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Research Article

THE EFFECTS OF KNOWLEDGE SPILLOVER ON INNOVATIVE PERFORMANCE IN KNOWLEDGE-BASED IT COMPANIES

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ABSTRACT
Companies invest in learning activities to improve their innovative efforts. These kinds of activities may be either internal or external. Knowledge flow among main actors is one of the external learning factors. Non-intentional knowledge flow among companies without any compensation or with compensation less than the real value of the knowledge is called "knowledge spillover" and in the case of companies located in a same area geographically, is believed to be the main stimulus of regional innovation and growth. Another form of knowledge flow may occur when money is paid in return for the transferred knowledge, which is called knowledge flow through market transactions. The knowledge spillover mechanisms are: labor mobility, informal interaction and spinoff companies. This paper aimed to analyze the effects of knowledge spillover on innovative performance of knowledge-based IT companies. The results from the gathered data denote that knowledge spillover has positive impacts on innovative performance of IT companies situated in science and technology parks in Tehran.

Keywords*: Knowledge Spillover, Knowledge Flow, Innovative Performance*

INTRODUCTION
Today all economists and business managers consider knowledge as one of the most important and the most influencing production factors and admit that knowledge can contribute to a great extent to the innovativeness, and therefore competitiveness, of a business. In developed countries, knowledge spillover taking place among different companies in an industry as the main stimulus of innovation, learning and economic growth (Acs *et al.*, 2009). Knowledge spillover is an intellectual advantage resulting from exchange of information, in return for which no direct reward is given to the knowledge producer or sometimes the value of reward is less than the value of produced knowledge (Acs *et al.*, 2009). In1920 Marshall in his book entitled "Principles of Economics" has emphasized that producers in industrial zones take advantage of the knowledge and ideas "in the air". Knowledge spillover can also increase the competition among companies in an industry since innovation is an important factor in competitiveness (Kesidou & Romijn, 2008).

Studies concerning the effects of knowledge spillover on performance of businesses can generally be divided into two groups. The first group asserts that knowledge spillover has positive impacts on innovative performance of businesses; meaning that the knowledge resulting from regional density of companies active in an industry or in different industries can be used in other companies and stimulate innovation and economic growth (Fallah, 2004).

The second group, opposing the first one, argues that free and non-intentional flow of knowledge formed in a specific area may decrease company's interest in investing on innovative activities due to their fear of being imitated. Therefore knowledge spillover among knowledge-based companies has negative impact on their innovative performance (Chan *et al.*, 2009). This paper, thus, tries to explain and justify the results of various studies by means of a quantitative analysis of the effects of knowledge spillover on innovative performance of knowledge-based companies. We also tried to examine the relationship

between different mechanisms of knowledge spillover and innovative performance of knowledge-based IT companies cooperating with high tech industries in Tehran.

Theoretical Foundations and Research Background

Few studies have been carried out in developing countries on the concept of knowledge spillover. Jeff and Tradjenburg (1993, cited in Agarwal *et al.*, 2007) have examined geographical distribution of patents and number of references to patent documents. They observed that references made to patent documents are to a great extent limited to a specific region, and concluded that knowledge spillover is limited to physical space (Agarwal *et al.*, 2007). However references to patents can only be a sign of knowledge spillover and cannot be used for validation of the theory of knowledge spillover because in less-developed countries, few innovation-related activities can succeed to be patented (Kesidou & Romijn, 2008).

Saxenian's study (1994, cited in O'mahony & Vecchi, 2009) concerning semiconductor industry in Silicon Valley showed that higher innovative performance of this cluster in comparison with Boston cluster 128 is a result of strong non-commercial relationships between its companies. These relationships contribute to informal exchange of ideas and knowledge necessary for learning and innovation. Gathering managers and employees of local companies contribute to informal exchange of information, and high circulation of workforce between companies and establishment of new spin-offs by employees leaving large corporations cause high circulation of knowledge based in human resources (O'mahony & Vecchi, 2009).

