THE PROPOSAL OF A FUZZY AHP BASED MODEL FOR THE EFFICIENCY ANALYSIS OF TECHNOPARK

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Abstract

In the paper, it is proposed a model to evaluate the efficiency of technopark by performing an activity analysis on the productivity of the technopark structure, aiming to contribute to the innovative movement and sustainable development goals, which may result in huge amounts of increase in added-value of Turkey's technological development. The initial point of the paper is to define technopark structure and activities, to determine and eliminate uncertainties concerning structure and operation. Technoparks are investigated based upon their management, firms & incubation firms, R&D activities, and cooperation level among university-industry. In the paper, a fuzzy analytic hierarchy process method is used. The paper includes four technoparks that operate in Istanbul. By applying the developed model, the results of the performance evaluation are reached and the results are interpreted. It is thought that the findings obtained from this research will be beneficial for all stakeholders related to technoparks.

Keywords: Efficiency analysis, fuzzy analitic hierarchy process, technopark

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TEKNOPARK VERİMLİLİK ANALİZİ İÇİN BULANIK AHP TABANLI BİR MODEL ÖNERİSİ

Özet

Bu çalışmada, inovatif hareket ve sürdürülebilir kalkınma hedeflerine katkı sağlanması düşüncesiyle ülkemizin teknolojik gelişmesine çok büyük katma değer sağlayabilecek teknopark yapısının verimliliği ile ilgili etkinlik analizi yapılarak, teknopark performansının değerlendirilmesi için bir model tasarlanmıştır. Teknoloji üretme konusunda bir ülkenin en önemli değerlerinden olan teknoparklar, bu çalışmada yönetimleri, firmaları ve kuluçka firmaları muhatap alınarak incelenmiş, söz konusu incelemede yönetimsel durum, teknoparklardaki Ar-Ge faaliyetleri, hem üniversite-sanayi, hem teknopark içi firmaların birbirleriyle iş birliği düzeyi hem de teknoparkların birbirleriyle iş birliği yapma düzeyi sorgulanmıştır. Bu çalışmada, bulanık analitik hiyerarşi süreci yöntemi kullanılmıştır. Çalışma, İstanbul'da faaliyet gösteren dört teknoparkı içermektedir. Geliştirilen modelin uygulanmasıyla performans değerlendirilmesine ilişkin sonuçlara ulaşılmış, ulaşılan sonuçlar yorumlanmıştır. Bu araştırmayla elde edilen bulguların teknoparklarla ilgili tüm paydaşlara faydalı olacağı düşünülmektedir.

Anahtar kelimeler: Etkinlik analizi, bulanık analitik hiyerarşi proses, teknopark.

Introduction

Imagining, thinking, producing, improving what you produced and changing it are the fundamental characteristics of a human being. A person questions her existence, life quality; asks the questions "why", "wherefore" and "how come". In other words, curiosity is the driving force behind the improvement of mankind. To exchange ideas during the process of technology and knowledge development, to have *Esprit de Corps*, to be able to build a team really accelerate the pace to the goal and eases the burden. Building a team requires multiple perspectives, thinking outside the box, criticism and development to serve the same cause. Technoparks are one of the best instances of team work, collaboration and cooperation prevailed environments on a macro level. In other words, they're the facilities that both universities and industries collaborate, cooperate, produce, question and develop under the same roof for the same goal. State, working to improve the national welfare; universities, working for public interests; industry, intrinsically eager to earn mutually, actually exist and produce technology under the same roof whereby techno parks. It's also highly important that operations, activities and performances of techno parks, carrying an important philosophy

within its roots, should comply with these roots. This paper, inspired by these roots and philosophy, is prepared to measure and degree the activities and performance of techno parks, which expected to be the initiation of technological developments and precursor of scientific studies. Initial point of this paper is to define technopark structure and activities, to determine and eliminate uncertainties concerning structure and operation. On the other hand, creating an effective plan to feed the competitive capacity of possible actors in the system and to help Turkey accomplish its sustainable development goals with enhanced solution offers, are also aimed. According to past researches; relationship among technoparks, communication with universities and recognition within public are lower than expected. Hence, this study is considered to be necessary for observing whether the technoparks are capable of fulfilling these expectations or not. Definition and importance of technology are studied, conception and scope of technology transfer are explained within the first section of this paper. Technology transfer methods are explained and definition of technoparks is mentioned in general terms. Historical development and establishment models of technoparks are explained through the benefits they provide to partners with their strengths and weaknesses. Also, the importance of this issue is separately mentioned regarding the activities of technoparks around the globe and locally. In the second section, method of this study is investigated; subject, scope, goal, importance and uniqueness of the research are especially mentioned. This study is assumed to be very unique since no other instance of measurement device exists for technopark related activities in Turkey. Through this unique study; determination of technopark related activities measurement criteria in line with opinions of prominent experts of this sector, development of *Techno Park Efficiency-Performance Index Model (TEPI)* regarding these criteria, computation of index values for each efficiency-performance criteria via this model, providing the opportunity of comparing with the other leading technoparks in the industry, determination of the issues that technoparks should modify or improve according to index values are set as goals and also acceptance of this study as a periodical efficiency-performance measurement tool by the sector intended. *TEPI Model* collects data from managements, firms and incubation centers separately in order to compute efficiency -performance of techno parks accurately. Hence, the uniqueness of this study is not only provided by general technopark efficiency-performance index computation, but by considering all of these three fundamental criteria, too. Moreover, it is intended that *TEPI Model* will provide a scientific tool for technopark managements in the process of making objective decisions during the evaluation of customers or firms. Available solution for the mathematical model built within method section of this study is mentioned,

universe and sampling is introduced. Moreover, preparation, testing and application of scale is included in this section. In the discovery and discussion sections of the study, solution for the application is discoursed, problematic issues are held with consistency and sensitivity, outcome of the model is interpreted. As for the last section of the paper, it can be seen that a structure that allows to determine where the concept of activity is within the current competitive environment and draws a road map about how good output can be generated from the inputs at hand, is not only the financial structure but also management, cooperation, R & D, intellectual property, import-export are vital. We assume that this study has an important impact on related subjects.

