REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

AN INNOVATION AND TECHNOLOGY TRANSFER ASSESSMENT FRAMEWORK FOR THE CONSTRUCTION INDUSTRY

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MSc. THESIS
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A thesis submitted by Gökhan DEMİRDÖĞEN in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** is approved by the committee on 06.07.2015 in Department of Civil Engineering, Structural Engineering Program.

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Gökhan Demirdöğen

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LIST OF SYMBOLS

χ^2	Chi-Squared

LIST OF ABBREVIATIONS

AGFI	Adjusted Goodness of Fit Index
BA	Business Angels
CFI	Comparative Fit Index
FDI	Foreign Direct Investments
GFI	Goodness of Fitness Index
KM	Knowledge Management
NSI	National Innovation System
R&D	Research and Development
RMR	Root Mean Square Residual
RMSEA	Root Mean Square Residual
SEM	Structural Equation Modeling
SME	Small And Medium-Sized Enterprises
SRMR	Standardized Root Mean Square Residual
TTO	Technology Transfer Office
VC	Venture Capitalist

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ABSTRACT

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Nowadays, knowledge and its applications such as innovation and technology transfer activities became crucial in all industries. Despite its conventional structure, construction industry as being one of the main drivers of macroeconomy of countries has a significant role in these developments since the industry comprises of so many sub industries in which construction technologies, new products, new managerial processes, softwares, simulation platforms etc. are developed.

In this study, first of all it is aimed at specifying indicators of construction companies' innovation and technology transfer success. Secondly, it is aimed at specifying measure factors of construction companies innovation and technology transfer success. Finally, it is aimed at presenting framework which shows relationships between external factors, internal factors, indicators of construction companies innovation and technology transfer success and indicators of construction industry. Structural Equation Modeling (SEM) is used to consist of models in framework. Therefore it was benefited from EQS 6.2 in the context of study.

In the context of study 52 questionnaires were collected from construction companies. 85% of these companies are specialized at building facilities. In the light of 52 questionnaire, three models were created for assessment framework. Effect of "resources and capabilities", "project management competencies", and "strategic decisions" on "indicators of construction companies innovation and technology transfer success" were investigated in first model. Model 1 showed that only "project management competencies" have direct relationship with "indicators of construction companies innovation and technology transfer success". Also "project management capabilities" have a role which distributes impact of "resources and capabilities" and "strategic decisions". Model 2 consisted of external factors and "indicators of construction companies innovation and technology transfer success". While "external factors(business environment)" have a direct impact on "indicators of construction companies innovation and technology transfer success", "external factors(general environment)" affect "indicators of construction companies innovation and technology transfer success" via "external factors(business environment". Model 3 was constructed measuring "indicators of construction companies innovation and technology transfer success" effect on "indicators of construction industry". Those three models were analysed with SEM methodology and relationships mentioned in the models were discussed. As consequent, all of models will be used for an innovation and technology transfer assessment framework for the construction industry.

Key words: Innovation, technology transfer, internal capabilities, external capabilities, construction industry, structural equation modeling (SEM)

ÖZET

İNŞAAT SEKTÖRÜ İÇİN İNOVASYON VE TEKNOLOJİ TRANSFERİ DEĞERLENDİRME ÇERÇEVESİ

Gökhan Demirdöğen

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Günümüzde, bilgi ve bilgiye bağlı uygulamalar hayati öneme sahip olmuştur. Buna bağlı olarak inovasyon ve teknoloji transferi faaliyetleri önem kazanmıştır. Fakat bu önem ve uygulama diğer sektörlerde açıkça görülebilirken, inşaat sektörü gleneksel yapsı nedeniyle, alt sektörleri dolayısıyla pek çok yeni süreç, ürün inşaat teknolojisi gelişmelereine sahipken diğer sektörlerin gerisinde kalmıştır.

Bu çalışmada ilk olarak, inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerinin belirlenmesi hedeflenmiştir. İkinci olarak inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerini ölçen faktörlerin bulunması hedeflenmiştir. Son olarak, kaynak ve yeteneklerin, proje yönetim yetkinliklerinin, stratejik kararların,dış çevre faktörlerinin, inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerinin ve inşaat sektörü başarı göstergelerinin arasındaki ilişkileri gösteren bir çerçeve sunulması hedeflenmiştir. Bu çerçevede sunulan modellerin oluşturulmasında Yapısal Eşitlik Modeli kullanılmıştır. Bu sebeple, bu çalışma kapsamında EQS 6.2'den faydalanılmıştır.

Bu çalışma kapsamında inşaat şirketlerinden 52 anket toplanmıştır. Ankete cevap veren şirketlerin %85'i bina yapımı alanında uzmanlaştığı belirlenmiştir. Fakat bu şirketler birden fazla alanda da uzmanlaştığı görülmüştür. Bu 52 anket ışığında, değerlendirme çerçevesi üç model oluşturulmuştur. İlk modelde kaynaklar ve yetenekler, proje yönetim yetkinleri ve stratejik kararların inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergeleri üzerine etkisi incelenmiştir. Model 1, sadece proje yönetim yetkinlerinin inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergeleri üzerinde doğrudan ilişkiye sahip olduğunu göstermiştir. Ayrıca proje yönetim yetkinlikleri, kaynak ve yeteneklerin ve stratejik kararların etkisini iletmede aracı role sahiptir. Model 2 dış faktörler ve inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerinden oluşmaktadır. Dikkate alınan dış faktörler (iş çevresi), inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergeleri üzerinde doğrudan etkiye sahipken, dış faktörler (genel çevre) inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerine dış faktörleri (iş çevresi) aracılığıyla etki etmektedir. Model 3 inşaat şirketlerinin inovasyon ve teknoloji transferi başarı göstergelerinin inşaat sektörü başarı göstergeleri üzerindeki etkisini ölçmek için oluşturulmuştur. Bu üç model istatistiksel olarak onaylanmış ve modelller içerisinde yer alan parametreler arasındaki ilişkiler yorumlanmıştır. Sonuç olarak, tüm modeller inşaat sektörü için inovasyon ve teknoloji transferi değerlendirme çerçevesi içerisinde kullanılacaktır.

Anahtar Kelimeler: İnovasyon, teknoloji transferi, iç kabiliyetler, dış kabiliyetler, inşaat sektörü, yapısal eşitlik modeli

CHAPTER 1

INTRODUCTION

Technological and innovational activities are seen the way out to improve the economical problems of the countries. Furthermore they have intermediary role in both development of the industry and countries. Another important role belongs to globalization. Globalization enables all companies to compete in different markets. This sparks competitive actions in construction industry as being in all other industries. However, structure of construction industry and lack of professionality impede innovation and technology transfer. According to the literature review various technology transfer mechanisms and innovation types were specified. Afterwards, these issues were investigated specific to construction industry. In this concept, technology transfer and innovation considered together because technology transfer mechanisms provide distribution of innovations to another companies. Moreover, these activities service the same objectives.

1.1 Literature Review

In review of the literature, Offori [1] stated that the development of construction industry is connected to development of materials, Project documentation and procedures, human resources, technology, contractors, and institutions. In another study of Ofori [2], it was stated that new and old technologies' adaption have a positive impact on company and industry, ease of implementation and diffusion, leading to local resources, high productivity, efficiency and economy should be considered, when technology transfer is realized in construction industry. Continious of the study, technology transfer vehicles in construction industry is presented being subsidiary, joint ventures, supply of plant and equipment, subcontracting, strategic aliances, counterpart training, licensing, contract R&D, government leel technical aid, attendence to conferences, and publications.

Another important finding is project based construction innovation. This causes to impede distribution of construction innovation. Therefore special precautions should be taken for realization of construction industry (Ozorhon et al., [3], Driessen and Ende [4] , Keegan and Turner [5]).

In some studies it was faced that effect of internal and external factors of companies (they are not the same our study context) are investigated (Tatum, [6]).

Continious review of literature, models were investigated. Related models presented in Chapter 3. As a result of literature review, innovation and technology transfer niche were specified. According to the niche, objective of the thesis was identified as below.

1.2 Objective of the Thesis

In this thesis, effect of internal and external factors on innovation and technology transfer indicators will be analyzed by using SEM. In other words, if construction companies want to achieve innovation and technology transfer indicators, the assessment framework shows which resources and capabilities, strategic decisions, project management competenies and external factor should be prioritized and considered by construction companies. Another objective of the Thesis is which area of construction industry will be affected positively by innovation and technology transfer indicators. In order to achieve this, the most common measures and indicators of innovation and technology transfer will be determined, and validity of the measure and the relationships between them will be justified.

Since construction management literature was focused on partial subject on construction innovation and technology transfer, proposal of such a framework has considerable contributions to inovations and technology transfer research in construction.

In this respect, following are the objectives of this research:

- Determination of the measures and indicators of innovation and technology transfer in construction industry with an in depth literature review
- Development of an innovation and technology transfer framework for construction industry
- Analysis of the all model and explanation of the inter-relationships between model parameters.

1.3 Research Methodology

A questionnaire consisting of questions about innovation and technology transfer measures and indicators was designed in order to analyse their influence on company and industry in construction industry. The questionnaire was administered via e-mail and face to face interviews to 52 construction companies located in in Turkey and they were analyzed by using structural equation modeling (SEM) methodology.

1.4 Hypothesis

Revealed models and the innovation and technology transfer measures with the indicators, there are a number of 8 hypotheses in the proposed framework on the way to measure the innovation and technology transfer of a construction company and its impact on industry.

H_1: Framework consisting of five constructs were designed in order to understand their effects on innovation and technology transfer.

H_2: “Resources and capabilities” construct of the model has a direct effect on “project management competencies”.

H_3: “Resources and capabilities” construct of the model has a direct effect on “strategic decisions”.

H_4: “Strategic decisions” construct of the model has a direct effect on “project management competencies”.

H_5: “Project management competencies” construct of the model has a direct effect on “innovation and technology transfer indicators”.

H_6: “External factors (General environment)” construct of the model has a direct effect on “External factors (Business environment)”.

H_7: “External factors (Business environment)” construct of the model has a direct effect on “innovation and technology transfer indicators”.

H_8: “Innovation and technology transfer indicators” construct of the model has a direct effect on “indicators of construction industry”.

CHAPTER 2

TECHNOLOGY TRANSFER

Technology has a big impact on the countries' macroeconomy. This impact is especially seen in developing countries (Lee [7]). Countries attain competitive advantages and adaptation to technologies through development of technologies (Barnes et al. [8]).

With globalization, knowledge-based activities have been came into the agenda of companies. This transformation was started with giving attention from tangible assets to intangible assets. This demonstrated that knowledge and human resources are just as valuable as other performance criteria in terms of firms because they provide competitive advantages in global economy to companies (Audretsch et al. [9]). If knowledge-based activities are well managed, innovations will be outputs of knowledge-based activities.

Macroeconomic benefits of innovation is undeniable anymore. Innovation contributes economic growth and productivity of countries (Slaughter [10]). Innovation gains may not be directly measured, but firms' competitive position, attractive, and dollar saving can get stronger. While innovations have a positive impact on both companies and countries, technology transfer is a kind of innovations' transmission mechanisms.

Technology transfer activities are made for financial gains. This financial gains are important in terms of both companies and countries. Nowadays, countries are interested in this situation. When they noticed importance of technology transfer activities, they have started forming knowledge-based in their countries and they are getting set their policy and programs. However successful applications in technology transfer is only gained with processes which must be convenience to nature of technology transfer process. For example, success of technology transfer can be provided by considering of knowledge transferability and transparency (Transferability implies types of knowledge which is distinguished to be tacit and explicit. Transform of tacit knowledge that is difficult affects utilization of technology effectively. Transparency means that technology producers' willingness about sharing of information with receiver firms.) (Teng [11]).

Establishments' strategies give a direction their future position and tasks. Therefore technology transfer are not discriminated from it. Mutual strategic intents of establishments are important because technology transfer processes are multilateral. Intents of their will facilitate both development of technology and achieving technology. As well as intents of other institutions are important as companies'. In the literature, Kuo et al. [12] wanted to see interactions between technology transfer modes in university and strategic intents. Therefore they specified transfer modes and strategies which are namely consulting, licensing, joint research or contract research, internalization-seeking intent, efficient-seeking intent, and resource-seeking intent respectively. They separated intents to passive and proactive attitudes. Passive approach was symbolized with higher interaction and short term relationship, whereas proactive approach required long term relationship and benefits from other institutions totally. This discrimination is demonstrated in Table 2.1. Their findings showed that licensing modes are affected from resource-seeking intent negatively. However these three types of intents have positive relationship with R&D cooperation.

Table 2.1 Taxonomy of Firms' Intents

Passive Intent	**Amid**	**Proactive Intent**
Efficiency-seeking intent	Resource-seeking intent	Internalization-seeking intent

Every industry has idiosyncratic conditions. Therefore technology transfer mechanisms are formed according to industry. In the literature, many studies, specific to particular industry, are found. One of them is construction industry. In the literature technology transfer and innovation systems in Construction industry are discussed. Because construction industry has both an important proportion in country's economy and underdeveloped structure. This instance can be seen easily in study of Ofori [2]. He stated that technology transfer mechanisms promote construction industry for development in developing countries. Moreover he made comparison between construction industry and other industry. His framework indicates that in developing countries poor proceeding at technology causes to high cost, foreign sources to be import, poor economic growth, lag in industry and uneducated workers. However when technology development activities are formed, some conditions should be important to advance in construction industry. These are “capital”, “socio-economic conditions”, “culture” and “suitable physical infrastructure” (Ofori [2]).

New equipment and machinery are instances of formed knowledge. So that this type of technology or knowledge transfer is the most common within industries. However structures of traditional manufacturing sectors and services sectors haven’t got capability for creating knowledge and innovating by themselves. This requires knowledge capacities for firms. So they can implement it on their work areas (OECD, 1997).

