to the process with the help of interorganisational networks; 4) The next two factors, processes, are to build on the foundation and make knowledge transfer happen. The product development processes define the needs for knowledge, and the organisational networking builds the structure to transfer knowledge. They are both analysed on product development process level. Finally the fifth factor—the knowledge transfer itself as the compilation of the four factors 5)—is a consequence and compilation of the enablers and processes. It will be considered both on firm level, and on technology park level.

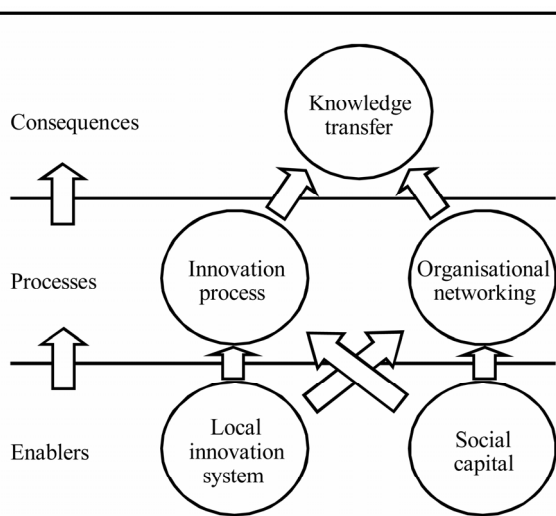


Figure 2. The logic and hierarchy of the elements affecting knowledge transfer in a local innovation system to firms' product development processes.

4. Comparing Open Innovation of the Constructed Framework

4.1. Open Innovation as a Concept

The extent and type of innovation has been analyzed by researchers in the following ways (as collected by Dodgson *et al.* [106]: radical or incremental [107]; continuous or discontinuous [108] or sustaining or disruptive [109]; change over life cycles [110]; modular or architectural [111]; emergence of a dominant design [110]; and open or closed innovation strategies (Figures 3 and 4) [112].

Open innovation (OI) has been highlighted and discussed as an important concept in understanding and analyzing the 21st century business and innovation environments [113]. As a whole, OI paradigm can be understood as the antithesis of the traditional vertical integration model where internal research and development (R&D) activities lead to internally developed products. OI is the use of inflows and outflows of knowledge to accelerate internal innovation—product development process, and expand the markets for external use of innovation. [113].

4.2. Comparison of OI and Developed Framework

The OI model also involves a marked change in the adopted principles of innovation (see Tables 1 and 2). It is instructive to compare the Open Innovation Principles to the pieces of constructed framework.

Since the first publication of Chesbrough's Open Innovation in 2003 [112], the ideas of OI have become influential among innovation managers in many industrial

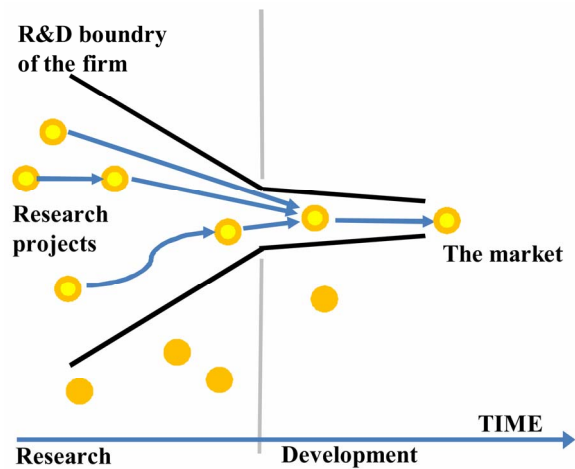


Figure 3. Closed innovation model [112].

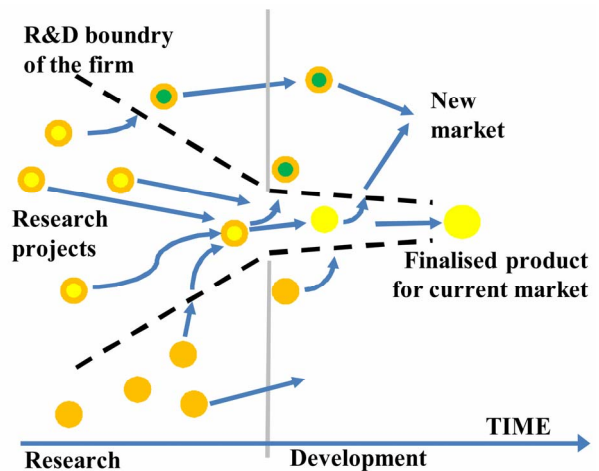


Figure 4. Open innovation model [112].

companies [114], however, not without some criticism. Like Dodgson *et al.* [106] note there is some controversy in the innovation literature as to how open companies should be towards external partners in their search for new innovations and in developing new routes to market [115,116]. Then Dodgson *et al.* [106] emphasizes that companies need to be careful in opening themselves to external partners for the following reasons: the danger of theft, managerial time demands and transaction costs, over-reliance on external partners, and slowing down of own internal innovation process due to increasing coordination costs.