I. Literature Review

A. Definition and Importance of Technology

Technology is the fullest extent of information, technique and power creation methods aiming efficient storage, processing or transfer. Technology can be information, process or material, pursuant to its definition and scope. Apart from these, technology can be perceived as the scientific effort aiming to satisfy the daily needs. Despite the fact that technology is descripted as the application of information on production process; design, development and transfer are other fundamental elements of technology that one should not skip. Therewithal, technology can be perceived as the operationalization of product or service as it is the main instrument presenting information into market (Kılıç, 2009). Various definitions do exist for technology as a result of its current multi-dimensionality and these definitions are, actually, outcome of the scramble people face in order to change and improve their environment (Ar, 2009). Technology has a huge impact on satisfaction of humane needs, development of countries and states to acquire the right to comment on the issues of international arena. Today's technological savvy primarily attaches importance to improvement of life quality for people, existence and consolidation for countries; and the importance of these principals are growing exponentially. Therefore, becoming an important player on international level is fundamentally related with being technologically competent. Such competency is a dynamic ability and it should constantly be developing for persistency. Under today's conditions, it is not possible for a new invention or technological development to remain closed. Because, in such business environment, organizations have a cutthroat competition for accumulation of knowledge, perpetuation of development and technology production. All those factors cause new technology to spread rapidly. Competence in technology is the key to be able to survive in such

competitive environment caused by new technology and globalization (Kılıç, 2009). Today, many well-developed countries utilize technology as an instrument for making their politics dominant over developing countries and this fact augments the importance of technology even more. Consequently, transfer of such an important asset carries even more importance than itself.

B. Notion and Scope of Technology Transfer

Transfer of technology is basically conveying of a technological development from one point to another. Technology transfer refers to movements of technology from the laboratory to industry, developed to developing countries, or from one application to another domain (Philips 2002). In other words, it can be perceived as the conduction of new technology from academy to industry. Also, adoption of technology produced for a specific cause for another cause, is one of the possible definitions for technology transfer. It is the transfer of information memorandum accumulated by production or production process from transmitter to receiver (Sarıhan, 2000). Common ground all these definitions meet is that technology transfer is a process and this process does not only contain physical components such as equipment, but a complex structure with humane issues and ideas. Technology transfer can be classified as vertical and horizontal technology transfer, according to flow direction of the process. Vertical technology transfer is the process of theory being applied in practice, horizontal transfer is application of technology in different areas with same or different goals. Development and change of technology with hair-rising speed, progressively shortening product lives, rapidly increasing consumption and continuously evolving customer needs accompany a competitive structure. Importance of technology transfer is even more important for developing countries since they struggle harder to survive within such structure. Technology transfer provides financial gain for countries and impulses their economic development. Technology transfer increases competitive advantage, as it does to technological development of industry and development level of transferor country (Wahad et al, 2010).

C. Technology Transfer Methods

Various agents feature in the technology transfer process. In a general framework, these agents are, local governments, R&D organizations, universities and industry agents. Subject agents can perform major or minor transfers according to their system and process. There are various technology transfer methods: Direct purchasing, copyrighting, obtaining license, co-investment, creating supply chains, company acquisitions, co-production, arranging expo

organizations or attending them, holding conferences, utilizing open literature, hiring new staff, employing qualified foreigners, educations, credit programs and subsidiary programs or cooperations. Operation of transfer process is almost the same for these methods. Adoption, assimilation, improvement/development, creation/dissemination are the four phases of this process (Karacasulu, 2001). Adoption includes the decision making of what kind of technology is needed, selection and adoption of that specific technology. Assimilation is basically customizing newly obtained technology according to current structure. Goal of this step is to optimize and retrofit the technology as good as possible. Hence, good engineering is vital for assimilation. Improvement/Development is, as one can guess, enhancing and advancing in new technology. R&D activities take place in this step, as re-production of new technology on a higher level is needed. If these activities are performed weakly, the new technology eventually will become hoary and not be able to satisfy the needs. In Creation/Dissemination step, all the definitions are instable and they get mixed since separation of creation and dissemination in favor of technology transfer is difficult. Engineering and R&D activities beginning with the purchase of new technology, actually, initiate the re-creation process. Therefore, designed and developed technology begins to expand, hence disseminate. Adopter does not only obtain new technology, but improves and delivers, too. Besides "technology transfer methods", other statements are used for the same process, such as "technology transfer channels", "technology transfer mods" and "technology transfer tracks" (Sakarya, 2012). Even though the statements are different, they all stand for the same content. Technology transfer methods can be examined under two groups, direct and indirect, according to application (Kiper, 2004). Expos, conferences and education are executed through open source and they are indirect methods, while direct purchasing, copyrighting, obtaining license, co-investment, supply chains, company acquisitions and co-production are direct methods (Kiper, 2004). Determination of which method is going to be used during technology transfer process holds a crucial importance. Technology adopters must take the structure, convenience, financial status, human resources and infrastructure services of new technology into consideration while deciding (Karaman, 2010). Adopting the most favorable method, obviously, leads to success and increases efficiency. Duration of market penetration, growth rate and capacity and costs should be taken into consideration, as well, in order to be efficient.

1.Direct Purchasing

Direct purchasing is obtaining a technology or its producer firm entirely or partly by making payment. It is the fastest method of all; increases market penetration, as well as eliminates product development risks and costs. (Karakaya, 2009)

2.Copyrighting

Copyrighting is leasing the technology via utilization permit or purchase of the property via assignation. It is the business relationship where the product owner allows to utilize her asset under a time limit, specific conditions and boundaries, in exchange for a fee.

3.Obtaining License

Obtaining a license is obtaining the rights to use of a technology secured by patent from its owner, in order to utilize it in favor of different activities. It is more preferred by developing countries, in order to protect their funds and capital.

4.Co-investment/Joint Venture

It is the technology transfer method where two or more entities merge their equities in order to create a third entity by venturing capital. (Karakaya, 2009) Parties should strike a deal where each party's task, obligations and activity areas are specified in detail. Joint ventures can be a whole new organization, as well as it can be founded by two different organizations' departments merging together.

5.Expo, Conference, Open Source

Organizing international exhibitions or expos, attending them, following information and experience flows are important potential channels for technology transfer. Especially, usage of open sources in electronic environment is significant.

6.Staff

Sending your staff to international programs and educations, employing qualified foreigner workers, business trips and consultancy are effective technology transfer methods (Şahin, 2010).