Technology transfer comes into prominence with existence of companies and commercialization of products. Because their efforts and needs shape direction of technology transfer activities in countries. At this point companies or institutions have two choice. These are make or purchase decisions. So their decisions like purchasing or collaborative activities can be count to be technology transfer activities. Now, some of technology transfer activities are going to range according to Kuo et al. [12]. “Arms-length purchase” comes into prominence if firms have necessary knowledge for assessing external technology. So that they can apply perceived technology to their process and technology. “Facilitated purchase” is buying decision of new. However this decision is not enough per se. This requires collaboration with public research institutions in order to benefit from technology completely. “Collaborative hand-off” requires if perceived technology is complicated in terms of firms, they interact with supplier of technology. Finally, “Co-development” is preferred that firms have not enough knowledge for developing new technology. Therefore they apply other institutions for doing collaborative R&D projects.

Technology transfer activities involve transfer of innovations from developer to receiver. So next section are going to begin with innovations and its notions. After innovations were defined, technology transfer mechanisms are going to be introduced. In other words, university-industry collaborations, technology transfer activities between countries, joint industry activities and nations’ incentives about technology transfer are going to be defined. Afterwards, technology transfer and innovation models are going to be shown from the literature.

2.1 Innovation

“Innovation is the implementation in a firm of significantly new processes, products or management approaches in order to increase its efficiency (improved quality, lower production costs) and/or effectiveness (greater market share, client satisfaction)” (Seaden et al [13]).

Innovations separate in its. These can be product-oriented, managerial-oriented or they include both of them. Now, some innovation types will be ranged below from literature;

- Organizational innovation: “It refers to the implementation of new organization methods. These can be changes in business practices, in workplace organization or in the firm’s external relations.” (Oslo Manual [14])
- Marketing innovations: “It involves the implementation of new marketing methods. These can include changes in product design and packaging, in product promotion and placement, and in methods for pricing goods and services.” (Oslo Manual [14])
- Process innovation: “It represents significant changes in production and delivery methods.” (Oslo Manual [14])
- Product innovation: “It involves significant changes in the capabilities of goods or services. Both entirely new goods and services and significant improvements to existing products are included.” (Oslo Manual [14])
- “Hidden innovation include effective use of new materials which involve learning on the job, new organizational structures and business models, novel combination of existing technologies and processes, innovative solutions to small scale problems and challenges” (Chan et al. [15]).
- Incremental innovation includes small changes. These advances emerge with technologic advances, knowledge and experience (Slaughter [10]).
- Modular innovation is gained by changing of concept in component (Slaughter [10]).
- Architectural innovation is gained by changing of component in a system (Slaughter [10]).
- Radical innovation is breakthrough innovations. Although they are rare, they affect whole technology (Slaughter [10]).

- System innovation is gained by using of lots of innovation together (Slaughter [10]).
- Open innovation: In open innovation, external resources are considered rather than internal activities Firms make collaboration with other institutes or firms in order to emerging innovation. Industry take more part when collaborative activities are realized (Perkman and Walsh [16]).
- Bounded innovation: Bounded innovations can emerge with a single efforts in firms. In construction industry. 2D Cad programs are given being instance and it serves to be drawing (Harty [17]).
- Unbounded innovation: Unbounded innovations consist of alliancing of more than one efforts. For example 3D Cad programs requires various actors and they present many outcomes (Harty [17]).

Stakeholders are accelerator or impediment factors in innovation or technology transfer activities. According to this, in the literature some studies support this concept. Widen et al. [18] sought relationship between stakeholder and innovation. They found that there are positive coloration between stakeholder management and innovation activities. Besides stakeholder management provides advantages to innovation diffusion.

Innovations are to support productivity, cost effectiveness and sustainable development of organizations. Rapid globalization, technological advancement and trends inflame innovations. Furthermore leadership is one of the important enablers to prepare suitable conditions for innovations. In the literature, one of the studies belong to Chan et al. [15] who investigated about relationship between leadership types and innovation climate. When they investigated leadership types, they specified three types. They were namely transformational leadership, development exchange leadership and corrective avoidant leadership. According to their results, transformational leadership has a positive correlation between innovation climates.

2.2 University-Industry Collaborations

After economic power of knowledge was discovered by governments, they have started constituting their regulations and standards depends on awareness of its power. Besides governments regulated promotions in order to increase between industries and universities interactions. Basically, after globalization, each side of countries' shareholders (institutions or companies) has special role. Because technology-based international companies compete in every countries. Therefore governments compel more collaboration, technological and knowledge activities in order that internal firms do not lose their competitiveness. For example universities make an entrepreneurial activities, knowledge transfer, technology transfer, and creating human resources. As a result, countries make universities and industries do more collaboration (Audretsch et al. [9]).

"Much of what the university does (teaching, research, publication, and public service) is transfer activity" (Lee [7]). As is stated, basically industry generally exploit from universities' tangible and intangible assets. However they don't notice that to be transfer activities. For instance, after students graduate from university, they are employed from companies. So that knowledge of university is moved with students to companies.

These collaborations provide benefits both universities and industry. When universities are handled, they gain income, experience, knowledge, new demands and implementation, budget acquirements and development business networks. In contrast to university, industry acquirements are qualified graduates, universities' knowledge and physical facilities, data, quality, cost and time (Lee and Win [19]).

In the literature, there are models which are emphasized importance of universities. These are triple helix models. Before the models weren't presented, there had been technology push and market pull. These had formed technology-based proceedings. However these were insufficient in commercialization. So intermediary institutions were generated by nations. However, they weren't remedy. Therefore Etzkowitz and Leydesdorff [20] developed triple helix models. These models are distinguished into three models. Triple Helix 1: Industry and university are under the set of control of government. Government manages their relationship. This framework is instance of former Soviet Union (Figure 2.1). Triple Helix 2: there are precise discrimination between institutions (Figure 2.2). Triple Helix 3: Even if three institutions have a special spheres, there are intersection area in which the institutions intersect. In this area, they generate knowledge infrastructure. So that every institutions take part with hybrid organization in another area (Figure 2.3).

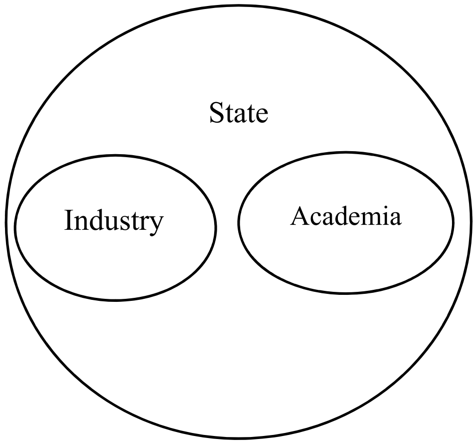


Figure 2.2 An elastic model of university-industry government

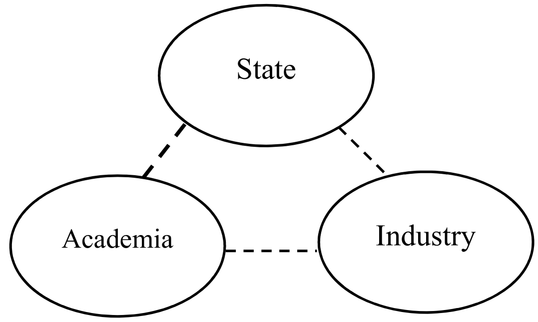


Figure 2.1 A "laissez-faire" model of university-industry-government

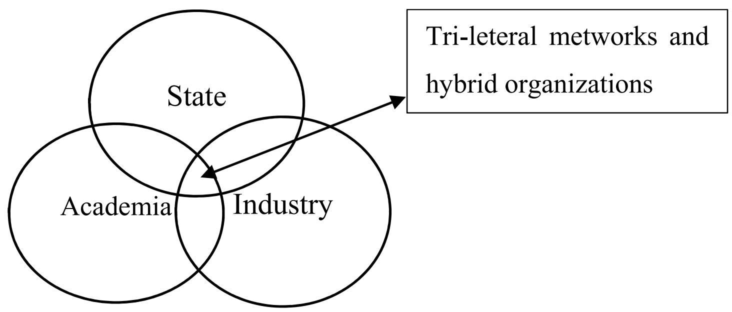


Figure 2.3 The Triple Helix Model of University-Industry-Government

However some external factors play an active role to facilitate these interactions/collaborations. These can be;

- R&D activities require costly implementation,
- Product life cycle-based problems,
- Continuous variable market dynamics,
- Complex problems,
- Necessity of receiving support, and
- Obligations (Lee and Win [19]).

As is concerned above, technology transfer activities accelerate countries' economy, they are tried to increase country-wide. This is generally provided by various intermediary institutions. These institutions are entitled to be Technology Transfer Centres (TTCs).

These institutions provide benefits which are consisted of knowledge transfer from university to industry, knowledge sharing among key actors, personnel mobility, and network by making boundary spanning activities. According to Comacchio et al. [21], their efforts are beneficial in terms of boundary spanning role. Another important finding from study is typological differences between TTCs. These are given in Table 2.2.

Table 2.2 Typologies of TTCs mapped and mission statement (Comacchio et al., 2012)

Typologies	Mission Statement
Experimental station	Carrying out pre-competitive industrial research and development analysis, testing and experimentation of products, processes and new technologies, technical and scientific dissemination of knowledge and documentation in specific sectors at the national level (IPI—Istituto per la Promozione Industriale 2005).
Science park and technology hub	Promoting the economic development and competitiveness of regions and cities by creating new business opportunities and adding value to mature companies; fostering entrepreneurship and incubating new innovative companies; generating knowledge-based jobs; building attractive spaces for the emerging knowledge workers; enhancing the synergy between universities and companies (International Association of Science Parks).

Table 2.2 Typologies of TTCs mapped and mission statement (Comacchio et al., 2012) (Cont'd)

Typologies	Mission Statement
Technology transfer office	Supporting the academic staff to identify and manage the organization's intellectual assets, including protecting intellectual property and transferring or licensing rights to other parties to enhance prospects for further development (European Commission 2004).
Business incubator	Accelerating the growth and success of entrepreneurial companies through an array of business support resources and services that could include physical space, capital, coaching, common services, and networking connections (National Business Incubation Association).
Business innovation centre	Offering a range of integrated guidance and support services for projects carried out by innovative SMEs, thereby contributing to regional and local development (European Business and Innovation Centre Network).
Chamber of commerce special agency and laboratory	Furthering the development and expansion of technological innovation through the offer of services that meet the requirements of the firms associated with the Chamber of Commerce (IPI—Istituto per la Promozione Industriale 2005).

Table 2.2 Typologies of TTCs mapped and mission statement (Comacchio et al., 2012) (Cont'd)

Typologies	Mission Statement
Territorial development enterprise	Gathering and coordinating scientific, organizational and financial resources in the region in order to transfer acquired information into new production processes and research results to the entrepreneurial context.
Topic centre	Promoting a specific industry or a specific technological area inside a geographical context (IPI—Istituto per la Promozione Industriale 2005).
Multi-sector centre	Supplying diversified services to firms operating in several sectors (IPI—Istituto per la Promozione Industriale 2005).
Public research organization	Performing research in its own Institutes, promoting innovation and competitiveness of the national industrial system, promoting the internationalization of the national research system, providing technologies and solutions to emerging public and private needs, offering advice to Government and other public bodies, and contributing to the qualification of human resources (Italian National Research Council).
Laboratory	Supplying qualified services of research and development, analysis and testing to client firms.

TTOs are intermediary institutions. Sometimes they can take place actively in processes. Sometimes they lay bridge between scientist and receiver institutions. Or they present another opportunities to scientist. Their responsibilities can be seen in the literature. For example: TTOs are responsible for achieving technology from university to industry (Markman et al. [22]). Role of TTO is to manage and protect IP (Siegel et al. [23]). Furthermore TTOs have some properties;

- Impede problems in UI collaborations,
- Higher income,
- More quality information,
- Commercialization,
- Business development,
- Independence from university managerial and financial controlling,
- Easy collaboration with third participants (Debackere, and Veugelers [24]).

Besides, productivity of TTOs are an important issue. This is investigated by Siegel et al. [23]. When they studied on productivity of TTOs, they realized that there aren't any performance factors for assessment of TTOs. At this point, they explored three affecting factors in TTOs' performance. These are namely "internal inputs", "environmental/institutional factors", and "organizational factors". Internal factors were explained to be transfer processes between university and receiver, and as for environmental/institutional factors, they can be summarized to be university policy, national economic growth, efficiency of TTO, and priority of R&D activities in universities. Latter is organizational factors which mean protect IP, find additional funding and achieve more researchers, overcoming cultural problems, and providing product commercialization without expiring of technology. As result of study they found that environmental and institutional factors have an impact on UITT. Efficiency of TTOs explained with organizational factors. These factors were reward systems, TTO staffing/compensation practices, and cultural crashes.

Although UI collaborations are important part of technology transfer activities, these interactions bring about some problems. Such problems are classified by Bruneel et al. [25]. These are "orientation-related barriers" and "transaction-based barriers". Their study were created on barriers which are investigated in terms of prior collaborations, balance of interactions and trust. Results of study shows that Intellectual Property (IP), orientation practitioners and TTO' behaviors, and policies like transaction-related barriers affects collaborations. Another result is about transaction-based barriers have strong impact more than orientation-related barriers and trust between participants is important factor overcoming these problems in collaborations. Another study, in the literature which is related with barriers belongs to Siegel et al. [26]. They stated that commercial knowledge transfer are transferred from university to practitioners. These collaborations are provided by various agreements. For example they can be used licensing agreements, research joint ventures and start-ups in the process. They considered a structure which consists of three stakeholders. These are namely scientists, TTO administration and industry. The structure begins with scientist invention. After invention, TTO determines whether being worth of patent or not. If they decide to patenting, commercialization stage is opened. According to these collaborations, some problems can arise. These problems can impede proceeding of process. So Siegel et al. [26] sought effectiveness of university-industry technology transfer process. Their results revealed that stakeholders' aims, cultural barriers, bureaucratic inflexibility, reward systems and TTOs' authority management style affect collaboration.