Audretsch and Feldman (2003) tested spatial distribution of innovation in the United States. They used new products in the US market as an innovative index. They measured the level of knowledge based-ness of an industry by identifying the ratio of its R&D expenditure to its sales scales, percent of skilled workforce (Human Capital) and academic researches. Their findings supported the idea that innovation is focused in a space due to the tacit nature of technological knowledge and showed that individuals' interactions are necessary for knowledge spillover (Audretsch & Lehmann, 2005). Zucker *et al.*, (1998) related the location of biotechnological companies to the existence of famous researchers. They first identified leading scientists by their research productivity, and then calculated the number of companies dealing with biotechnological issues in every region of the United States (1998). They also tested the existence of knowledge spillover by growth of spin-offs and location of leading specialists which is only one way of knowledge spillover. This study did not consider other possible ways of knowledge spillover, e.g. those observed in Saxenian's work (1996), prefer informal exchange of knowledge and labor mobility (Anitra, Mcdougall, & Audretsch, 2008) .

Also, in 2003 Caniels and Romijn tried to show how regional density facilitates knowledge accumulation in businesses and therefore increases innovativeness and competitiveness of clusters. Knowledge spillover happens through various mechanisms: free circulation of knowledge through interactions between companies, circulation of specialist workforces and establishment of spin-off companies (Kesidou & Romijn, 2008). Other studies have been done concerning the effects of geographical clustering on process of knowledge accumulation in developing countries but none has clearly considered the role of knowledge spillover, though they generally pointed the advantages and importance of accumulation. In their 2008 study on software companies located in Montevideo, Uruguay, Kesidou & Romijn examined the mechanisms of knowledge spillover in a developing country and assessd its effects on innovative performance of these businesses. At the end, they stated that the identified mechanisms of knowledge spillover have positive effects on innovtive performance of IT businesses. Table (1) summarizes the experimental stuides on knowledge spillover.

Companies increase their innovative capabilities during technological learning process. Innovative performance of a company is a latent variable output called innovative ability of that company. Innovative ability is gained through internal activities and external resources. Mechanisms of innovative abilities acquisition in Romijn's study are classified as follows:

1. Technological ability may be gained through internal technological activities, like in-house R&D efforts or systematic reverse engineering.

2. Knowledge may be gained from external resources, or may be a by-product of different ways of interacting with world, or may be gained through active and targeted search.

3. Innovative ability increases by making use of human capital or through formal and informal training activities happen in the company.

Table 1: Prominent Experimental Studies Concerning Knowledge Spillover

Author	Methodology	Results	Limitations
Jaffe *et al.*, (1993)	References to patent documents	Knowledge transfer happens through references to patent documents	Not all references to patent documents represent knowledge spillover
Saxenian (1994)	Longitudinal comparative case analysis	Knowledge spillover happens through informal exchange of knowledge, labor mobility and spin-off companies in semi-conductor industry in Silicon Valley, the US	Characteristics of the industry can influence the results
Audretsch and Feldman (1996)	Innovations of new organizational product and power of industrial R&D	Innovative activities tend to cluster in knowledge-based industries	Mechanisms of knowledge spillover are not modeled
Zucker *et al.*, (1998)	Workforce market and spin-off companies	Localization of knowledge was described with researchers from the US biotechnology industry	They considered one area in which knowledge can be highly preserved and is less capable of spillover
Almeida and Kogut (1999)	References to patent documents and labor mobility	labor mobility between companies explains the localness of knowledge spillover	Labor mobility alone does not cause knowledge spread, it rather transfers it from one company to another
Breschi and Lissoni (2003)	References to patent documents and social network	Knowledge spillover first exists in social networks then in local networks	A series of small data from a country
Kesidou and Romijn, 2008	Identification of knowledge spillover mechanisms	Mechanisms of knowledge spillover have positive effects on innovative, technological and organizational performance of IT companies	This method of measuring knowledge spillover is more applicable in developing countries

Innovative ability refers to skill and knowledge necessary for improvement and/or modification of new product/service (Lall, 1992). Lawson and Samson (2005, cited in Kaiser, 2002) showed that innovation capability refers to the ability to continuously converting knowledge and ideas to new products, processes and systems for benefits of the companies and stakeholders. In general, innovation relates to all efforts to gain technological advantage, production or improvement of technological condition (Kaiser, 2002).