7.Reverse Engineering

Reverse engineering is the process of learning how an object is produced, designed and working, by applying or operating the specific object. (Neil et all, 2005) Goal of reverse engineering is to disintegrate a technology in order to copy it, understand its working principle or improve it. In this method, parties do not form a formal relationship which the adopter

performs technology transfer without notice to owner, patent and intellectual property are two issues that adopter should be careful about.

8.Subsidiary Programs

States play crucial roles for technology transfer with subsidiary programs. In order to advance in technological production, improve innovation and increase welfare, states do give support, grant or credit subsidies to private sectors, entrepreneurs, universities and R&D organizations.

9.University-Industry Cooperations

Cooperation between universities and industry is, perhaps, the most important channel in order to increase accumulation of knowledge and perform technology transfer. This method provides huge benefits to parties and countries aiming to have the right to comment on international arena must dwell on this issue studiously. University-industry cooperation is to benefit from academic manpower and equipment of universities, experiences and accumulation of industry, aiming to produce new technology and develop R&D activities (Şahin, 2010). As it is understood in Şahin's definition, technological information transfer is bidirectional in this channel. Industry creates new opportunities to access new technology while university finances for researches. When strong research capacity, qualified man source and scientific information accumulation of university are put in the same melting pot with time-indexed and profit-oriented working discipline of industry, a new structure that is highly beneficial for both sides originates. Through these cooperations, university finances new researches, fulfills its public interest favored mission, creates new application fields for academic personnel, creates new internship and job opportunities for students and contributes to development of economy and technology; while industry can access to university's information infrastructure, create its own research opportunities, access to qualified man power and contribute to public welfare efficiently. One of the best instances for such cooperations, techno parks, hold missions of providing new and advance technology for its partners, creation of processes and products with high added value and providing a basis for university and industry to perform efficient technology transfer.

D. Definition and Importance of Technopark

1. Conception and Definition

Technoparks are the organizations where universities, R&D centers and business world can perform research, development and innovation activities, communicate each other continuously, transfer information and technology dually. Technoparks are usually defined as the physical instances of cooperation between industry and university. Techno parks update country, industry and university by producing new technology in order to compete in international market (Kılıç, 2009). They are organizations with missions of improving local industry and performing innovative, progressive works. Yalçınkaya (1996) describes techno parks as following: "Technoparks are places where technology producer or adapter corporations cooperate with universities." According to International Association of Science Parks and Areas of Innovation's (IASP) 2012 declaration, technoparks are organizations that have formal relationships with one or more universities or research centers, designed to encourage technology-based companies to be established and developed, support these firms and companies in issues like technology transfer and management. Technoparks are defined differently in different countries, as they are structured differently. *Research Park* in the USA, *Science Park* in England, *Tehnopóle* in France, *Technopolis* in Japan, *Grunderzentrum* in Germany, etc. Also; *Enterprise Center, Innovation Center, Industrial Park* are other commonly used definitions. In Turkey, although various names such as *"teknokent (techno-city)", "teknopark (techno-park)"* and *"cyberpark"* are used, *"technology development zone"* is determined as formal name with *Technology Development Zones Law no. 4691*. There are number of various definitions made for techno parks, operating different from each other according to geographic features of established area, science and technology policy, conditions of the university, industrial texture and technological development level.

Science Parks: They are group of firms located near a big and qualified university in order to produce technology. They form important cooperations with the university. They benefit the qualified workforce within university's academic infrastructure.

Research Parks: They are R&D based organizations producing science-oriented technology, forming a close relationship with a university or research institution in the scope of their projects. They only support the subject project up to prototype production level. Mass production and marketing of the product are aside from their activity area.

Innovation Centers: They are innovation-favored organizations collaborating with universities in order to give tech-based firms opportunity to be established.

First Development Centers or Incubators: They aim to support small businesses or startups for them to be released; in issues such as equipment, consultancy, education, etc.; under

certain conditions such as tenancy. Entrepreneurs, concurrently tenants, should move out when they become ready for commercial production, to give place for new entrepreneurs.

Technology Parks: They are technology producer organizations giving top priority to application phase. They aim to develop quality improvement and production processes in order to strengthen international competition power.

Technology Development Centers: They have the mission of supporting establishment of tech-based firms, utilizing university's scientific potential and infrastructure in order to develop industry and improve economy.

Techno-cities: They are municipal service and economic activity zones rigged with universities, research institutions and industrial units.

Technoparks: Cooperation between university and industry concretizes here. Entrepreneurs willing to produce new and high-tech output, can operate their industrial and commercial activities near universities and benefit from universities, thanks to techno parks. (Harmancı & Önen, 2009)

2. Importance of Technoparks

Technoparks carry huge importance for both their establishment areas and home countries since they provide and spread new technology. It is a fact that all partners of a techno park both utilize from this structure and contributes to its development. Especially, their importance can be better understood since success of technologically advanced countries is related with success of their technoparks. (Özdemir, 2006) Technopark provides a faster solution for industry to meet the technology deficit and allows it to benefit from university infrastructure. Helping and guiding to industry with possible troubles that can occur during commercialization process of the new technology is one of techno park's duties. That applies to university as well. University's prior duty is to research and allow public to benefit from its results. Concordantly, techno parks are helping universities with their core mission. Another service they provide for universities is to prevent the long-known issue of failure in applying academic knowledge in practice. Also, they provide new employment opportunities for graduates of the subject university. Besides these, technoparks carry huge importance for the state, as well. Technoparks are in leading position when it comes to economic and technological guidance. They reduce the development gap between different regions within a country and help improving public welfare.

3. Missions and Functions of Technoparks

Founding mission of technoparks is to encourage production of technology within national policy framework, by providing a cooperation opportunity for state, industry and university (Özdemir, 2006). Meeting national technological needs with local resources, strengthening educational activities, allowing industry to benefit from academic knowledge of universities to find better solutions, increase industry's competitiveness and profit R&D researches provide within GDP are key goals of techno parks (Özdemir, 2006). They are structures aiming to develop new technologies, boost sectors that are in regression or recession, create innovative environment. Another mission of techno parks is to accelerate the innovation process beginning with invention and leading to value added product, by melting ideas and financial possibilities in the same pot; which results in economic development of the country. (Yalçınkaya, 1996)

4. Structures and Establishment Models of Technoparks

Technoparks must have an organizational structure in order to be able to fulfill their foundation missions; increase cooperation level between universities and industry, develop new technologies. A simple, de-bureaucratized and transparent structure is apparently key to success. Technoparks can be viewed under following groups, according to their precursor partners:

State Oriented Model: In this model, state directly undertakes the technopark's establishment. State works together with local governments in order to exercise infrastructure works; roads, water, electricity and communication networks. In addition to these, state provides tax concessions to the firms within techno park.