University-Industry research activities can be realized various ways. These ways are compared in Lee and Win [19] study. They stated that university-industry interactions are realized with "collegial interchange, conference, publication", "consultancy and technical services provision", "exchange program", "joint venture of R&D", "cooperative R&D agreement", "licensing", "contract research", "science park, research park", "technology park or incubators", and "training".

In the literature university-industry interactions distinguished various part. Some of them presents in Table 2.3.

Table 2.3 University-Industry Interactions

Types of Interactions	Writer
Research partnerships	Perkmann and Walsh [16], Rogers et al. [27], OECD, 1997, Cohen et al. [28]; Kuo et al. [12]

Table 2.3 University-Industry Interactions (Cont'd)

Types of Interactions	Writer
Academic entrepreneurship	Perkmann and Walsh [16], Rogers et al. [27]
Human resource transfer	Perkmann and Walsh [16], OECD, 1997, Cohen et al. [28]; Kuo et al. [12], Lee and Win [19]
Informal interaction	Perkmann and Walsh [16], OECD, 1997, Cohen et al. [28]; Kuo et al. [12]
Scientific publications	Perkmann and Walsh [16], OECD, 1997, Cohen et al. [28]; Kuo et al. [12], Lee and Win [19]
Patent	Audretsch et al., (2014), OECD, 1997, Cohen et al. (2002); Kuo et al. (2014)
Trademarks	Audretsch et al. [9]
Public meetings and conferences	OECD, 1997, Cohen et al. [28]; Kuo et al. [12], Lee and Win [19]
Graduates	Perkmann and Walsh [16], Lee and Win [19]
Licenses	Cohen et al. [28]; Kuo et al. [12], Lee and Win [19], Rogers et al. [27]
Contract research	Perkmann and Walsh [16], Cohen et al. [28]; Kuo et al. [12], Lee and Win [19]
Consulting	Perkmann and Walsh [16], Cohen et al. [28]; Kuo et al. [12], Lee and Win [19]

Lee and Win [19] compared various university-industry interactions which are specified above. According to their findings, joint R&D activities is better than others, government role has a positive impact on transfer (like funds), and risk sharing between partners affect transfer positively.

UI interactions can be categorized by looking at participating of industry partner. Moreover these can change according to transfer types. Frequency of relationships between them is presented Table 2.4. According to the table, participating of industry partners are divided by three categories. They are ranged high, medium and low.

Table 2.4 A typology of university-industry links (Perkmann and Walsh [16])

Extent of relational involvement		
High: relationships	Medium: mobility	Low: transfer
Research partnerships Research services	Academic entrepreneurship Human resource transfer	Commercialization of IP
Use of scientific publications, conferences and networking		

Degrees of finalization in industry-funded researches are presented Table 2.5. In this table, research partnerships present benefits academics in terms of publications. While industry exploits from outputs of research services. Another concept is about finalization degree which imply to what extent are researches considered social, economic and technical dimension of study rather than gaining knowledge (Perkmann and Walsh [16]).

Table 2.5 Degrees of finalization in industry-funded research (Perkmann and Walsh [16])

Research partnerships	Research services
Collaborative research University-Industry research centers	Contract research Consulting

low ← finalization → high

UI relationships has been realized various way throughout history. One of them is “neotransferism” which gives a new impulse to UI relationship. This conceptual was emerged at 1980s. These imply that UI collaboration realize transfer of IP, start-up assistance, partnership based on equity, consortia, alliances, consultation, and exchange of personnel across intuitions (Lee [7]).

Debackere and Veugelers [24] explored appropriate technology transfer mechanism between university and industry. They considered decentralization model in their study. Decentralization model means that various research groups, individuals and technology transfer offices take role in transfer activities. They emphasized that decentralization approach promotes technology transfer activities. Other findings were about clearness of IP regulations, incentives, policy structure that if they prepare carefully, they affect technology transfer activities positively. Moreover liaison office needed to perform necessary investigation, management activities, monitoring activities and informing.

It is obvious that technology transfer between university-industry technology transfer methods change according to from one industry to another. This differences was investigated specific to technology transfer mechanisms and barriers by Gilsing et al.[29]. They thought of technology transfer mechanisms as formal and informal relationship at upperscale, and as for subscale, they distinguished two parts which are science-based regimes and development-based regime. Science-based regimes are symbolized transfer of university intensive knowledge to industry. Whereas development-based regimes consider non-economic knowledge. However applied knowledge came into prominence in development-based regimes rather than raw knowledge from university. As a result of study, they found that transfer mechanisms change according to regimes.

In the literature, some studies about technology transfer barriers were summarized. Some of these studies were found that "the risk of information lackage", "conflict of interest", raw scientific knowledge in terms of industry, absorptive capacity, cost, lack of experience on knowledge" block technology transfer (Gilsing et al. [29]). Furthermore, technology diffusion is determinants of technology transfer in terms of industry. So technology diffusion related problems affect realization of technology transfer from donor to receiver completely. Like lack of knowledge, financing, expertise, and creative thinking are some of them (OECD, 1997).

2.2.1 Research Partnerships

Research partnerships are realized by formal collaborations. Participants specify aims. Accordingly, they perform their research and development activities (Perkmann and Walsh [16]). Research partnerships are divided into two part R&D and cooperative R&D agreement. They are going to explain below.

2.2.1.1 Joint Venture of R&D

Joint venture of R&D activities start with signing of contract. It is signed by university and industry partners. Expenditures are shared between them according to the provision of contract. In this types of collaboration, partners can work together from R&D phase to commercialization of products (Esham [30]).

2.2.1.2 Cooperative R&D Agreement

This types of research partnerships include multilateral partners. These partner can be more than one university or industrial partners. In this collaborations, university presents their staffs and laboratories etc. whereas industry can provide resources such as funds, personnel, services, equipment etc. (Esham [30]).

2.2.2 Academic Entrepreneurship

Academic entrepreneurship involves like start-ups companies, spin-offs. When academic entrepreneurship establishes, commercialization of technology are performed as below.

2.2.2.1 Spin-off

A spin-off organization is set by person who takes place forming of new technology at parent organization. Spin-offs enable commercialization of product by researcher. This promotes R&D activities by researcher. Furthermore, this type of technology transfer induces new jobs and wealth. Therefore they contribute national economy more than others (Rogers et al. [27]).

Another study about spin-offs are made by Macho-Stadler, and Perez-Castrillo [31]. They stated that TTOs can take place in creating spin-offs. They defined spin-off partners who can be researchers, TTOs, Venture Capitalist (VC) or Business Angels (BA).

2.2.3 Human Resource Transfer

Todays, assets of companies are distinguished to be tangible assets, and intangible assets. Whereas tangible assets continue economic performance of companies, intangible assets like human resources capital is difficult to convert to economic indicators. However their experience about facilities of companies is formed feature of companies. Their transfer activities means that valuable knowledge transfers to rival. According to this, this ends in loss of profits of company. Another types of human resources transfer is realized from public institutions to private industry. While this is acquisition in terms of companies, it is loss in terms of institutions (OECD, 1997).

2.2.4 Informal Interaction

Informal interactions is realized with networks or relationships of person. Knowledge is gained thanks to interactions by industry.

2.2.5 Publications

Publications are published by both industry and academics. These includes codified knowledge. Valuable knowledge can be attained from these resources in order that they are open resources.

2.2.6 Patent

Patents are used to provide rights to owner of invention. This rights are used for saving inventions in order that third parties who don't have got any permission for produce or exploit don't use it.

2.2.7 Trademarks

Trademarks differ from patents. Patents don't include business models, and service innovations. Therefore trademarks are more comprehensive when comparison between trademarks and patents is made (Audretsch et al. [9]).

2.2.8 Public Meetings and Conferences

These meetings and conferences bring close together both academics and delegate of industries. Proceeding in industry and science are shared in this platform. According to value of information, it is conveyed from industry/university to university/industry. This enables knowledge transfer between institutions.

2.2.9 Graduates

Graduates move their knowledge from university to industry. This presents continuous relationship between university and industry.

2.2.10 Licences

Licenses are used assigning of right to receiver institutions. These agreements provide rights which are used sell or use products (Rogers et al. [27]).

In the licensing agreements contract design takes an important place. Contracts defines who performed R&D activities and they show who will how much earn. Three possible action at design of contracts were confronted. They are namely royalty, fixed payments, and shareholding system. Profitability of firms and universities vary according to choosing of these systems. Shareholding system is different from others. Because they don't bring extra cost like being royalty and fixed payments. However if firms have big size, perceived technology doesn't reflect their profitability because of taking small place in total budget. These are compatibility with small size firms, so that they can measure their importance (Macho-Stadler, and Perez-Castrillo [31]).

As known, university technology transfer can vary with transfer mechanisms. Relationships between these mechanisms, licensing strategies and phase of commercialization products are investigated by Markman et al.[22]. These structures are "traditional university structure", "non-profit research foundation" and "for-profit private venture extension". Licensing strategies are namely "licensing in exchange for sponsored", "licensing for equity in a company", and "licensing for cash". Finally, phase of commercialization of products are early stage inventions, proof of concept, reduction to practice and prototyping. In this study, they researched interactions among these three factors. They saw that there are correlation between them.

2.2.11 Technology Park

Lindelöf and Löfsten [32] studied on new technology based firms. If they establish a connection with university on locating university' science park, they gain both competitive advantages and exchange of knowledge from collaborations. Results of their study shows that located firms in contrast with off-science park firms have more percentage in innovative activities.

2.2.12 Research Services

This topic distinguish two part. One of them is contract research. Latter is consulting. Academics/researcher provides services third parties. In this collaborative activities, way of collaboration is led by firms (Perkmann and Walsh [16]).

2.2.12.1 Contract Research

Firms apply universities in order to perform their R&D activities by favor of university. This requires formal agreements between institutions and firms. In contract research, firms demand their requirements from universities. In return, they pay what they guarantee in the contract. This requires research activities in order to explore industrial problem (Perkmann and Walsh [16]).

2.2.12.2 Consulting

Consulting services meet firms' the needs. This is realized with transferring of existing knowledge to firms (Perkmann and Walsh [16]).

2.3 Technology Transfer Activities Between Countries

Technology transfer is realized with international licensing agreements or foreign direct investments (FDI). As you know, licensing agreements are made with developer companies. In some circumstances, some of them can be found at different countries. Therefore companies of host countries make licensing agreements with developer. As a result of agreements, they meet conditions of licensing agreements against to licensee.

FDI consists of two parts. One of them is realized which firm department is opened in host countries. Other is multinational corporations. Both of them enacts market conditions and contributes productivity. Their knowledge and own technologies are spread in host countries. However, these knowledge have a meaning with comprehending of local firms. Because this requires knowledge capacity in companies (Blomström and Sjöholm [33]).

Common innovation and R&D activities can be made between countries. However this requires well-established communication system for collaboration (Audretsch et al. [9]).

2.4 Joint Industry Activities

R&D activities are costly decisions. So companies do not realize R&D activities themselves. According to condition, they seek partners who have more technological capability, and knowledge than themselves. This is often realized with strategic technical alliances. Therefore they can attain necessary information from their partner. Besides they have another options in order to gain knowledge from partners. It is realized with taking over. So knowledge capital and technologies are handover from buyer or recipient (OECD, 1997).

Technology may not be available in the industry which firms are in service. Another industry's solutions can be beneficial to other industries. So firms can be attained necessary information or innovations by communicating with other industries. Besides technologies that emerge being process innovations can be used product innovation another industries (Arditi et al., [34]).

2.5 National Innovation Systems/Public Policy

Innovation is formed by knowledge. Knowledge can be separated being tacit knowledge or codified knowledge. Tacit knowledge is gained from informal interactions while codified knowledge is formal interactions like patents, partnerships, movement of personnel etc. basically, national innovation systems have been regulated for promoting innovation and facilitating institutions interactions (OECD, 1997). Their transmitting is to affect national innovation systems.

As to definitions of national innovation systems, they can be defined to be "… the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies." (Freeman, [35]; OECD, 1997).

Seaden and Manseau [36] investigated innovation policies of nations in construction industry. They benefited 15 countries and they make a comparison between them. Study results showed that governments do not generally interfere to construction industry, although governments were owner of most proportion of project. This affects government intervention to innovations. Other findings on construction innovations were not understood completely in terms of benefits such as productivity, efficiency and innovation process. They stated that local presence in technology development and innovation activity, government prevention about long-term value and performance,

performance-based evaluation, compatibility with socio-cultural environment, sustainability.

Various actors take part of consisting of innovation. These actors can be clients, contractors, consultants and suppliers. Public sector clients can be one of the clients. Therefore Manley [37] studied about repeat public sector clients impact on innovation. Their findings show that there are impact on innovation. However their ability and capacity play an important role on impact of clients on innovation.

2.6 R&D Activities of Firms

Innovations can be gained firms' own efforts. After firms applied R&D activities, they would gain knowledge according to their knowledge capacity. If they correlate between knowledge and market, they exert to transform to successful and commercial applications. According to OECD report, this link and phase are presented in Figure 2.4.

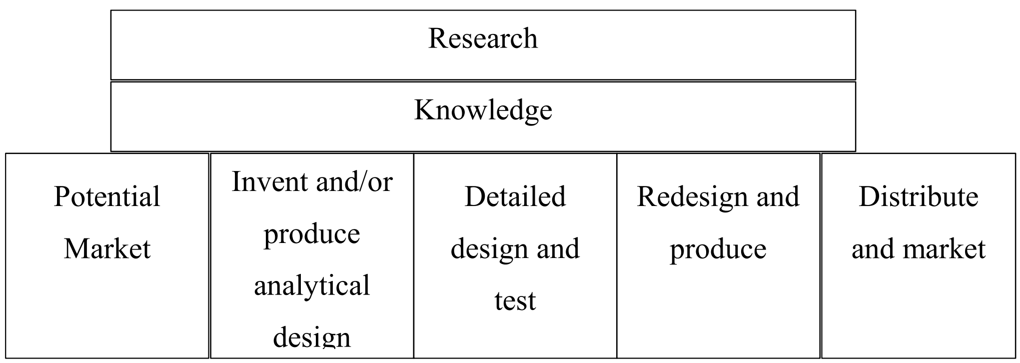


Figure 2.4 The chain-link model of innovation (Kline and Rosenberg, 1986; OECD Manual [14])

2.7 Technology Transfer Models

As is mentioned above, technology transfer can be performed various ways. In this ways, technology transfer can be generated with interactions of firms-firms, firms-research institutions, and among countries. In the literature, some of them transformed into models. In this section, now some of them will be presented. The section includes university-industry collaboration and inter-country technology transfer models.