Guan and Ma (2003) stated that innovation ability is a specified asset of a company. This ability to fast introducing new products and embarking on new processes is really important for competitiveness of companies. This two authors grouped innovation abilities to seven dimensions: learning, R&D, production, marketing and organizational capability and capability to making use of strategic resources. Studies show that companies with higher levels of innovation ability are averagely two times more profitable than others (Tsai & Tsai, 2010). As results, reviewing literature on technological learning

shows that the main focus has been on learning resources and less attention has been paid to factors influencing the process of learning (Kotha, 2010).

Lately direct tools for measuring knowledge spillover based on information from businesses have been created as results of innovation researches, like the European Community Innovation Survey (CIS). Using the questions of CIS as a starting point in this study, we tried to assess different knowledge resources that the mentioned companies may make use of.

Hypotheses

H: Knowledge spillover has positive effects on innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran.

MATERIALS AND METHODS

This study is an applied research with a descriptive-correlative nature. The tool for data gathering was questionnaire and the statistical population consisted of knowledge-based IT companies contracting with Hi-tech industries in Tehran (according to the available information, 79 companies were identified). Based on Morgan table, in a statistical population of 79, at least 66 samples must be assessed. It is necessary to mention that stratified random sampling is used in the study. Distribution of the statistical population is shown in Table (2).

Table 2:The Number of Statistical Samples of Companies Located in Technology Parks in Tehran

		Areas of Activity			
Tech. Parks	Communications	Hardware	Software	Counseling	Total
University of Tehran	-	4	6	2	12
Sharif University of Technology	4	5	8	1	18
Amirkabir University of Technology	-	6	2	-	8
Tarbiat Modares University	2	5	4	1	12
Jahad Daneshgahi	1	3	1	2	7
Pardis	3	4	2	-	9
Total	10	27	23	6	66

According to previous studies and the leading hypotheses of this study, conceptual model used in this study to examine the effects of knowledge spillover and its mechanisms on innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran, Iran is shown in Figure1.

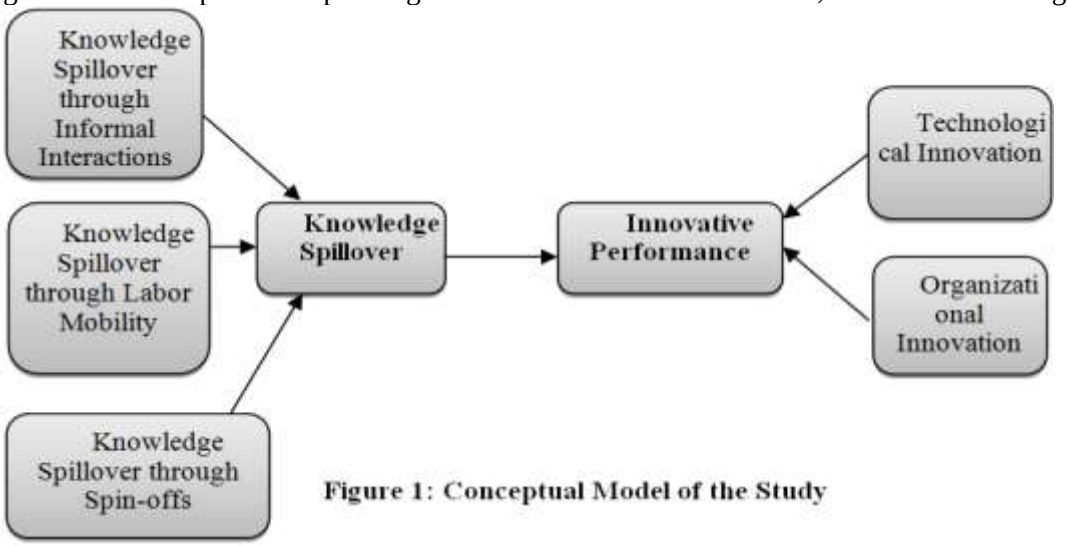

Figure 1: Conceptual Model of the Study

Variables

Based on the conceptual model of the study, innovative performance is the dependent variable which its dimensions -Indexes measuring these dimensions are presented in Table (6) - are examined: 1) technological innovation, and 2) organizational innovation (Table 3).