University Oriented Model: In this model, university uses its own sources to establish a techno park. It is the lead actor in every process regarding establishment and operation of techno park. Even though this provides an interference-free and nonprofit-making environment, it creates the risk of being disconnected of the business world.

Private Sector Oriented Model: In this model, financially powerful corporations cooperate with universities. Establisher firm is predominant in the board and firm selection.

Local Government Oriented Model: In this model, local governments establish techno parks through own resources or support they get from international organizations. They also supply infrastructure needs themselves.

Hybrid Model: In this model; universities, local governments, banks or foundations cooperate to establish techno parks.

5. Strengths and Weaknesses of Technoparks

There are several strengths and weaknesses of technoparks, one of the most important players of technological progress. Existence of legal recognition for establishment, exemption from tax, inviting regulations for foreign investment, and both national and global incentives for R&D operations, productive network, common meeting points, mentorship activities and information sharing events are noticeable strengths. State, local governments and chambers working together increases the synergy of collaboration is also an important point. Although they have some inarguable solid advantages, there are some weak cases that need to be improved: Bureaucratic issues and delays, legislative and administrative issues, financially insufficient resources, problems with university management, poor display and publicity, lack of collaboration among firms.

6. Benefits Technoparks Provide for Partners

Benefits of Universities: It is crucial for a university to be able to create an environment for its students to practice their ideas in real life. Thanks to techno parks, universities with intimate connections with industry are actually able to be up to date technologically, and their students are able to get to know the industry before their professional lives. Universities can configure their educational programs according to industrial needs and niches since they are in this loop, hence they become one step ahead of other universities, which is really important in such competitive era. A student can gain professionalization ground faster and more solid if she could find opportunities to apply her ideas in practice. In addition to these, university labs can always update their testing and computation devices, hardware and equipment according to sectorial needs, due to they are intimate with that sector.

Benefits of Entrepreneurs: Techno parks play an active role in development of strategically prior sectors. An entrepreneur equipped with professional support can accelerate his opening to market process, he can manage to do a lot more in a lot sooner. A techno park teaches an entrepreneur project-oriented work principle, gives industrial corporations the insight of R&D praxis, expands R&D capacity through tax exemptions and incentives. (DDK, 2009) Besides these; entrepreneurs can benefit from university's research infrastructure and firm's sectorial experiences, technology transfer gets a lot faster and easier, a backdrop is installed for R&D operations, they can get consultancy from university and form solid cooperations with university, a better communication among similar firms is provided for entrepreneurs to watch and learn. (Ramirez & Dickinson, 2010) Techno parks create opportunities for new job potentials and contribute to progress of young firms, with the information, capital and physical infrastructure they provide. These possibilities create a viable

environment for entrepreneurs to transfer their all potentials directly to investment and projects, eliminating many costs and risks. This advantage relieves growth and development pains for a young firm. (DDK, 2009) Just like tax exemptions, incentives attract entrepreneurs to work within a techno park. (Ramirez & Dickinson, 2010) Firms within a techno park is in intense interaction with other firms and university. Through mechanisms such as partnerships, exchange of workers among firms, conferences, projects and recreation of spare times in the same environment, both amount and development rate of creative products and services do increase. (Bella Vista et all, 2009) Techno parks create a viable environment for new firms with incubation centers, idea-box applications, innovation competitions, grant programs and international funds; presents entrepreneurs a wide range of services from marketing to financial issues, social activities to administrative support. (Bigliardi et all,, 2006) Small firms can focus on their core business easier and find more opportunities to produce technology, develop and research, thanks to aforesaid services. Techno parks of developing countries are actually catalysts in young tech-based firms' development and guide to current firms in process and product development issues. (Bigliardi et all, 2006) They also contribute to learning abilities, experience and skills of a firm's employees (Bella Vista et all, 2009), enhancement of firm's R&D skills (DDK, 2009), learning skills of the firm by increasing of information sharing among firms, providing exchange of workers among operations and creating links with external information sources such as universities and other firms. (Westhead & Batstone, 1998) All these benefits enlighten an entrepreneur's path of uncertainty and helps her to reach the goal with minimum loss.

Benefits of Region: Techno parks contribute to the development of the country by providing a healthy interaction between universities and industry. They encourage national production and helps reducing deployment rates. Besides these, techno parks allow generation of innovative firms, more efficient utilization of university's infrastructure sources for research, enhancement of national economy and as a result, improvement of national welfare. In spite of some regions do have important economic potentials, they remain incapable in transforming that potential to production and progress. Techno parks do play an important role in making use of that potential. Regions could not manage to achieve their deserved progress can have their infrastructures to strengthen, physical environment to change positively, more employment opportunities, better transportation and varied socio-cultural activities.

II. Research And Method

A. Subject and Scope

Existing studies show that national welfare can be enhanced through advanced technology production centers. Technoparks represent such structures in Turkey. They are supported from establishment phase by the state with national politics and various implementations. Some of those technoparks carry the mission of founding a cooperation between universities and business world, where academic perspective of universities and capital of business world melt within the same pot. In addition to these, some techno parks aim to make progress in real estate investment. Another establishment goal of technoparks is to become able to produce and develop high technology locally, hence lower the production costs and commercialize technological knowledge. Supporting technology production and entrepreneurship, corporations to be up to date technologically, creating new investment opportunities, employment of innovative and qualified workers, helping technology transfer, providing sufficient technological infrastructure to accelerate the foreign capital's penetration speed to Turkish market are other unmissable goals of techno parks. Inarguably, to be able to produce today's most important fortune, scientific knowledge, will improve social development and community development. Some of the firms within techno parks are actually activating their units in organized industrial zones to mass produce their own technologies. Besides, supporting new graduates and academics, establishment of incubator firms by academics provide the essential cooperation between university and industry, thereby, entrepreneurs can obtain a business-friendly environment. Also, qualified personnel with at least undergraduate degree can be employed through this law. Another point worth to be mentioned is that personnel actually lives in the region, thus they can contribute to development of the region. Penetration of foreign capital or overseas investments are another success of technoparks. Our economy benefits technoparks as they provide workforce, increase employment, produce technology and extend Turkey's influence on international level with innovative steps. Economic effects of techno parks accrue both directly by having qualified personnel employed and indirectly by creating specialization areas. Therefore, intellectual capital can stay in Turkey since techno parks provide a both materially and morally attractive environment.R&D is an expensive process needing patience and time. Technoparks, in essence, lower R&D costs for countries and firms with saving gap, since they are perfect instances of common R&D centers, thanks to their accelerative and productive effects on R&D operations. The technological dependency we adopted through technology transfer can be defeated with technoparks. In fact, foreign capital that technoparks lure in Turkey is a steadier solution than ephemeral capital movements, in terms of economic growth. Maybe the most crucial benefit of technoparks is that they catalyze