The choice between vertical or horizontal integration of the product creation or production value chain has been discussed for decades, but the issue of openness seems more recent. In knowledge-intensive organizations and industries, open innovation is already in use—maybe not exactly according to the OI model, but in reality, yes. For example, Nokia has successfully applied collaboration strategies for more than ten years.

Table 1. Comparing the factors affecting knowledge transfer to firms' product development processes in context of small technology parks into the principle of open innovation.

Open Innovation Principles [112]	Framework Developed in This Study
Not all the smart people work for us. We need to work with smart people inside and outside our company.	Innovation system enables more than a single company can create; it promotes future competitiveness in certain areas. The context of technology park is to co-operate; networking is a process of co-operation.
External R & D can create significant value; internal R & D is needed to claim some portion of that value.	Social capital enables companies to develop new products. The roots of new ideas and models of thinking but also products are in interfaces.
We don't have to originate the research to profit from it.	It is important that others are successful too, success in supporting areas is not a "zero sum game".
Building a better business model is better than getting to market first.	To concentrate on own core competencies and let others concentrate on supporting competencies. Better possibilities to develop successful end products can be created.
If we make the best use of internal and external ideas, we will win.	By concentrating on developing our own organisational capabilities—we will be also beneficial for others.
We should profit from others' use of our innovation project, and we should buy others' IP whenever it advances our own business model.	Everything may not be necessary or needed in order to achieve on our own, instead of developing technology. We can acquire it from outside the company. Again learn from others.

Table 2. Comparing the principle of open innovation into the factors affecting knowledge transfer to firms' product development processes in context of small technology parks.

Framework Developed in This Study	Emergence in Open Innovation Model	Emergence in Open Innovation Model
Innovation systems	Allows organizations to acquire new knowledge outside their own organizations—especially in B-to-B environment	
Social capital	Secures the possibility of new ideas to develop and mature in their own context	
Product development process	The target of OI—OI provides fuel for this engine	
Networking	Provides interfaces for small companies and actors	
Knowledge transfer process	The heart of OI—this is what OI is about	

5. Discussion and Conclusions

The literature review confirms that there are very little studies on small technology parks. Knowledge is a necessity for innovations, new products and services. Small technology parks in remote locations have incomplete knowledge related services, and a small number of actors. In the innovation system study, the unit of analysis was the local innovation system with focus on the technology parks. On the other hand, the product development processes and knowledge transfer were studied on the level of firms' processes. Social capital and its effects should be studied both on company and innovation system level. The results of the study imply that neither research on innovation system level, research on the firms' product development process level, nor on firms' interaction within product development processes are adequate to explain how, where from, and what type of knowledge is transferred to the firms' product development processes.

A small technology park is not an adequate basic unit to study the knowledge transfer but also other local actors have to be included, as well as links to regional, national, and sectoral (industry or business specific) innovation systems. The main strategies—incubation, or attraction—affect on the constellation of firms, and thus the knowledge transfer processes. Also the history of the

technology park has major influences on the choices that firms make, and also on the social capital and thus on networking between the firms. The local actors, their existence, and activities should be noted because they affect what types of firms locate in a technology park, how they transfer knowledge, and what type of knowledge is transferred. The Triple-Helix concept is usable in measuring of the overall functionality of a technology park but detailed exploration demands a more detailed study. Studies on social capital—especially from the social network point of view—is necessary for the understanding of networking among firms and other actors in a small technology parks. Further on, to understand the local social networking and social capital, also the actions taken to foster social capital, have to be included in to the analysis.

When studying knowledge transfer to firms' processes, the product development processes and the knowledge needs differ a lot, depending on the independence of the firm, independence of the process, role of intermediates, and several other factors. The product development processes vary between firms. The knowledge needs in each of the process phases can be analysed by first fitting the process to a model with standardised phases. After studying the enablers—innovation system, and social capital—and analysing the knowledge needs in the product

development processes, networking can be analysed by using data from the firms product development processes. To understand the knowledge transfer to a firm's product development process, networking should be analysed both on dyadic and portfolio levels. A dyadic relationship with trust and adaptation tells usually about a long-term relationship with also tacit knowledge transfer, while a portfolio relationship tells of managing competing relationships with weaker links and transfer of explicit knowledge or subsystems.

Finally, the purpose of open innovation is to provide more ideas on the product development process to get more success through products. In general, level industry is opening its innovation processes, through exchange and brokering of technology resources [106] and applying social innovation. It is not important whether these practices are found through extensive literature search (innovation systems; social capital; product development process; networking; and the knowledge transfer process as a compilation) or from totally different approach of open innovation. It is however interesting to note that both of these approaches emphasises the same features. Based on **Tables 1** and **2** you can find features of our framework from open innovation principles or the other way around.

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