2.7.1 University-Industry Collaboration Models

As is known technology transfer activities are realized with various mechanisms. One of these mechanisms are presented in Figure 2.5. In the literature linear transfer mechanism took place more than once. One of these studies belong to Siegel et al. [23]. Their flow chart of technology transfer process (for TTOs) are presented in Figure 2.5. Their processes start with scientific discovery. They decides for patent. In this process, if Industry present sufficient justifications, this facilitates patent.

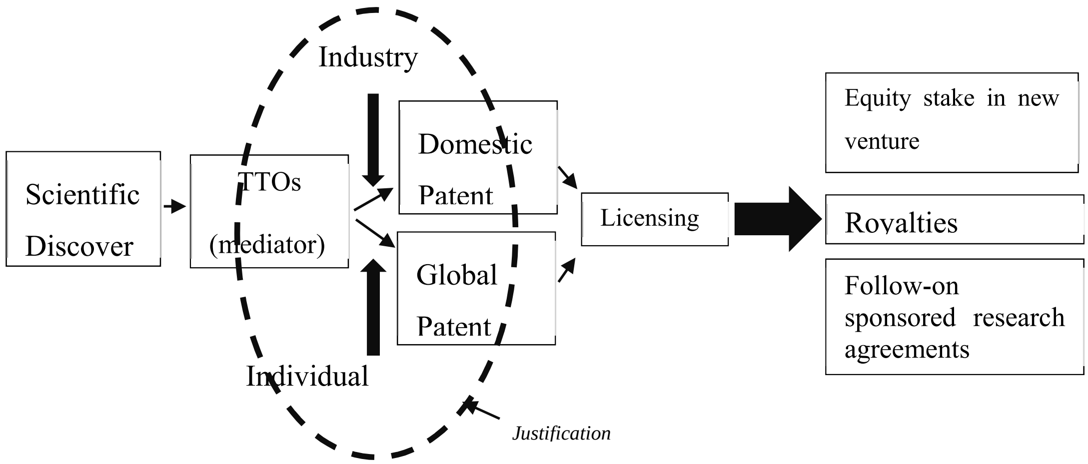


Figure 2.5 Technology transfer models with TTOs

In the literature, one of the technology transfer mechanisms are developed for research universities. Their technology transfer processes are given in Figure 2.6.

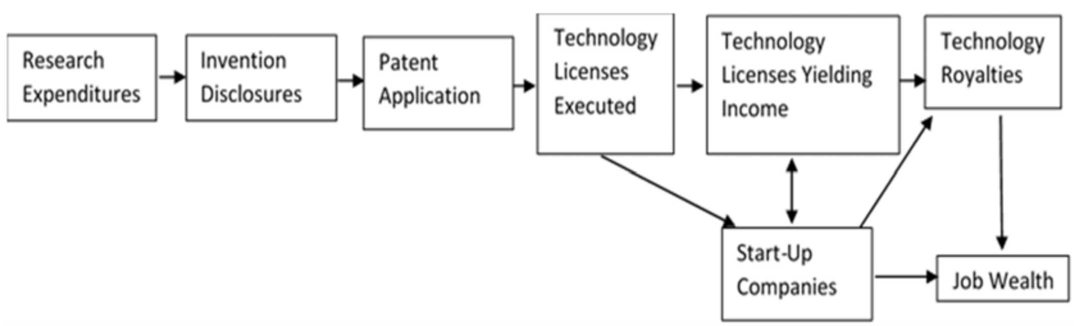


Figure 2.6. The process of technology transfer from a research university (Rogers et al. [27])

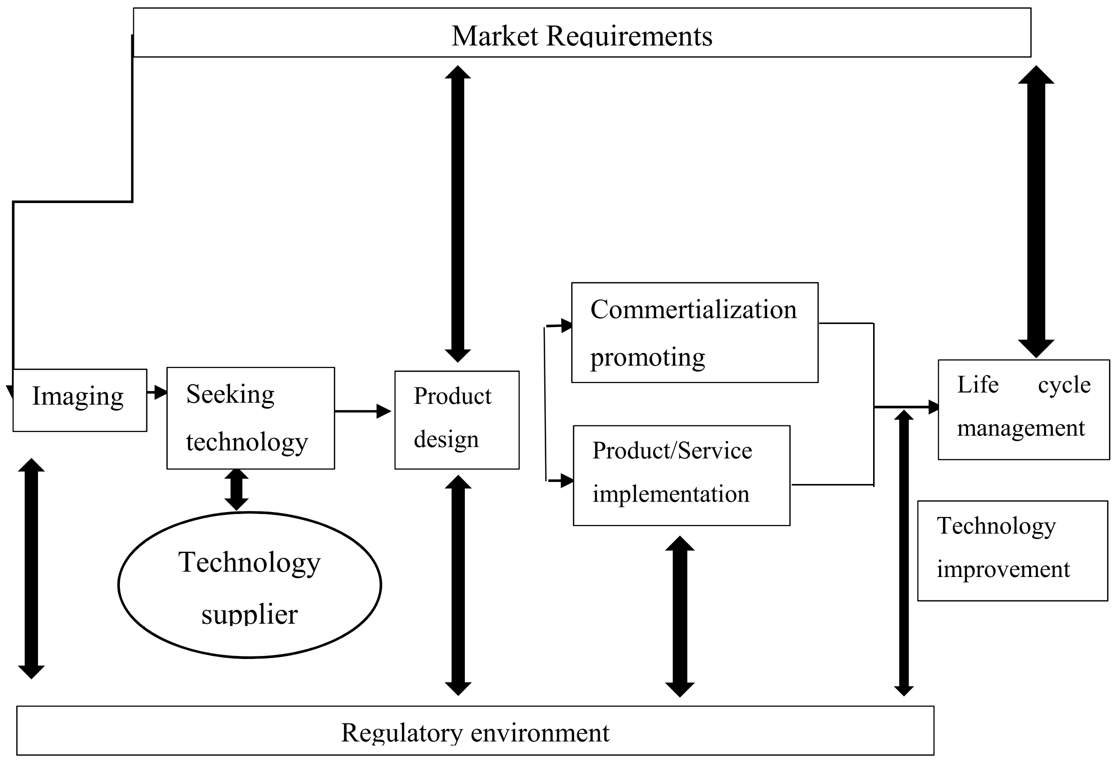


Figure 2.7 Framework of technology transfer (Teng, [11])

Another study about technology transfer in terms of firms were made by Teng [11]. Teng distinguished transfer mechanisms into six category. Content of model was explained according to their phase. “Market requirements” means addressing to clients’ demands. “Imaging phase” includes solutions and process however in this phase they consider economy and political impacts. “Seeking technology”: according to solutions, firms find available technologies. Generally, they find this at universities in which R&D activities and technology are intensive. “Product design” includes that developed product compatibilities of technology to market conditions and regulatory. “Implementation phase” is consist of finalization of product and delivered to customers. “Life cycle management” includes review of developed product.

Collaborative R&D projects provide less risk and cost for companies. This relationships enable more knowledge and technologies more than internal R&D activities. In the collaborative R&D activities, some success factors are defined by Barnes et al. [8]. They are investigated success factors. These titles are distinguished subtitles in itself. After these factors are assessed specific to six projects, findings are presented in Figure 2.8. These subfactors presented important elements for effective university-industry interactions. When they handle effectiveness of interaction, they considered in terms of both university and industry.

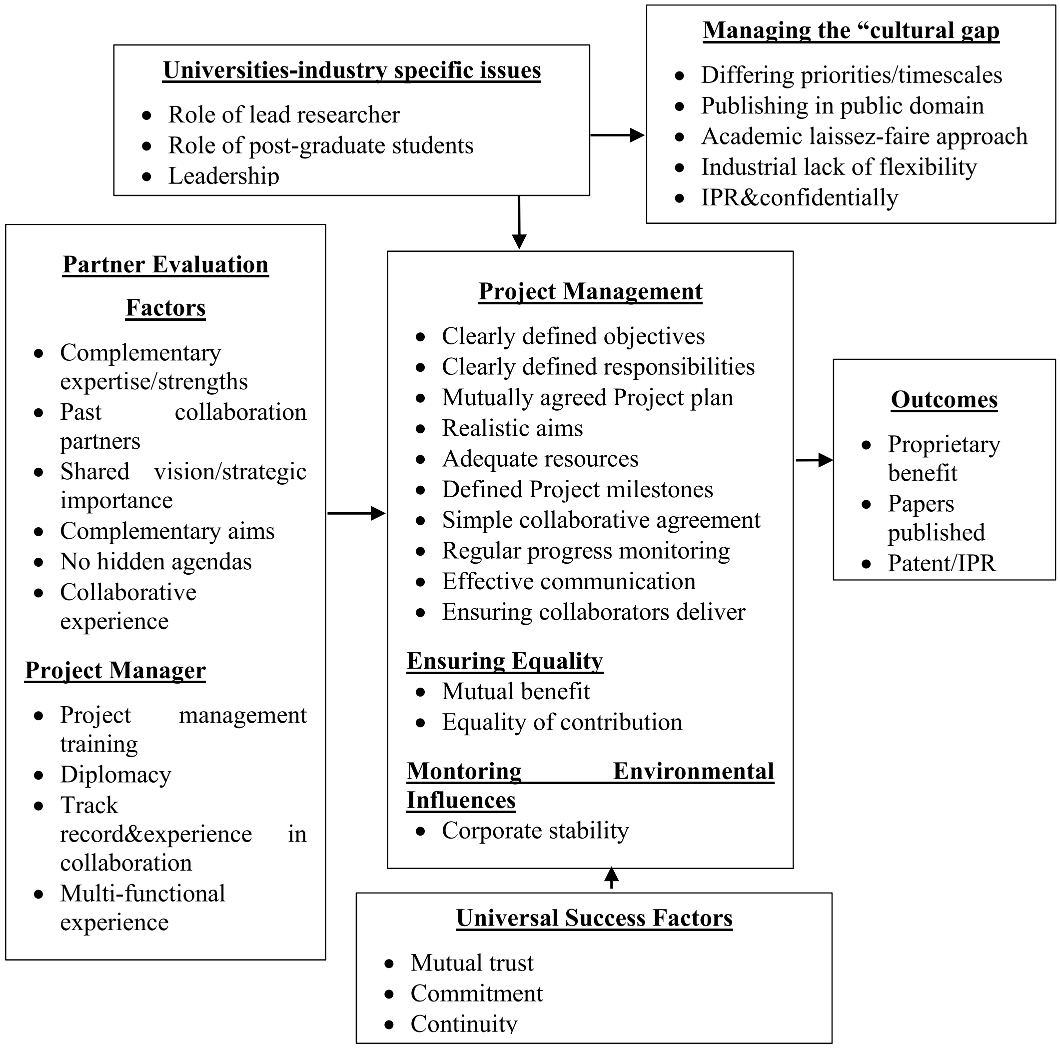


Figure 2.8 Good practice model for collaboration management (Barnes et al. [8])

Macho-Stadler, and Perez-Castrillo [31] examines technology transfer process, and contract. They considered licensing of technology and spin-offs. Licensing of technology is presented in Figure 2.9. In Figure 2.9, when development stage is finalized, (if they are successful at development product), commercialization stages begin. This stage can require extra additional funds and development for market utilization.

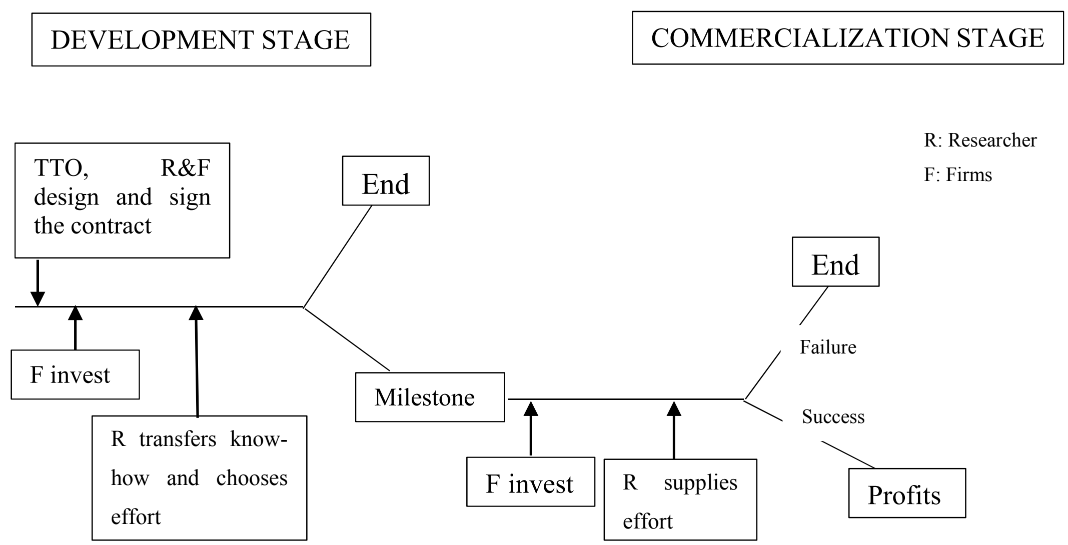


Figure 2.9 Patent licensing with development and commercialization stages (Macho-Stadler, and Perez-Castrillo [31])

Spin-off agreements are complex than licensing agreements. In spin-off contract includes distribution of cash flow rights and control rights between participants. These participants are namely researchers, financiers, and TTOs. Interest of them induces problems. Some of these problems arise from lack of knowledge. For example, researchers have only scientific value, whereas financiers have information about commercialization of products. However TTOs are balancer institutions in order to know two aspects of efforts. If there is high uncertainty at activities, they should separate to steps. When they are finished, renegotiation should begin between participants. However this may have a negative impact on activities because each renegotiation will constitute new conflict between them. These participants' efforts and participation to stages are portrayed by Macho-Stadler, and Perez-Castrillo [31] in Figure 2.10. They distinguished spin-off processes into three parts. Development stage constitutes of contract and R&D activities. If it is accomplished, second stage (commercialization stage) begin. This stage may require extra effort and funds. So new financier can participate. However this causes to redistribution of shares of participants. Exit strategies are specified by participants in this contract phase. This will help participants possible conflict in IPO or acquisition.