the process of adoption of information-oriented economic structure. By this means, high value-added high-tech products can be manufactured locally, which provides an important competitive advantage in international market. Observing and measuring the process, activities and working philosophy of technoparks, performing activity analyses and designing a model for technopark performance evaluation will be an important contribution to national economy and development goals. During the evaluation of technoparks, since attaching all the importance to financial data would be misleading, they should be evaluated under subjects like production, intellectual property, cooperation and import-export rates. Through this study, in contemplation of innovative movement and contribution to national development, a model is designed for technopark performance evaluation, by performing an activity analysis regarding technopark efficiency. Goals of the study are determined to be build *Techno Park Efficiency-Performance Index Model (TEPI),* generate a measurement system through this model and determine the activity gradation for technoparks. Efficiency measures the output obtained from pre-defined amount of input. In other words, efficiency means output/input ratio (Bektaş, 2013). Efficiency analysis is a guide allowing the determination of a firm's place in competition and calculation of data efficiency. A solid efficiency analysis requires comparison among organizations sharing the same environment. Recently, multi-criteria decision-making model is being preferred more since many objective and subjective evaluation criteria are being used in efficiency /performance analysis (Çakır et all, 2013). An inactive structure causes the output/input ratio to be low, wastes resources and results in low performance (Çınar et all, 2010). It creates big disadvantages for the subject or partners of it. Efficiency analysis is being performed in order to measure the activeness of applications implemented to eliminate major problems and determine the order of priority of operations. Scope of efficiency analysis concept becomes even more important for technoparks contributing to national development, economy, employment and technology production.

B. Theoretical Model of Study

Theoretical model of this study is developed through information obtained from literature search. Model is mainly built according to key criterion of activity measurement and expert opinions are taken into consideration. Managing firm, other firms and incubators have big importance for techno park activity evaluation. Subscales determined through literature search and expert opinions are included in this study, too. Weight values of main scales and subscales are calculated and their importance for research model is determined. Theoretical model is shown in figure-1.

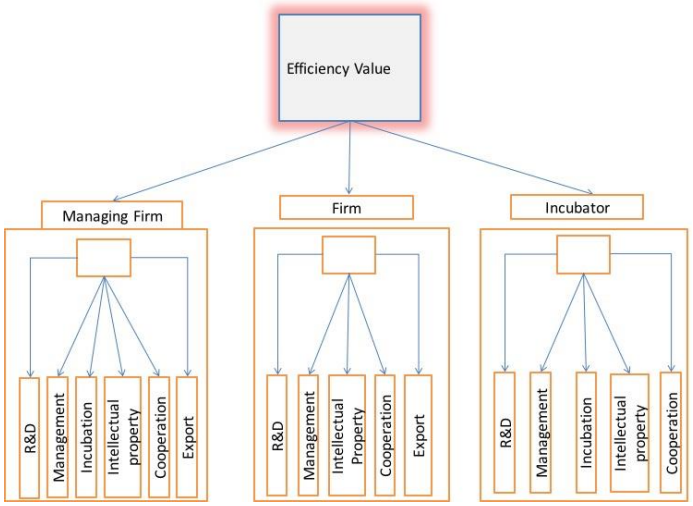

Figure 1. Techno Park Efficiency-Performance Index Model (TEPI)

There are lots of sources regarding techno parks, technopark firms and technology transfer in the literature. Harmancı and Önen's study in 1999 is held to determine how techno parks in Turkey should operate, basing on global techno park activities. Polat (2003) has applied surveys to 242 firms within İTÜ, TÜBİTAK MAM, GEBZE, BİLKENT and METU techno parks, in order to determine development activities, and interpreted the results. Problems of techno parks in Turkey and of companies in incubation phase are investigated and offered solutions for, by Başalp and Yazlık (2006). Taşçı and Güder (2006) have studied the importance of techno parks for software industry within the scope of West Mediterranean Techno Park. Baki and Ar (2007) performed a general research about techno parks in Turkey. Ataman (2008) has questioned the employment capacity of techno parks, specific to Ankara, he argued that they have high capacity on micro level but have a limited impact on economic growth. Vucic (2009) mentioned about the importance of improving the cooperation level between universities and industry, in his research about cooperations between tech-oriented organizations and clustering strategies. Kılıç (2009) interpreted the current situation of technology transfer applications of Turkish Defense Industry in Ankara techno parks. Ar (2009) argued the innovative factors effecting settled firms by building a structural equation modeling for 270 firms in 10 techno parks. Yaşar (2010) investigated techno park informatics clustering status specific to METU and Küçük (2010) investigated the importance of techno park activities in

local economic development specific to Gaziantep Techno park. Ayvaz and Kılıç (2011) questioned the current status of technology transfer cooperations with Likert scale. Uzun (2011) interpreted techno parks as a production unit of neo social transformation process. Within the scope of his research about effects of cooperation applications on technology transfer performance, Erün (2012) has analyzed five techno parks in Ankara, executed differentiation tests through demographic data and he obtained a positive conclusion. Sakarya (2012) viewed internal cooperations increasing technology transfer and techno park support activities' effect on assimilation capacity of firms, through public surveys in Ankara. Orhaner, Alkibay, Korkmaz and Sertoğlu (2012) discussed managerial issues of techno parks. Kayalıdere (2014) mentioned the importance of techno parks in Turkey's technology policies and tax advantages granted to techno parks. Yalçıntaş (2014) discussed effects of techno parks on national economy, specific to Techno park Istanbul. (Tepe S., Zaim A.H., 2016).