Table 3: The Dependent Variables (DV) of the Study

DV	Other Variables	Variable	Definition / Measurement
Innovative performance	Technological innovation	Tech-inno	Shows the ability of company to produce or develop products/services in the market based on scientific and technological advances
	Organizational/commercial innovation	Org-inno	Shows the ability of company to create or improve changes in methods of management, strategy and organizational structure

The variable of new product or service (new- ps) represents the number of innovations which are introduced to the market for the first time and are not imitation at all. This variable mainly relates to standardized products rather than customized products or services (Kesidou & Romijn, 2008). The second index, changes in products or services (change - ps), shows fundamental changes applied to current products and services in the last five years. These changes may be made to meet customer's need. The difference between this index and the previous one is that companies, introducing a new product to the market, have not only created a new capability and function, but have had also the ability to do that by making slight changes in current products. The amount of changes in business strategy, using management methods of marketing and changes in organizational structure of the company are some other variables of innovative performance (Kesidou & Romijn, 2008).

Also, mechanisms of knowledge spillover identified in theoretical principles as dimensions of independent variable are: 1) Knowledge spillover through spin-offs, 2) Knowledge spillover through labor mobility, and 3) Knowledge spillover through interactions, which are shown in Table (4).

Table 4: The Independent Variables (IV) of the Study

IV	Other Variables	Variable	Definition/Measurement
Knowledge spillover	Knowledge spillover through spin-offs	LKS_S	1, if the company is a spin-off of a university or larger multi-national companies located in the cluster; otherwise, 0
	Knowledge spillover through labor mobility	LKS_L	A percent of employees from other companies in the cluster, who entered the company in the last five years
	Knowledge spillover through interactions	LKS_I	Descriptive number based on Likert scale, which shows the importance of free resources of knowledge resulting from informal interactions between locals

To validate of the measuring tool of the study, the questionnaire was reviewed by specialists, and its ambiguities were resolved, and then content-related reliability of the questionnaire verified too. Cronbach's alpha of the questionnaire was calculated to test its reliability which was 84 percent and showed high stability and internal homogeneity of the questionnaire. In order to examine the relationship between observer variables (indexes and questions of the questionnaire) and latent variables (independent and dependent variables), conformity factor analysis was used and the results shown in Table (5) and Table (6).

Table 5: Factor Analysis of the Dependent Variables

	Technological Innovation	Organizational Innovation
New products for the market	**0.739**	0.1253
New products for the company	**0.8449**	0.1747
Change in business strategy	0.0132	**0.7581**
Change in management methods	0.1974	**0.6849**
Change in organizational structure	0.1878	**0.8036**

Table 6: Factor Analysis of the Independent Variables

	Labor Mobility	Informal Interactions	New Spin-off Company
Continuous monitoring of the environment	0.1085	**0.1183**	0.0853
Customers	0.0883	**0.6944**	0.1631
Interactions with rivals	0.8543	**0.9303**	0.8074
Specialized seminars and conferences	0.2438	**0.5627**	0.3.92
The importance of knowledge resource of holding company/university	0.2065	0.3873	**0.6557**
The importance of relationship with holding company/university	0.793	0.7659	**0.1748**
The ratio of new employees	**0.9114**	0.8208	0.7886
The importance of new employees	**0.6914**	0.4282	0.3339

As it is shown in Table (5) and Table (6), conformity factor analysis states that the questions concerning new products for the market and company are good measures of technologically innovative performance, and the questions concerning business strategy and change in management methods and organizational structure can reveal the variable of innovative performance of an organization. Bold values in each column, the factor analysis of the independent variables, represent functionality of the related indexes in describing these variables.

RESULTS

To predict any changes in the dependent variable as a result of changing independent variable, a method like the regression analysis should be used. In fact, multiple regression is an expansion of two-variable correlation. The outcome of regression is an equation which is the best prediction of a dependent variable based on several independent ones. Regression analysis is used when independent variables are correlated with each other and with dependent variable.

It should be noted that regression analysis can be used only when its assumptions are considered. Therefore in this study, the independence of errors (the difference between real values and those predicted by regression analysis) was examined by Durbin-Watson test. Since the value of statistic (d) of Durbin-Watson was (1.720) which is between (1.5) and (2.5), the assumption of correlation between the errors is rejected, so regression can be used.