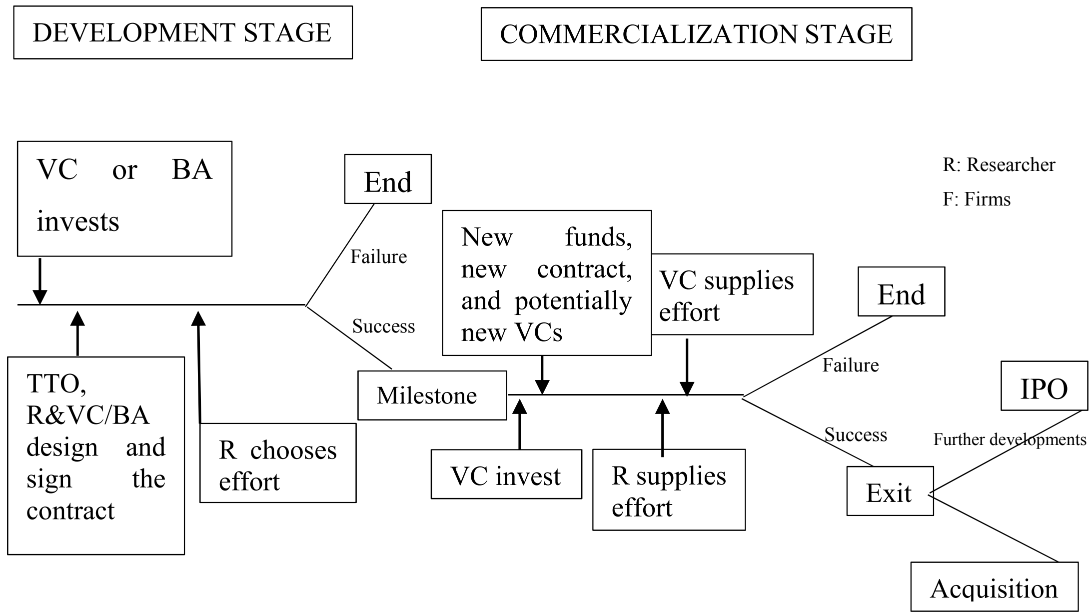


Figure 2.10 Spin-off with development, commercialization and exit stages (Macho-Stadler, and Perez-Castrillo, [31])

Morrissey and Almonacid [38] investigated technology transfer process between university and small and medium-sized enterprises (SMEs) in food industry. Food industry properties such as competition, market share are as same as construction industry. They stated that traditional models (idea, proposal, research, publication and technology transfer) have not responded today's conditions. So they developed new framework. This structure considered consumer demands (such as safety, quality, and environment), slow proceeding, inefficient transfer activity and external impact leads dynamic models. If their expected results did not realize, dynamic model enables exiting from processes. Besides it enables investigating in terms of not only research, finances, company but also implementation, banking/marketing and company.

2.7.2 Inter-country Technology Transfer

Technology transfer processes doesn't imply that it will be made domestic resources. Products and services of all countries had been opened to every countries thanks to globalization. As result of their proceeding at something creates new opportunities to them or when domestic companies don't find solutions to their problem, they search other sources. One of them is foreigner resources. In the literature, related a flow chart is presented in Figure 2.11. It symbolized necessary steps and actions for successful technology transfer.

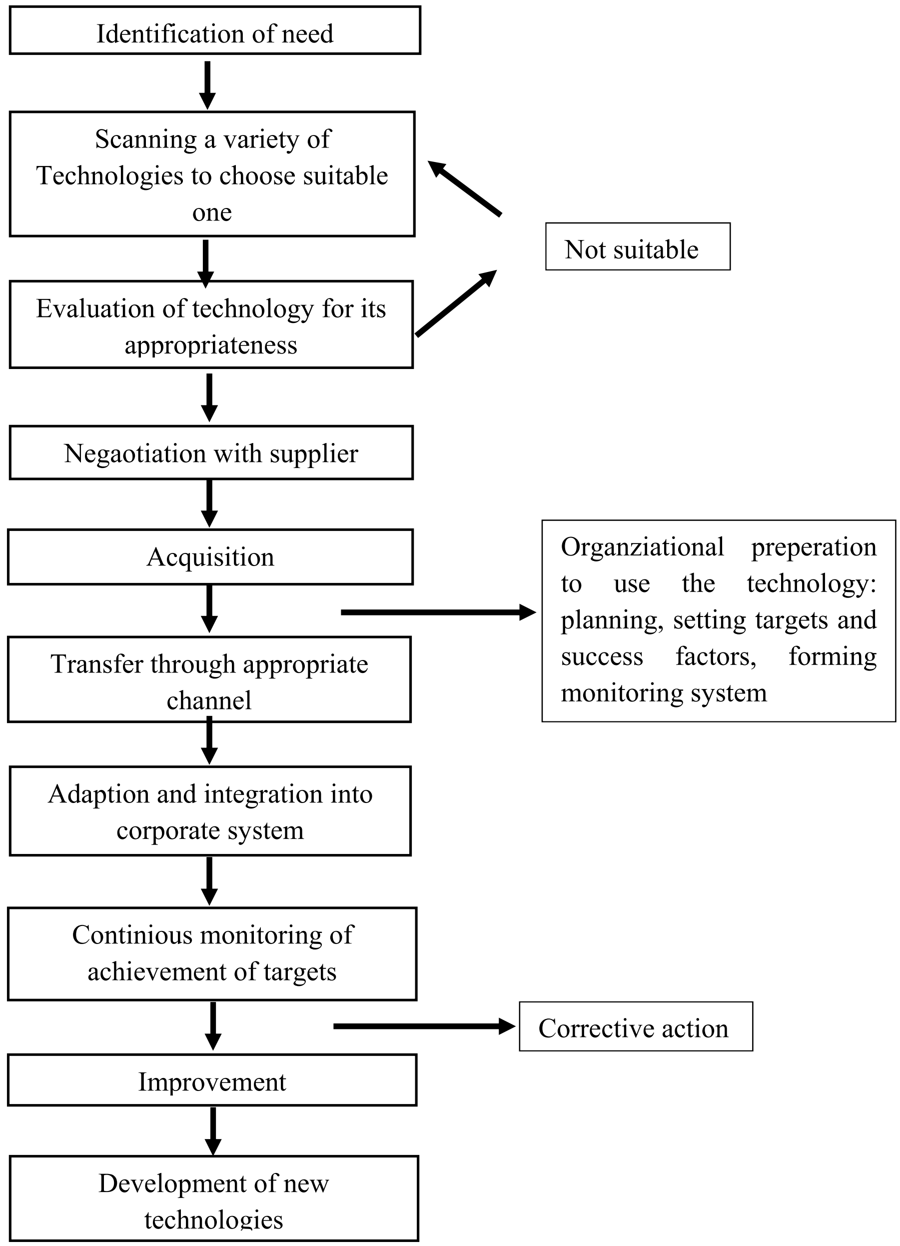


Figure 2.11 Technology Transfer Process (Offori [2])

2.8 Innovation Models

Knowledge of innovation can be everywhere. The truth is that firms have capabilities like understand of knowledge and transform to innovations. This demonstrates us importance of absorptive capacities of firms. In the literature, relationship between absorptive capabilities and innovation is clarified by Kostopoulos et al. [39]. Briefly they examined between external knowledge, innovation and financial outcomes via absorptive capacity. Their model are given in Figure 2.12. In this figure, ACAP is symbolized the concept of absorptive capacity. Results of study showed that ACAP affects innovation directly. However it affected financial outcomes indirectly. In other words, Innovation affects financial gains more than ACAP. (ROA: return on assets, ROS: return on sales)

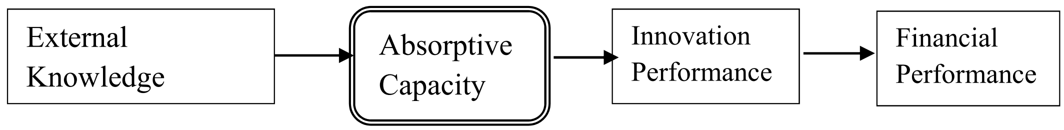


Figure 2.12 Standardized coefficients of the path analysis model (Kostopoulos et al., [39])

CHAPTER 3

TECHNOLOGY TRANSFER IN COSTRUCTION INDUSTRY

Construction industry is affected by globalization similar with many other industries. This situation stimulates developments of construction industry. However, development of construction industry have to handle totally. Dynamics of development of construction industry are given in Table 3.1. If they consider and improve totally, development of construction industry can be enabled. However it has to include regardless of private or public institutions (Ofori [1]; Ofori [40]).

Table 3.1 Development of construction industry

Metarials
Project documentation and procedures
Human Resources
Technology
Contractors
Institutions

Construction industry includes specific properties. These are briefly collaborative, project-based, communication-based, inter-organizational, and distribution of power and controlling in construction works (Harty [17]). In other words, if companies want to accomplish projects aims, company structure should be compatibility with them. Accordingly, at innovational and technology transfer activities in construction industry, these factors must be reviewed by companies.

“Construction technology embraces the materials, plant and equipment, organizations, procedures and information systems used in planning, designing, constructing, maintaining, repairing, altering and demolishing buildings and infrastructure.” (Ofori [2]).

New and old technologies' adaption have a positive impact on company and industry, ease of implementation and diffusion, leading to local resources, high productivity, efficiency and economy should be considered, when technology transfer is realized in construction industry (Ofori [2]).

As stated above, while they cause to increase innovational activities in construction activities, another findings by Ofori [2]. is given below which facilitates technology transfer activities in construction industry.

- Clients' demands-based innovations [41;2]
- Technological development in other industries [2]
- Obligation-based innovations [41;2]
- Competition –based innovations [2]
- Government regulation –based innovations [2]

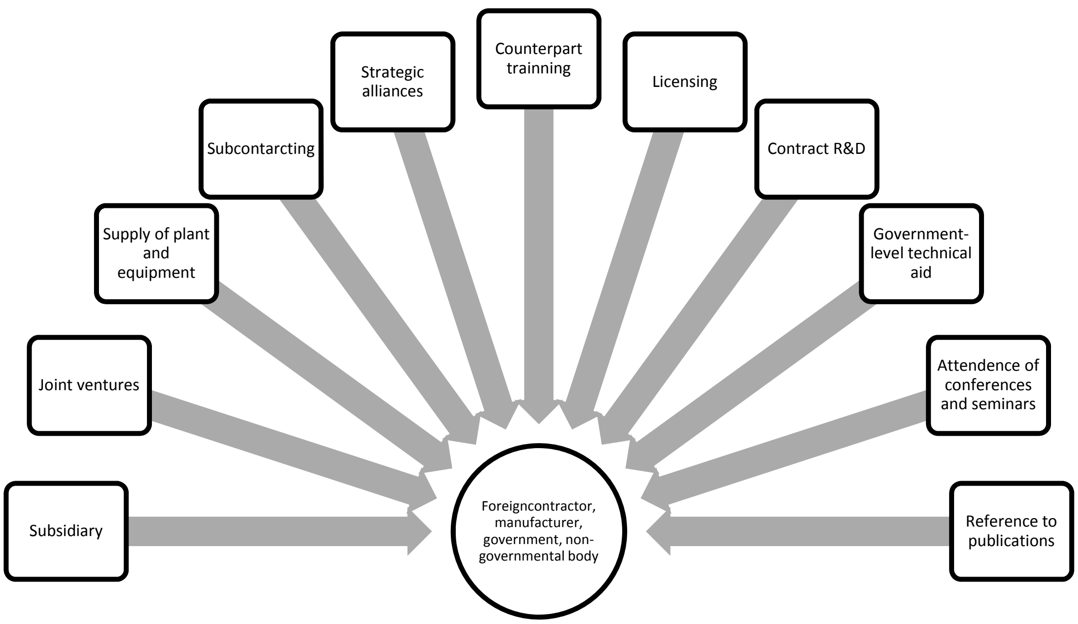


Figure 3.1 Construction technology transfer vehicle (Offori [2])

As is known, technology transfer activities come into prominence in university industry collaborations as much as foreign contractors can provide this in construction industry. However donor firms may not accept transfer of knowledge, technology, know-how etc. In contrast government takes precaution to realize technology transfer activities. Some of them is presented below and while primary three premises affect positively technology transfer activities between countries, latter premises affect negatively.

- “Mandatory subcontracting”,
- “Mandatory joint ventures”,
- “Specified training of local personnel”,
- “Imposition of floor limits on projects for which foreign firms can tender”,
- Vertical “Differential taxation of foreign and local firms”, and
- “Offering of tendering preferences to local firms” (Ofori [42];Ofori [40])

Moreover participation of private sectors and collaboration with firms which are supply chain have a positive impact on forming construction development (Ofori [40]).

3.1 Construction Innovation

Construction innovation is situation in which new technology invigorates in old process or product. However, in order to be construction innovation, it is not necessary to be old process or product. They can be new by itself. Their positive impacts are propellant. So that construction firms can attain financial, social, ease of work, efficiency and effectiveness under favor of innovation.