1.Fuzzy Analytic Hierarchy Process

Fuzzy analytic hierarchy process method is utilized in this study. Fuzzy logic has been used in the name of examining the event from a broader frame since classical logic is insufficient in the studies. The reason for using fuzzy AHP is that it is the most widely used decision-making method with multiple criteria. The concept of fuzzy accuracy shows similarities with the concept of classical accuracy, but it is more general and the application field is wider. When making decisions, decision-makers usually use qualitative expressions instead of quantitative expressions of certainty, since they are uncertain about the decisions and future estimates. The basic idea in the fuzzy logic is that a proposition is called "right," "wrong," "very correct," "very wrong," "approximately correct," "approximately wrong" ext... In other words, accuracy is a function that associates a set of values with an infinite number of truth values, between the classical right and wrong, or numerically with a real number interval of [0, 1]. Analytic hierarchy process is a solution to multi-criteria decision problems, shaped by Myers and Alpert in 1968, developed by Saaty in 1977. Decision is a process involving many subjective and objective occasions. Analytic hierarchy method can be used for making decision based on quantity of obtained data, making decision with risky possibility-defined data, making decision with data with unassigned weight. (Karakaya, 2009) This method has decision alternatives measured according to a numeric-scaled gradation. Hence, both subjective and objective scales can be included within decision making process. Analytic hierarchy process models the multi-criteria problem with a hierarchic setup in terms of purpose, main scales, possible subscales and alternatives and helps finding the best decision. Analytic hierarchy

process compares the components of the structure one-to-one through utilizing a preset comparison scale. In this comparison, importance values 1, 3, 5, 7, 9 are used with sub values 2, 4, 6, 8, if necessary. 1 when cases that both factors have the same importance, 3 when the first factor is slightly more important than second factor, 5 when the first factor is more important than second factor, 7 when the first factor is dreadfully more important than second factor and 9 when the first factor has absolute importance over the second factor. However, classical analytic hierarchy process is being criticized for remaining unqualified in ambivalence cases. In real life, it is nearly impossible to have absolute definitions for a lot of situations since they bring in many uncertainties. Analytic hierarchy process is recommended in order to surpass this circumstance. Fuzzy logic and fuzzy set theorems are found by Zadeh in 1965. Digitization of linguistic statements and difficulty of creating a common ground for different approaches can be overcame through analytic hierarchy process. (Güneri et all., 2012) Each member of fuzzy sets is defined as the member of the set to a certain level, instead of "belongs to set" or "does not belong to set" as in classical set theorem. Fuzzy numbers are subset of reel numbers. Membership function is triangular fuzzy number, stated with following $\tilde{S}$ fuzzy number: $\tilde{S}$ = (a, b, c)

$$\mu_{\tilde{S}(x)} = \begin{cases} 0 & x < a \\ \frac{x-a}{b-a} & a \leq x \leq b \\ \frac{c-x}{c-b} & b \leq x \leq c \\ 0 & x > c \end{cases}$$

(1)

Here, $a \leq b \leq c$. "a" stands for the possible lowest value, "b" stands for the most promising value and "c" stands for the possible highest value. Buckley's (1985) method is adopted for this study, in order to be able, determine importance levels. Buckley (1985), used the geometric mean technique to calculate fuzzy weights and determined blur priorities. In this study, fuzzy AHS method based on Buckley's method was preferred in order to make the process steps clearer, shorter and the more understandable results.

Method can be explained as the following:

Step 1: Paired comparison matrixes are generated and linguistic statements are assigned to matrixes.

$$\tilde{C}_q = \begin{matrix} 1 & \tilde{C}_{12} & \cdots & \tilde{C}_{1n} \\ \tilde{C}_{21} & 1 & \cdots & \tilde{C}_{2n} \\ \vdots & \vdots & & \vdots \\ \tilde{C}_{n_1} & \tilde{C}_{n_2} & & 1 \end{matrix}, \quad q= 1, 2, 3, \ldots . , Q \qquad (2)$$

Linguistic statements and their correspondent fuzzy sets are used as the following:

Fuzzy Scale	**Linguistic Statement**
(1,1,1)	Equal
(1,2,3)	Important
(2,3,4)	More Important
(3,4,5)	Very Important
(4,5,5)	Absolutely Important

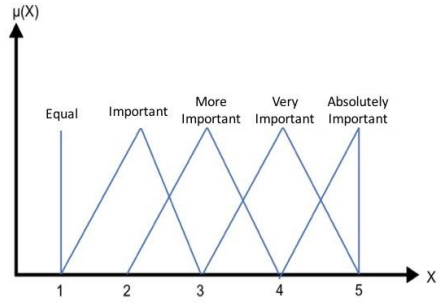

Figure 3. Fuzzy Scale

Step 2: Fuzzy geometric mean and weights are calculated.

$$\tilde{r}_i = (\tilde{C}_{i1} \otimes \tilde{C}_{i2} \otimes \ldots . \otimes \tilde{C}_{in})^{1/n} \qquad (3)$$

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 + \tilde{r}_2 + \ldots . + \tilde{r}_n)^{-1} \qquad (4)$$

Step 3: After obtaining fuzzy weight matrix, best non-fuzzy performance value is found for each criteria, through the following equation. Total integration method in used in this study. This method is suggested by Liou and Wang (1992). "p" defined as the optimism of decision-maker is within (0-1) range. $0 \leq p \leq 1$ (Kahraman vd., 2014) Optimism is represented by growing "p" value and pessimism is represented by decreasing "p" value.

S being a fuzzy number, $f_{\tilde{S}}^{L}$ being left-membership function and $f_{\tilde{S}}^{R}$ being right-membership function:

$$E_w(\tilde{S}) = wE_R(\tilde{S}) + (1\text{-}w)\,E_L(\tilde{S}) \quad (5)$$

$$E_R(\tilde{S}) = \int_{\alpha}^{\beta} X\, f_{\tilde{S}}^{R}(X)dx\,, \quad (6)$$

if $E_L(\tilde{S}) = \int_{\gamma}^{\delta} X\, f_{\tilde{S}}^{L}(X)dx$, for $\tilde{S}$ = (a, b, c):

$$-\infty < \alpha \leq \beta \leq \gamma \leq \delta < \infty \quad (7)$$

shown as:

$$E_p(\tilde{S}) = \frac{1}{2}[p(a+b) + (1-p)(b+c)] \quad (8)$$

p is taken as 0.5

2. Universe and Sampling

Universe of the paper is limited with four technoparks in Istanbul, consisting of managing firms of techno parks, other firms within techno parks and incubator firms. In order to reach to whole universe, necessary permissions are obtained from techno park managements for survey executions, support for surveys, approved by ethics committee of the university, from management is requested. After the negotiations, surveys are executed to management face to face. Thereafter, surveys are applied on 135 of 424 firms and 38 of 65 incubators within techno parks, total 173 of 489, and sample is tried to converge to universe. Data regarding sample and universe is shown in table 1 and table 2.