Testing the Hypotheses

According to the hypotheses of the study, knowledge spillover has positive effects on innovative performance of knowledge-based IT businesses cooperating with Hi-tech industries in Tehran; since significance level calculated for this study (0.000) is less than (0.05), 95 percent of assurance would reject the null hypothesis; therefore it is verified that there is a significant linear relationship between knowledge spillover and innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran. In Table (7), standardized Beta coefficient of simple linear regression test shows that knowledge spillover has a 56 percent effect on innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran.

Table 7: The Results of Linear Regression Test of the Main Hypothesis

	Un-standardized Coefficients B	Standard Deviation	Standardized Beta Coefficient	T value	Level of Significance
Constant Coefficient	1123	587.623	0.56	4.452	0.000
Knowledge Spillover	1.154	0.035		36.6	0.000

About the alternative hypotheses mentioned as variables and described in table (4), the results of multiple regression test in Table (8) show that the three mechanisms of knowledge spillover, because of their calculated significance which are less than 0.05, affect innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran. According to standardized Beta coefficients of regression table, the effects of knowledge spillover through skilled labor mobility on innovative performance of knowledge-based IT companies cooperating with Hi-tech industries in Tehran is 54 percent, through informal interactions is 36 percent and through spin-offs is 15 percent.

Table 8: The Results of Multiple Regression Test of the Alternative Hypotheses

	Un-standardized Coefficients B	Standard Deviation	Standardized Beta Coefficient	T value	Level of Significance
Constant Coefficient	9676.9	2459.458		3.892	0.000
Knowledge Spillover through Labor Mobility	22.779	3.089	0.54	6.963	0.000
Knowledge Spillover through Informal Interactions	15.568	8.526	0.36	5.358	0.000
Knowledge Spillover through Spin-offs	2.165	3.323	0.15	2.256	0.000

As Beta standardized coefficients in Table (8) show, knowledge spillover through skilled labor mobility and informal interactions between employees of companies has more effects on innovative performance of knowledge-based companies in current study.

DISCUSSION

This paper examines the concept of knowledge spillover and mechanisms leading to that, and its effects on innovative performance of knowledge-based companies. Due to different results in the literature concerning the relationship between knowledge spillover and innovative performance of companies in different countries, we tried to quantitatively examine this relationship using multi-variable regression analysis in 66 knowledge-based IT companies cooperating with Hi-tech industries studied in Tehran. An important point considered in this study is the different methods of measuring knowledge spillover in developed versus developing countries. In developed countries, it is usually estimated based on analysis of references to patent documents and expenses analysis of R&D activities; however, in developing countries, since not all researches and produced knowledge would become innovative products or patent documents, these indexes cannot really reflect the occurrence of knowledge spillover. Therefore, according to a study by (Kesidou & Romijn, 2008) in Uruguay, other mechanisms such as labor mobility, informal interactions and spin-offs which are channels of non-intentional flow of knowledge between different actors of an industry were examined in order to determine the effects of knowledge flow through these channels on innovative performance of companies.

The results of linear and multi-variable regression test in this study show that knowledge spillover and its mechanisms have positive effects on innovative performance of the subjects. The results of examining the alternative hypotheses of this study show that through skilled and experienced labor mobility and informal interactions between companies, a non-intentional flow of knowledge happens that has positive effects on their organizational and technological innovative performance; which is supported by Fritsch & Franke (2004) Almeida (1998) and Cuguet (2002).

Establishment of spin-offs is a way that leads to knowledge spillover in a region or cluster, pointed out in (Saxenian, 1996) and Zuker (1999). Employees of spin-offs have individual relationship with employees of other companies. These relationships are often between former co-workers, former classmates and also between people meeting each other in a professional environment and lead to exchange of information. As declared in the results of the analysis, all mechanisms of knowledge spillover have positive effects on innovative performance of subject companies. These results resemble those of previous studies concerning the positive relationship between knowledge spillover and innovative performance of knowledge-based business. Finally, we can conclude that knowledge spillover and its mechanisms can play an essential role in realizing the concept of communicating vessels and creating synergy in researches and preventing waste of time and money mostly in knowledge-based IT organizations.

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