Innovation is a continuous process in which various actors play an important role. Therefore, these actors need to have some properties. According to Ozorhon et al. [3] study, construction innovation should be considered project-based because of structure construction industry. They considered enabler and barriers at innovation in their study. They revealed that joint effort and leadership contribute innovational activities positively. Another study is about project-based firms which are investigated by Driessen and Ende [4]. They stated that project-based firms produce unique and complex projects for their customers. This requires some differences apart from another firms’ types. These can be summarized to be less hierarchy, controlling frequency, changeable related to case and condition, and capability. In project-based firms, development project is developed separately from organization. These projects include innovation activities. In this study, they determined some success factors for realizing development project in project based firms. Their factors are; planning, senior management (project selection, support from authorization), authority responsibility (cross-functional teams, expertise, leaders, product champion, and communication), external groups (customer and supplier interactions) and phase of pre-release (commercial and technical feasibility, market research, testing, and launch) (Driessen and Ende [4]). In the literature, another study is investigated by Keegan and Turner [5]. They studied on innovation in project-based firms. Their result, which concerns with supportive structure, shows that project based firms support according to the nature of its structure in which is created unique products. This demonstrates us it is innovative. However, generally innovation and project management are thought together. Nonetheless innovation management is dominated by project management in firms. In other words project management is more important than other tasks. Therefore it affects innovation negatively. Another finding, is about useful, is that firms interest in direct results innovations like competitiveness. Last findings shows us that resource slack in innovation can change depends on using properly.

Rigby et al. [43] investigated ways of realization of innovation in construction industry. Their findings from the literature is vertical and horizontal ways. These are presented in Table 3.2. There are differences between vertical and horizontal. Horizontal innovations are realized with transfer of innovations from firm to stakeholders and construction projects. Vertical innovations include diffusion of innovative systems within particular project stakeholders or project phase.

Table 3.2 Innovation in the Construction Industry (Rigby et al. [43])

Vertical	**Horizontal**
Sharing Information,	Product,
Products, and	Information, and
Processes	Processes
across the various stakeholder groups and/or phases of a construction projects	used among particular group or project.

Successful of innovational activities can vary capability of firms. These capabilities can differ current technology, skill of labor, market, target groups, organizational structure and culture of companies. When it was investigated in terms of organizational structure and culture impact on innovation, Tatum [6] stated that organizational resources and culture intended innovation has a positive impact on construction innovation. Furthermore his study shows that organizational resources (organization structure, organization environment and employee), policies (long-term oriented working, risk taking, planning and culture), flexibility and technical resources, interactions of various groups or individuals, proactive approach, skepticism, anybody who searches suit technologies to firms and demands have a positive impact on construction innovation.

Even if firms have sufficient resources, they face some external factors. These are given below;

- Competitiveness
- Private firms openness to new technology
- Complex projects' requirements
- Technological proceedings trigger performance improvements
- Risk of foreign firms (Entrance to market) (Tatum [6])

Construction innovation models were investigated by Slaughter[10]. Five types were specified. These are namely incremental, radical, system, modular, and architectural innovations. She evaluated these innovation types depends on construction innovation. She mapped essential activities associated to innovation types. These are given in Table 3.3.

Table 3.3 Construction innovation and needs (Slaughter [10])

Types of innovation	Timing of commitment	Coordination within project team	Special resources	Supervision organizational level	Supervise type	Supervision competency
Incremental	At any time	None	None	At locus of improvement	Notification	Specific product or process
Modular	At design/ selection	None	For concept change	At design level	Notification, review	Technical competency
Architectural	At design-to-implementation stages	Among Effected parties	For complementary changes	At affected system level	Notification, agreement, review	System competency
System	At conceptual design stage	With all project team members	For integration of set of investigations	At top engineering management level	Project scope, agreement, review	Technical and system competency
Radical	At technical feasibility stage	With top management from all involved organizations	For breakthrough	At top management level	Project objectives and scope	Specialized technical competency

Strategic decisions which are given by construction firms affect innovativeness of firms. In Seaden et al.' [13] studies, these relationships are inquired considering firm sizes (small, medium and large). They visualized their findings in Figure 3.2. In this Figure, Business environment imply that such as rapid technological change, competitive threats, consumer/competitors predictability, suppliers, and material obsolescence affect innovativeness of firm. Marketing strategy like market share expansion, client retention, expanded product range, geographic expansion, and awareness of clients operating costs are correlated with innovative practices. One of the study results show that firm size is small or medium if they apply to innovation, they gain competitive advantages.

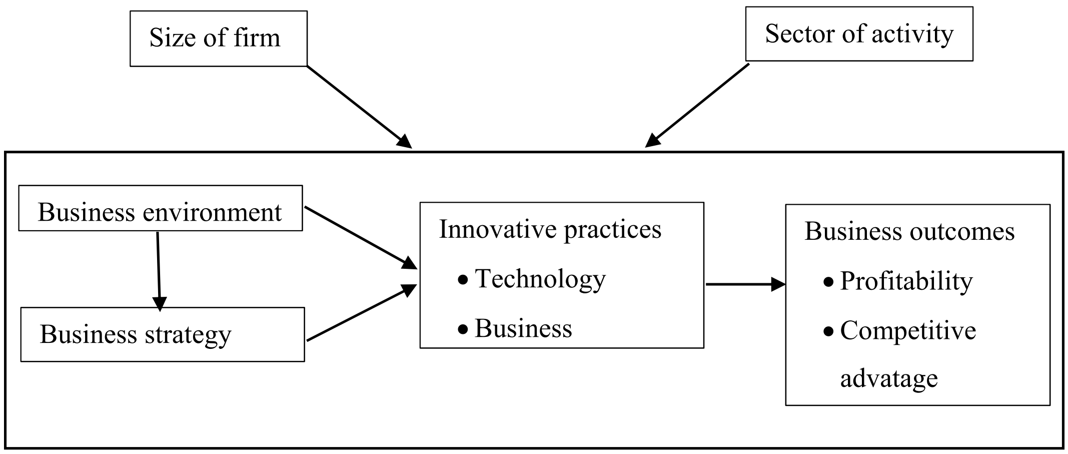


Figure 3.2 Size of firms and innovative practice (Seaden et al. [13])

Another study about strategies and innovation outcomes belongs to Manley et al. [44]. They considered five types strategies and they wanted to see their impact on the innovation outcomes. Their strategies are presented in Table 3.4. These strategies were surveyed both high innovator and low innovator. So that they specified important strategies in construction industry.

Table 3.4 Strategy types (Manley et al. [44])

Strategies	**Sub-strategies**
Employee strategies	Recruiting experienced employees
	Using multiskilled teams
	Recruiting new graduates
	Participating in apprenticeship programs
	Actively encouraging your employees to seek out improvements and share ideas
	Providing or supporting training programs for your employees

Table 3.4 Strategy types (Manley et al. [44]) (Cont'd)

Strategies	**Sub-strategies**
Technology strategies	Enhancing your business's technical capabilities
	Investing in research and development (R&D)
	Protecting your business's intellectual property
	Participating in the development of industry standards and practices
Marketing strategies	Building relationships with existing clients
	Delivering products/services which reduce your clients' costs
	Attracting new clients
	Providing a broader range of services to your clients
	Increasing your market share
Knowledge strategies	Actively monitoring international best practice
	Maintaining a formal system for transferring project learnings into our continuous business processes
	Measuring how well our changes have worked
	Actively monitoring advances in related industries that might be applicable to our business
Relationship strategies	Rewarding staff for maintaining networking linkages with strategically useful industry participants
	Pursuing partnering on projects
	Pursuing alliance projects
	Maintaining long-term collaborative arrangements with other businesses

Construction projects are performed in complex environment. In this environment, project participants play an important role occurring of projects. Starting from this point, when construction innovation perform, their interactions come into prominence. Their efforts and behaviors to innovation form construction innovation. Participants of construction projects are given Figure 3.3 (Blayse and Manley [45]).

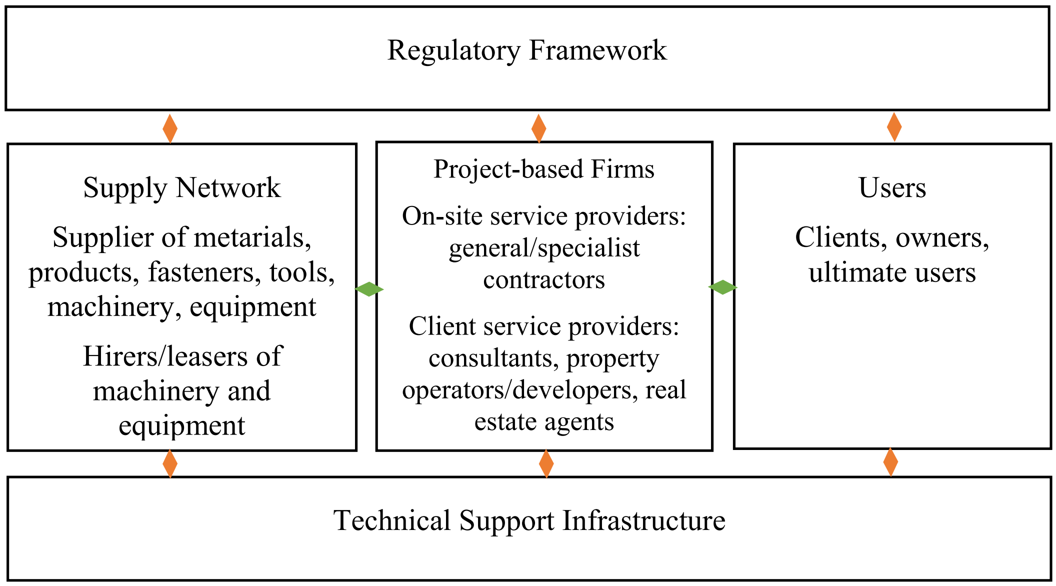


Figure 3.3 Participants in the building and construction project systems (Gann and Salter [46]; Blayse and Manley [45])

Blayse and Manley [45] are studied on influential factors for construction industry. These are given below:

- Users of product of construction constitutes exert pressures for construction innovation. This pressures originate from requirements about quality, services, and new products. According to the requirements from users, construction companies are obliged to new methods, services and products. So their requirements cause to pave the way for construction innovation,
- One of the dynamics of construction innovation is manufacturing firms in order that their R&D activities single-handed.
- Construction firms that depend upon the project complexity face many problems in construction area. Solutions of their problems can be hidden in their relationships. For example, adaptation of a production to site condition or project enables with supplier of its. Furthermore, their relationship with research institutions can be beneficial in terms of solving problems. This instance can often be seen university-industry interactions,

- Contract types are almost as important as other factors because constraints such as time and cost impede construction innovation,
- Well-establish regulations/standards constitutes exert pressures on every industry. However legislator have extensive knowledge about market dynamics. The same conditions is valid for construction industry. If legislator promotes construction innovation by regulations/standards, construction industry can realize innovation. In construction industry like performance based approaches and technical requirements have a positive impact on construction industry,
- Organizational resources such as culture of innovation, absorptive capacity, innovation champions, knowledge codification, and strategies on innovation are important to emerging new advances in construction industry.

Some troubles promote innovation in construction industry. For instance, they can be demand, competitive advantage, productivity and risk of international firms etc. In order to handle with these troubles, managerial actions are one of the important factors. In other words their technological strategies enable opportunities for overcoming innovation in construction firms. Their decisions like “maintaining a strategic vision of technology”, “taking a broad view of risk”, “providing technological challenges and leadership”, “fostering unbridled planning”, “prompting internal and external integration”, and “formulating and implementing technology strategies” are factors which form innovative activities in design and construction companies (Tatum [47]).

Construction innovation can confront us various way. Some of them is stated with sub subjects. These are cited from study of Gambatese and Hallowell [48]. They investigated innovation generating organization in construction industry. They targeted finding organizational characteristics, management strategies, market forces, and resource investment from successful innovation generating organizations. So they distinguished technical innovations into five categories in construction industry. They presents in Table 3.5.

Table 3.5 Types of Innovations (Gambatese and Hallowell [48])

Types of Technical Innovations	Definitions
Information Technologies	Information technologies are considered innovations by itself. Benefits, which are ranged above, trigger construction industry to make or use more these technologies. Such technologies are considered to be project information management system and lessons learned systems.
Computer based electronic devices	Computer-based electronic devices are investigated into three subcategories. These are namely estimating and biding software, project control system, and leak noise correlator.
End products (Design and construction)	End products consist of material products, mechanical products, and electrical products.
Construction means and methods	Construction means and methods are distinguished to three subcategories. These are namely concrete formwork/placement, task management, and welding.
Construction equipment	These are distinguished heavy/civil equipment components, and concrete materials washout.

3.2 National Systems of Innovation (NSI)

When construction industry compare with other industry, they are not intended level in terms of innovation. This situation causes to take precautions by government-level. These precautions aims whole industry and stimulate innovation industry-wide.

"NSI as the network of actors in the public and private sectors whose activities and interactions initiate, modify, and diffuse innovations and organizational forms." (Freeman [35]; Na et al. [49]. NSI considers entire relations. This relations contain technology receiver and donor institutions and individuals. Furthermore, in this relations things which cause to invent new technology consider by NSI.

“Network, rivals, transfer and absorption, knowledge and skills, construction clients, local contractors, foreign contractors, suppliers, research institutions, and government” are important parts of NSI (Na et al. [49]).