Table 1. Information about technoparks participated in study

Technoparks Participated in Study	Number of Firms in Technopark	Number of Firms Surveyed	Number of Incubations in Technopark	Number of Incubations Surveyed
Teknopark İstanbul	90	90	21	20
Boğaziçi Teknopark	14	12	2	2
Yıldız Teknopark	300	20	36	10
İstanbul Teknopark	20	13	6	6
Total	424	135	65	38

Table 2. Information about participation rate

	Teknopark İstanbul	Boğaziçi Teknopark	Yıldız Teknopark	İstanbul Teknopark	Total
Universe	111	16	336	26	489
Sample	110	14	30	19	173
Participation Rate	%99	%87,5	%9	%73	%35,37

35.37% participation rate is obtained with four-months-long face to face survey executions. Assuming the level of sampling is enough for the study, surveys and data collection is put to an end. Many meetings are held with the experts of the subject; techno park managers, firm managers, incubator managers, academics, Secretariat of Defense Industry officers and experts from TÜBİTAK. Surveys are questioned with them and changed in accordance with expert opinions. TUBİTAK TEYDEB (TÜBİTAK Technology and Innovation Support Programs) Technology Development Zone Impact Assessment Reporting Procedure and Methods are studied, evaluation scales of Ministry of Industry are taken as a basis and evaluation scales of IASP are analyzed. Survey subjects are determined as; *Management, R&D Competence, Incubation, Cooperation, Intellectual Property* and *Import/Export.* Under *management,* questions are addressed to techno park managements regarding the operation. Efficient utilization of ministry grant, operational costs and structuring costs are questioned in order to perceive the financial statement and get brief information about investment activities. In order to learn the interest of technology firms show for techno parks, number applications to techno parks, number of accepted applications and number of active firms within techno parks are asked. Information of the duration of acceptance period and complacency about location of the techno park is asked. In order to perceive the supervision process of the firms, question of frequency of inspections is posed to management. In order to determine focus structure of the techno park; management is asked to sort firms under energy, transportation, healthcare, defense, informatics, finance, education and consultancy sectors, according to their numbers. Under the topic of R&D competence, firms operating within the techno park are questioned about the general R&D composition. Numbers of local and global projects that firms own are asked, in order to perceive their project development and innovation skills. To be able to measure a firm's contribution to national wealth, whether they produce an equivalent product of an imported product or not. In order to learn the financial statement of the firms, we asked their R&D profits gained through their own resources, R&D grants they accepted and total R&D costs. Besides these, number of staff in R&D, number of staff not in R&D, number of staff doing master's degree or PhD are learnt. Hence, ratios for R&D department to all departments and academic personnel to all personnel are learnt. Some questions under incubation topic are posed to techno park management such as number of firms in incubation, total number of firms that have been in incubation and control level of incubation firms' development process. Through these questions, interest level of entrepreneurs to techno parks

and existence of an efficient control mechanism for incubations are determined. Rest of the questions are posed to firms in incubation, such as their operation fields under energy, transportation, healthcare, defense, informatics, finance, education and consultancy sectors. Also, their satisfaction level about Technology Transfer Offices (TTOs) is asked, as well. Question of whether the firms have academic co-founders or not is asked, in order to see the academic workforce in management. Also, expectations for durations of opening to market process of firms are asked to be able to perform relevant estimations about their life time.

Under cooperation topic, incubation firms, firms and techno park management are taken as respondents. To incubation firms, we asked their cooperation level with other firms and number of the firms they have formal relations, in order to be able to observe their potentials to stay within market and increase competitive edge. To firms, we asked number of their TÜBİTAK, SANTEZ supported projects, in order to see how often they benefit from state incentives. In addition to these, number of universities, within techno park and off techno park, they do cooperate with is asked, aiming to have a brief information about industry-university cooperation level. Again, same question is posed to firms about their cooperation with academics, but this time in terms of consultancy, service procurement, internship and scholarships. In order to view how the synergy techno park generates is beneficial for the firms, we asked firms following questions: numbers of firms they cooperate within the techno park, number of firms they cooperate off the techno park and number of foreign firms they cooperate. Then, in order to learn sector frequency, we asked them to sort their work areas gradually under energy, transportation, healthcare, defense, informatics, finance, education and consultancy topics. We wanted the firms to reveal their presence level in common areas of techno park, in order to see if common grounds participate to cooperation level or not. Under intellectual property topic, firms within techno park are taken as respondents. Number of their national patent applications, number of their registered national patents, number of international patent applications, number of registered international patents, number of registered utility models, number of national and international published materials they have and whether they benefit techno park management's legal support services or not. By this means, we tried to get brief information about patent-oriented operation of firms and management’s encouragement and support level regarding intellectual property. Under import-export topic, in order to be able to observe contribution of value-added products of firms to national welfare and demographic structure of firms, we posed following questions to techno park managements: number of firms executing import or export operations, export profits of firms, number of foreign firms within

techno park and number of firms with foreign partners within techno park. A draft is designed through these questions after receiving opinions of all related partners and approval from ethics committee regarding survey questions, and reliability analysis are executed and data collection is initiated.

3.Reliability Test of Scale

Reliability analysis for the survey, through SSPS software. Results are revealed with table 3. As seen, reliability results of the questions are above acceptance level, hence none of the questions are discarded.

Table 3. Reliability Test of Scale

Management Firm Survey	Firm Survey	Incubation Survey	Total
0,822	0,825	0,759	0,802

Main scales providing basis for theoretical model of the study are determined as managing firm, firm and incubator firm, this determination is executed with experts. Then, expert officers of these three components performed a study to compare the main scales according to their significance level. Results are shown in table 4.

Table 4. Results

	Teknopark İstanbul	Boğaziçi Teknopark	Yıldız Teknopark	İstanbul Teknokent
Results	1,80	1,38	1,94	1,41

4.Sensitivity Analysis

Sensitivity analysis examines the effects of changes in scale importance levels regarding a decision-making process, in other words the effects of changes on input or output, namely final decision. In the study held with designed two scenarios, importance levels of main scales are changed and effects of these changes on result is observed. In the first scenario, weight values for main scales are assigned as following: 0.1 for managing firm, 0.7 for subject firm, 0.2 for incubator firm and effects of these values on the result are determined. In the second

scenario, weight values are assigned as following: 0.2 for managing firm, 0.7 for managing firm, 0.1 for incubator firm and effects of these values on the result are determined. In the third scenario, weight values are assigned as following: 0.02 for managing firm, 0.80 for managing firm, 0.18 for incubator firm and effects of these values on the result are determined. In the fourth scenario, weight values are assigned as following: 0.03 for managing firm, 0.75 for managing firm, 0.22 for incubator firm and effects of these values on the result are determined. Results are shown in table 5.

Table 5. Sensitivity analysis results

	Teknopark İstanbul	Boğaziçi Teknopark	Yıldız Teknopark	İstanbul Teknokent
Scenario 1	1,91	1,58	1,92	1,48
Scenario 2	1,99	1,62	2,03	1,54
Scenario 3	1,95	1,63	1,94	1,50
Scenario 4	1,91	1,59	1,91	1,47

III. Conclusion

Through this research, in contemplation of innovative movement and contribution to national development, a model is designed for techno park performance evaluation, by performing an activity analysis regarding techno park efficiency. By taking managing firms, firms and incubators as respondents within the scope of this study, managerial status, R&D operations, and cooperation level for university and industry, among firms and among techno parks, one of the most important elements of technology production in Turkey, are investigated. Since technological infrastructure must be strengthened in order to shift to information society level, operational activities of techno parks, expected to play an active role in this process, are questioned. When the results are evaluated in the sense of managing firms; it is concluded that high numbers of applications to a techno park is directly related with its location, number of accepted firms and actively operating firms are directly related with corporations' level of techno park. Again, the most corporate techno parks offer the lowest time period for application and acceptance processes. When survey results are viewed, it can be seen that the size of the techno park is inversely proportional with supervision and inspection frequency. The most common sector is software within techno parks, while other sectors differ for techno parks. All

four of the subject techno parks show a great performance in terms of incubation circulation speed. However, during this fast process, some firms could not manage to incorporate since they went unnoticed or could not receive enough support. Unfortunately, this is a downside for techno parks. With respect to this, successfully incorporated firms are the ones who received enough attention and support from techno park managements. Cooperation level among techno parks are found to be low, in the sense of managing firms. In order to gain publicity for techno park structures and increase the cooperation level, managing firms should be more cooperative, perform more enterprises, projects or events together.

When the results are evaluated in the sense of active firms within techno parks; it is concluded that utilization level of techno park services is high. Based on this, we see that firms are aware of the opportunities techno parks offer. Regarding cooperation topic, it is concluded that cooperation among firms is high but cooperation among firms and university is low. Techno parks providing a fast and easygoing environment for firms to communicate with each other and support of management result in high cooperation levels. Reasons for inadequate cooperation level among firms and university are disconnectedness and divergence of partners in terms of opinions and goals, university's lack of advisory skills, disregarding techno park output when evaluating university success, academics' lack of courage for entrepreneurship, lack of "engineer executives" in management, inadequate promotion of techno parks on undergraduate and graduate levels and bureaucratic difficulties. Although intellectual property issue can be a success criterion for the firms, they fail on patent product development. It is assumed that bureaucratic difficulties cause this recession of intellectual property issue. Regarding R&D operations, it is seen that firms have some lot employees in their R&D departments. In fact, it is expected that these employees, most of them with Master's degree or PhD, will perform positive contribution to interdisciplinary interaction.

In the light of these results, all related partners must do their bits. State, one of the most important partners of technopark structure, is obligated to constitute a sustainable environment for spreading of produced technology and a national innovation system. Suggestions such as accelerating processes of public institutes, eliminating bureaucratic difficulties, taking risk sharing precautions for R&D operations, making high cooperation level criteria for incentives and grants, encouraging patent production more and providing public liaison services within techno parks, are crucial for state to fulfill its responsibilities. As to universities, another important partner of techno parks, there are a lot to be done. University must stipulate industrial operations for academic promotion and perform needs assessment for active operations. Also,

dissertation topics on all levels must be determined in the light of various field researches. Researches executed in university should be on display together with techno park operations, on the same website. This will increase the interaction and contribute to cooperation quality. University should provide more consultancy and opportunities regarding service procurement for techno parks to minimize lack of interdisciplinary managers and consultants. Also, instituting Master's degree and PhD programs oriented for needs of technopark employees, will be contributing positively to cooperation quality. Undergraduate programs regarding generating an entrepreneurship culture should be consistent and cooperations should be more corporate instead of being personal. Last but not least, firms should constantly look for cooperation and partnership opportunities and utilize university's research opportunities. Firms should provide more internship, scholarship and part-time work programs for college students, their potential workforce, in order to employ qualified workforce. Performing common broadcasts in the light of collaborative works will grant prestigious and new work areas. This study includes four technoparks operating in Istanbul. Developing a measurement tool and software regarding this designed model, performing periodical measurements and evaluations, generating a dynamic structure for all related partners to follow the results and determining current activity sorting in the light of these results are recommended actions for technoparks. Creating a portal with these output for all partners to use, publishing all updates and results regarding technopark activities on this portal and portal's concordant usage by universities, R&D centers, technoparks and related departments of the state will provide a big contribute to technopark performance. Scales of this study can easily be adopted by other technoparks. In this way, application field of the study can expand to a national level. New studies comparing local technoparks with foreign techno parks can be executed utilizing information provided by this study. Also, with slight transformations, scale can be adopted by researches from other disciplines, as the structure of designed model, as well. Our model can lead to new model and methodology studies by blending it with other methods. Also, collected data can be utilized in new products by using them in artificial neural network, genetic algorithm, etc. methods. Each topic of this study's theoretical model can become a subject of study or research field for techno parks. Many different research topics regarding techno park structure can be found for follow-up studies.

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