Na et al. [49] investigated National System of Innovation in construction industry specific to local contractors, suppliers, national research institutions, government, and foreign contractors. These actors analyzed mutual relations. As a result of analysis, below results are attained:

- When NSI is evaluated in terms of contractors, they fear from failing of innovation because this may induce sinking of companies,
- Customer demands regarding quality and productivity promotes innovations,
- High profit margins facilitate collaborations between firms and suppliers, and as for social pressures, it cause to negative impact on the collaborations,
- Innovation sometimes aren’t realized with internal capabilities. When companies confront of these problems, they apply research institutions to gain essential information. Moreover they yield skilled worker at the end of processes. As a result, collaboration with national research institutions are important for innovation,
- Foreign contractors are one of the important technology transfer resources. While presence of foreign contractor have positive impact on host countries’ construction industry, R&D activities of local firms affect negatively. Collaboration between local and foreign firms can be beneficial in terms of technology transfer. However react of local contractor’s R&D activities cause to decrease in number of FDI and it will be more efficient in terms of host country,
- In regulations, incentives to local firms, providing technology transfer from FDI to local firms, and social pressures must be used forming innovation in construction industry,

3.3 Advantages and Disadvantages

Tatum [50] investigated whether innovations can be applied to construction industry or not. His study is stated some advantages and disadvantages in this direction. These are summarized in below table from him study. Furthermore, he offered some suggestions; project demands, individual initiative, construction input to design, and transfer from other industries are possible mechanisms in order to improve construction industry. In addition to these, he proposes 3 steps plan to increase awareness of construction innovation. First step includes classification of technological advancements. In second step, these innovations are assessed. Final step is to develop strategies around technological advancements in construction industry. He stated that this plan contributes technological advancements in construction industry.

Table 3.6 Construction industry compatibility with innovation (Tatum [50])

Advantages	**Disadvantages**
“Project organization”	“Investment reluctance”
“Necessity and challenge”	“Competitive conditions”
“Engineering and construction integration”	“Institutional framework”
“Low capital investment”	“Seasonal and economic cyclicity”
“Capability and experience of key personnel”	“The role of suppliers”
“Process emphasis”	“Structure of production” (Blayse and Manley [46])
“Variation methods”	

Construction innovations can be hidden in modern methods. Modern methods of construction is gained assembling various innovative approaches (Pan et al. [51]; Rahman [52]). These methods facilitates construction phase. This acceleration is enabled with offsite manufacturing and assemblage in construction area. Rahman [52] researched barriers of modern methods in construction industry. When he investigated barriers, he distinguished barriers into nine categories. These categories are related to investment-capital, untutored labor, miss-knowledge background about modern method products, absence of evaluation of product (like standards etc.), market dynamics, deficiency of construction industry, inflexibility to project changes during the project implementation, truck jobbers of modern methods companies, and countries conditions. According to study results, cost-related problems and inflexibility to change play an important role forming modern methods activities in construction industry. In addition to these, these results differ related to country, responder groups and firm-sized.

3.4 Construction Innovation Models

A core of a knowledge based economy requires economic growth, competition between rivals, and quality of life. Knowledge creation and transfer are possible with innovations and technology transfers. These factors compels leading industries. Construction industry being one of the leading industry has got own structure and external factors. These factors have taken place many studies. One of them, which belongs to Xiaolong et al. [53], investigated construction innovation. However they firstly emerged industry structure like project-based, service enhanced, and fragmented structure. In the light of these, they prepared construction innovation models (Figure 3.4).

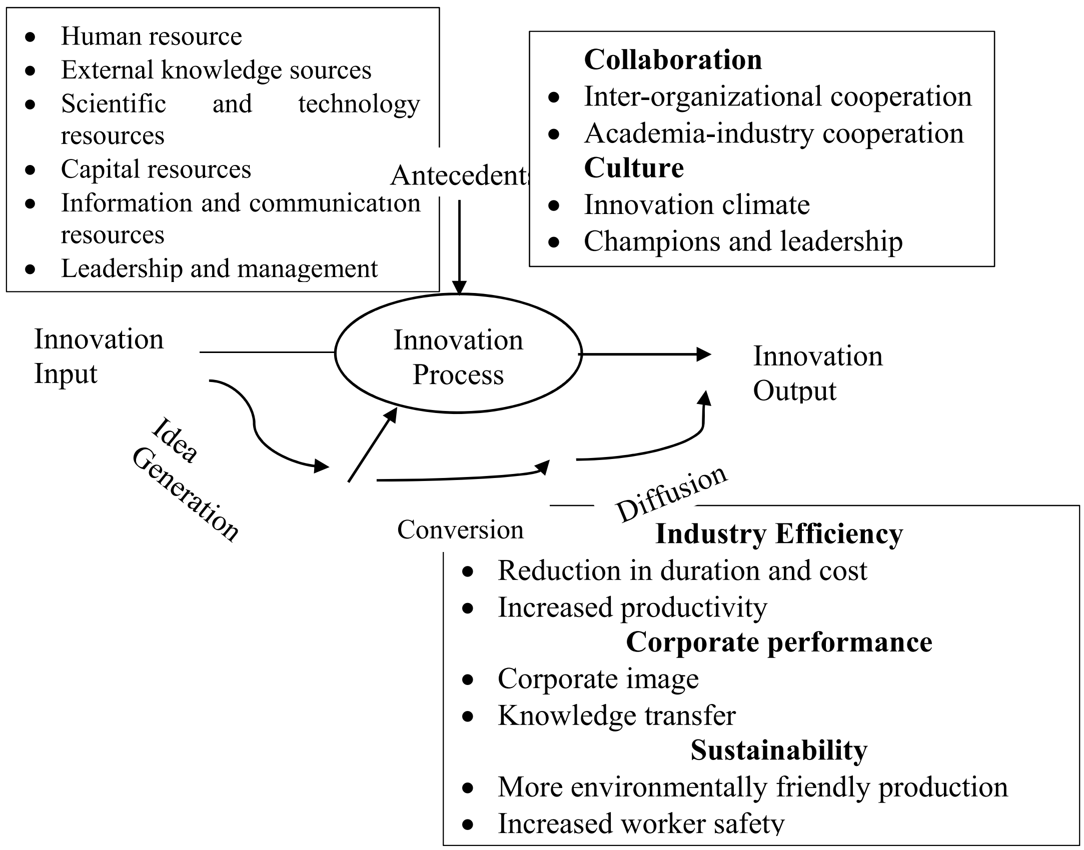


Figure 3.4 Conceptual framework of construction innovation (Xiaolong et al. [53])

Innovation in construction industry can be realized various forms. One of them is given Figure 3.5. In this figure drivers are defined to be regulations, demand, and competition. Inputs are defined to be labor knowledge on innovation and absorptive capacity of innovation. Innovations are divided to be MMC and lean production. Barriers are defined to be inexperience labor and materials. Enablers are summarized to be contractors, clients, suppliers, and policy. Outputs are defined to be less cost, waste, time and flexible design (Ozorhon et al. [3]).

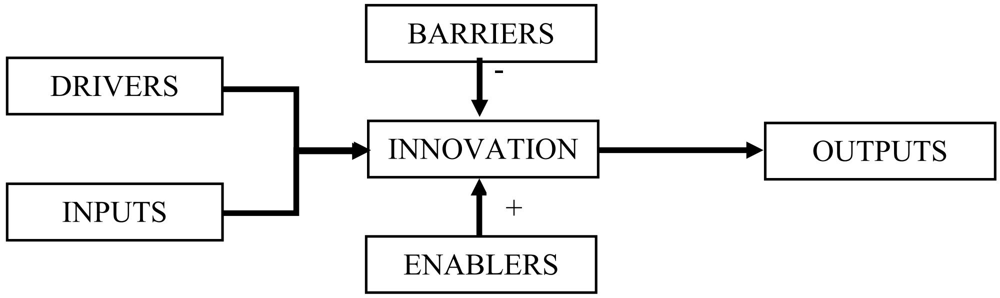


Figure 3.5 The innovation process (Ozorhon et al. [3])

As a result of their study, they proposed constituted construction innovation phase as below Figure 3.6.

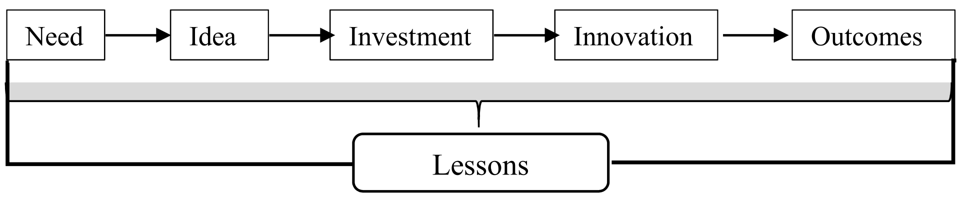


Figure 3.6 Phase of innovation (Ozorhon et al. [3])

Because innovation has complex and dynamic structure, they consider project-based in construction industry. Furthermore construction industry has various actors. Ozorhon [54] propose framework about construction innovation at project level. Her study considered innovation processes into seven categories. These categories are namely; drivers, inputs, enablers, barriers, innovative activities, benefits, and impacts. She also shared their propelling forces. Drivers are policy, clients, and sustainability. Inputs are collaborative activities. Barriers are investment, commitment, change in organization and process, and repeatability. Benefits are experience, cost savings, time, quality, health and safety, and minimizing of waste. Impacts are image, knowledge transfer, and sustainability. She considered types of innovation in her study to be MMC, lean construction, energy efficiency, and community engagement.

Pellicer et al. [55] investigated systematic innovation in construction companies. They consisted of model by deducing innovation management. Their proposed model is more comprehensive in order to consider innovation at all points. Their models are presented in Figure 3.7. They considered four indicators and one outputs. Their models stated that "drivers of innovation" affects "innovation systems". However "innovation system" has mutual relations with "business environment" and "organizational capabilities". As a result of innovation system, outputs of innovation presented in terms of both companies and projects. Their findings could be arrayed like;

- Obstacles of projects and demand are the main incentive,
- Construction industry may start with satisfy needs (such as internal process, and projects) to innovations, and
- Necessity of Quality Management.

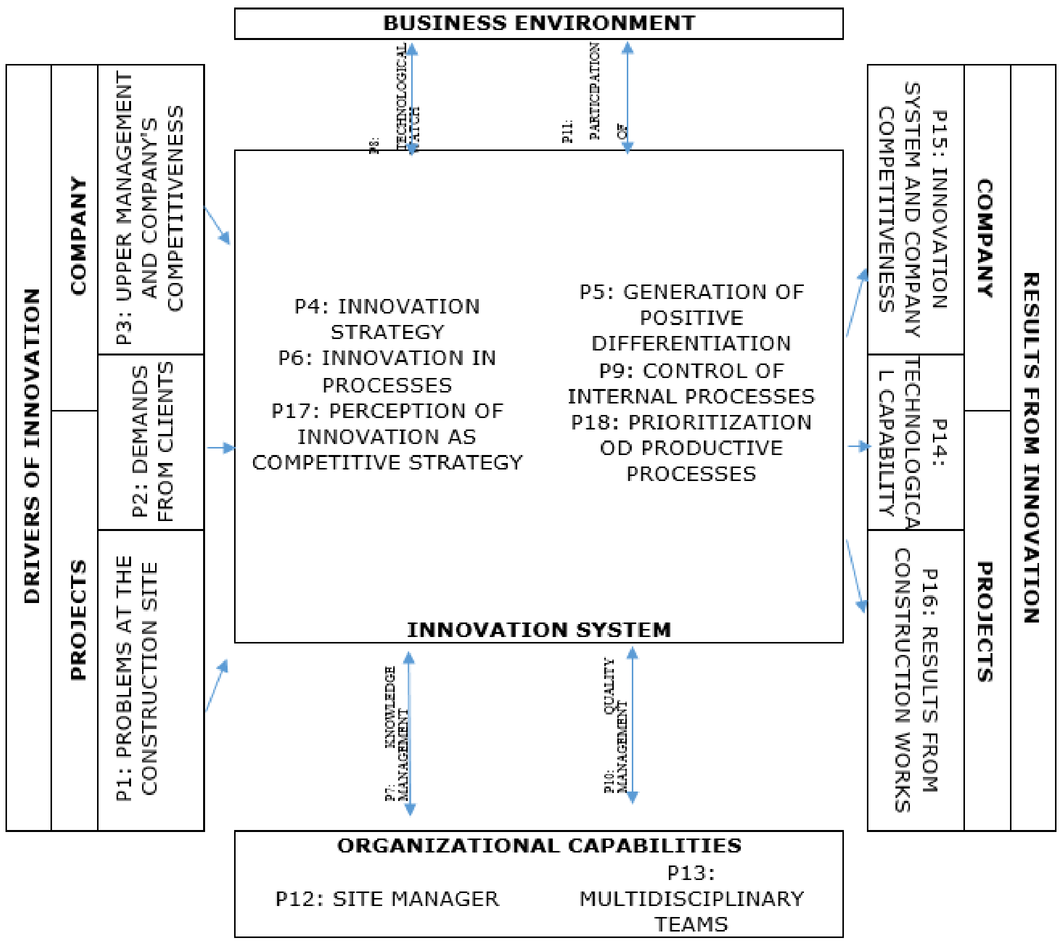


Figure 3.7 Innovatıon management model stating the level of validation of the proposition (Pellicer et al. [55])

In the literature study of Gambatese and Hallowell [49] conducted comprehensive study about innovation in construction industry. First of all they handled existing knowledge about innovation in construction industry. They confirmed enablers of innovation to be "support from upper management, good communication within the firm, and the overlap of design and construction phases". Whereas barriers of innovation in construction industry were specified to be "aversion to risk/change, lack of resources, low return on investment, and strict regulations and codes”. They offered some recommendations for overcoming barriers like organizational climate and organizational structures. In addition to these owner/client commitment is the most powerful enabler of innovation in construction industry. Furthermore knowledge capacity of companies, delivery and contract types are important factors in terms of innovation in construction industry. And they added construction innovation processes their study. It presented in Figure 3.8.

Figure 3.8 Necessary component for construction innovation

Gann and Salter [47] investigated relationship between project-based, service-enhanced firms and innovation in complex construction products. They offered model in which gained knowledge from project is tried to integrate in company. Model is presented in Figure 3.9.

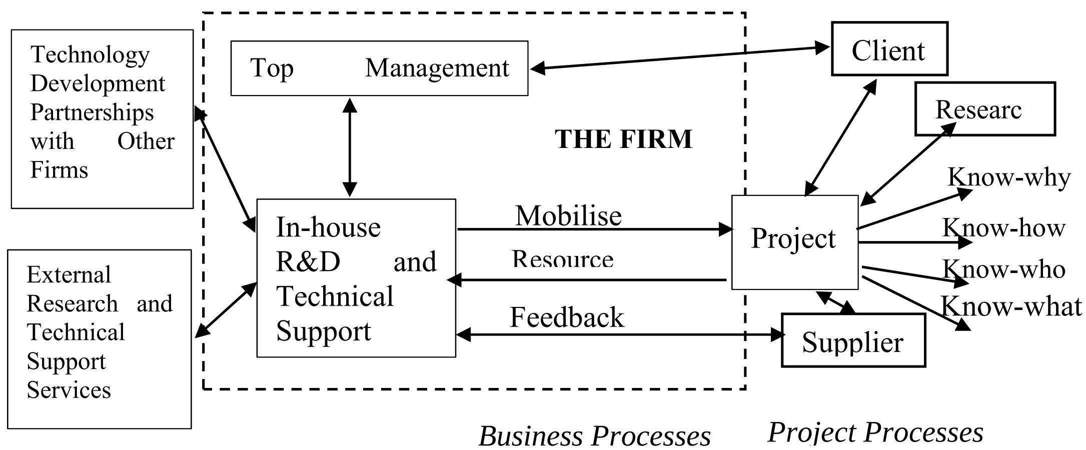


Figure 3.9 The project-based firm and technical resource flows (Gann and Salter [47])

3.5 Project Management Knowledge Areas

Project Management Knowledge Areas include necessary processes in order to realize project efficiently, and productively. According to project-based structure of construction industry, project management knowledge areas are important in terms of construction companies. Normally, project management knowledge areas include general approaches to projects. They can adapt according to industries. Knowledge management knowledge areas comprise of ten different areas. Such areas are namely “Project Integration Management”, “Project Scope Management”, “Project Cost Management”, “Project

Time Management", "Project Quality Management", "Project Human Resources Management", "Project Communication Management", "Project Risk Management", and "Project Stakeholder Management".

Project Integration Management: necessary resources for project are allocated in project Integration management. It provides coordination between project' aims and alternatives. As is known, project management authorities are to apply knowledge, skills and time according to conditions of the projects (PMBOK [56]). In project integration management, project authorities assess all process of project. As a result of assessment, they decide to level of implementation. In this process, all alternatives are taken into consideration. If technology transfer and innovation are thought, they can be beneficial in terms of time and cost efficiency.

Project integration management includes tools and technics associated with project. In this process, technical and managerial details must be consisted in order to ensure intended conditions. When innovation and technology transfer advantages take into account within the scope of integration management, they can be beneficial to ensure in terms of project quality, productivity, cost and time efficiency.

Project integration management is planning phase. Therefore existing technics and methods might not be met project needs. These requirement could induce innovations and using of technology transfer mechanism. However they are not beneficial themselves. Therefore it requires overall management activities. Tatum [57] suggested to firms that are met their requirements create new ideas. Such ideas impede problems, reach a consensus, gain commitment, preplanning and provide openness to innovations.

Project Scope Management: It is phase in which necessary project activities are specified. Also such activities are controlled whether it is appropriate to project needs or not (PMBOK [57]). This requires scrutiny about project stakeholder request. In project scope management, there are various tools and technics. They are used to reveal project needs and aims. One of them is group creativity technique in which new ideas are generated. These can be sources of innovation or it can be opportunity for using of technology transfer mechanism. Moreover this knowledge area includes how project will be conducted. When technology transfer mechanisms and innovations are taken into account, project constraints like time and cost efficiency can be provided with it.

Project aims must involve strategic aims of companies. Majority of project has lack of well planned structure and clearness in terms of it. Therefore project scope management comes into prominence. Innovations that are learning and discover efforts of firms require inflexible organization structure (Kenny [58]). This can be structured in this phase.

Project Time Management: In this process each project activity relationships are identified. Besides it includes planning of worker, equipment and tools in order to realize specified activities. In parallel to their time planning is conducted (PMBOK [56]). If this phase enriches with innovations, work packages can be realized with less worker, time and cost. In addition to these innovations and transferred technologies or methods can be beneficial on productivity and depreciation.

Project Cost Management: Technology transfer with international companies take long time and it consists costly decision in terms of companies. This leads to ban technological advanced. However if technology transfer mechanism accomplish with high success construction companies earn abilities such as handling bigger project and making well established organization (Carrillo [59]). Although technology transfer can be long process they have a positive impact in the long term. In this context if technology transfer and innovations are considered, not only it provides positive impact on project budget, but also it increases companies' competitiveness. In other words like these efforts it can provide cost leadership in their markets.

Project Quality Management: Innovations are made for maximum outputs from available or less inputs or in order to gain more qualitative products. Quality is adjusted to clients' needs because concept of quality change their perceptions. So this management includes meeting their demands and according to it, works are controlled. If there is a deficiency of quality, it can be overcame with well applied project. They can provide solutions. Like these transfer activities affect project positively. So these shouldn't be dissociated from project quality management.

Project Human Resources Management: It includes organization of project teams, their guidance and management (PMBOK [56]). In this management, number of optimum personnel is sought. According to findings, work packages are arranged. Besides personnel performance is tried to increase. When innovations take into account, they can provide time efficiency by making faster. Because this knowledge area includes organizational structure and processes, successful organizational implications can be transferred.

Project Communication Management: It includes project' information. They are created, collected, disseminated, recorded and when they are necessary, it includes achieving processes (PMBOK [56]). In this area, software are used to be innovational solutions in construction industry.

Project Risk Management: When risk management is made in a project, project risk identification, analysis, responses, monitoring and controlling activities are determined (PMBOK [56]). Events that have a positive impact on project are increased. However negative impacts are tried to eliminate. For instance, worker health and safety is one of the important area in this management. Innovations can provide improving in this area.

Project Procurement Management: It includes processes in which necessary materials, services, and products are procured from out of project (PMBOK [56]). In this process if contract types are chosen carefully, innovations can be attained.

Project Stakeholder Management: As is known, projects includes various stakeholders. So their commitments on projects are tough. Their expectation must be provided. Therefore it requires systematic management activities. This management includes both processes and products. Possible innovational and transferring of existing innovation can be solution for stakeholders' commitments.

3.6 Construction Technologies Contributor

Construction industry a lot of stakeholder and subunit inculde in itself. In this title, their relationship with innovation will be explained depending on literature.

3.6.1 Construction Manufacturers

Construction manufacturers are one of the main actors in construction projects. They take place supplying required services. Furthermore, in the literature stated that manufacturers spend much time and efforts in order to make innovation in construction industry (Manley [60]). Manley [60] assessed manufacturers' innovational efforts in construction industry. She evaluated 12 different projects in order to specify manufacturers' impact on innovation. Therefore, they used below framework. Subtitles of the framework used to analyze project-based innovation which is handled by manufacturers. These subtitles are “relationships and knowledge-flows” (in which performance and innovational activities form them), “advanced procurement systems” (creates shift on existing procurement system. It provides choosing best value for money than lowest cost.), “robust internal firm competencies” (Companies have to have assessment capability), “performance-based regulations” (performance-based regulations promote innovation), “effective technical support providers” (firms attain essential knowledge and technology from universities or research institutions) and “project-imbedded manufacturer”. She also stated that their products’ implementation on site, intended product produce, integration for compatibility with other components, bespoke solutions and quality promote innovational activities by manufacturers.

3.6.2 Construction Subcontractors

Subcontractors perform expected project or plan. This leads to low profit and low cost based tender selection. If they emerge their tacit knowledge, they will differentiate from rivals (Manley [60]). Innovational activities which are handled by subcontractors provides not only competitive advantages but also sustainability of companies.

Procurement procedures come into prominence to specify construction subcontractors. However according to traditional evaluation of subcontractor, they are assessed with “iron-triangle” (cost, time, quality”. However such evaluations does not include assets completely. As is known, one of the important asset is intangible assets. This cause to differentiation of companies at prevalence market. Like this assets are considered by Erikson and Westerberg [61]. They added environmental impact, work environment, and innovation to iron triangle. As a result of study, they proved impact of procurement procedures on project performances. However they considered trust and commitment impacts to be subsidiary factor.

3.6.3 Construction Materials

Construction industry gains products by forming construction materials. Therefore advances in construction materials industry affects construction industry. Todays, awareness about demands, environmental protection, and limit of resources have taken place.

Subcontractors and contractors can be labeled product assemblers. This requires high interactions, and relationships between assemblers and suppliers. Basically, companies collaborate a lot of individuals and institutions to produce their product or services. These mutual relationships should be long term so that suppliers can respond assemblers' requirements easily. For example suppliers provide solutions like technological innovations. However if companies would like to gain from external supply chain, it can be costly and risky (Bygballe and Ingemansson [62]).

Nanomaterials products' application in construction materials can be given to be instance. Nanomaterials provide less cost, durability, flexibility etc. to construction industry. In the literature Arora et al. [63]conducted a study about nanomaterials adaption into construction industry. They conducted their research with patent records and interview. They found seven critical factors which affects adoption of nanomaterials to construction industry and these factors are quested according to various occupational groups. As a result of study, they found out relationships between factors and adoption. This is given below Figure 3.10.

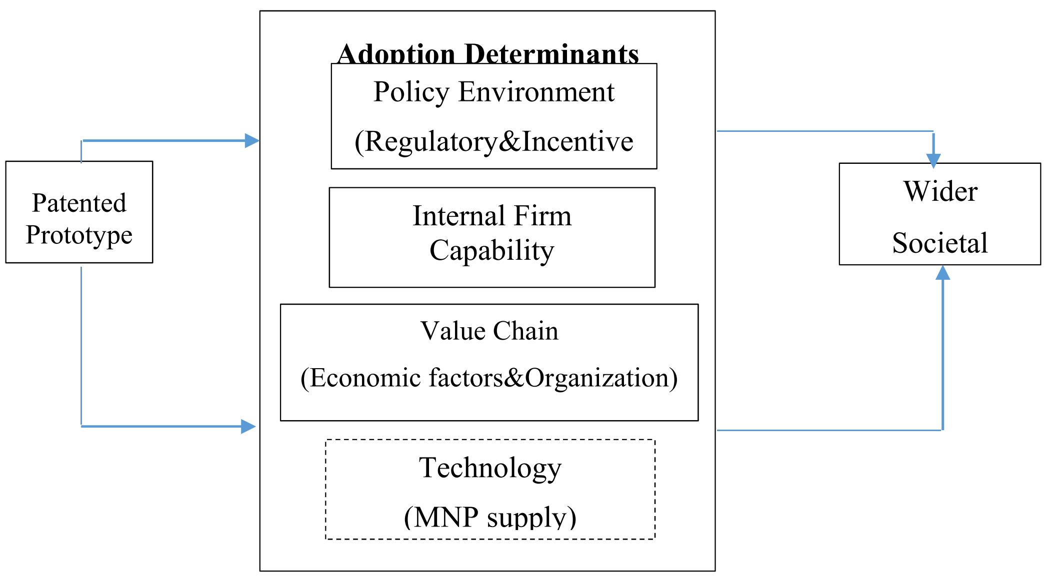


Figure 3.10 Adoption determinants in the construction industry at a key transitional phase in the sequential innovation process (Arora et al. [63])

3.6.4 Machinery and Equipment

Arditi et al. [34] conducted research about construction equipment industry and innovational progress for 30 years. They specified that technological advances from other industries cause to progress in construction industry. Therefore when they investigated, they distinguished these industries into four categories. These are namely, "Supplier-Dominated Firms", "Production-Intensive-Firms", "Science-based Firms" and

“Specialized Equipment Suppliers”. Another findings about their study customer demands in construction equipment industry forms emerging new technology. These advances affected construction industry of productivity, worker safety, quality, cost and market conditions.

3.7 Knowledge Management in Construction Industry

Knowledge can be distinguished into subcategories according to its meaning. These subcategories and their meanings are presented in Figure 3.11.

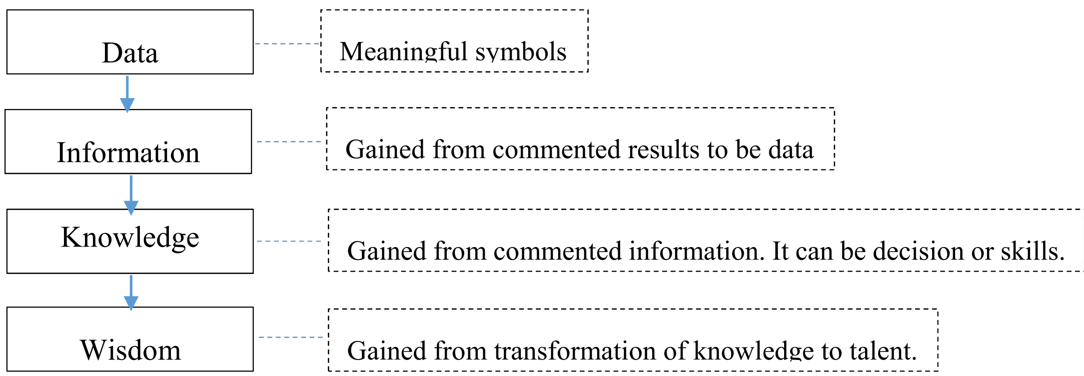


Figure 3.11 Transformation of data to wisdom (Odabaş [64])

As is stated above, knowledge ends in decisions or talents. If this is commented companies’ perspectives, they provides competitive advantages to companies.

Knowledge is a source in terms of companies. However knowledge gains value if it is managed well-establish structure in organizations. So Knowledge Management (KM) is used in order that problems remove in organizations. However KM is not as easy as it seems. Because knowledge resource is often not in writing. This requires transforming from tacit knowledge to codified knowledge. Phases of KM is presented in Table 3.7.

Table 3.7 Process of Knowledge Management (Avci and Avci [65])

Knowledge Acquisition	Knowledge Processing	Knowledge Recording
1. Knowledge acquisition from external resources 2. Knowledge acquisition from internal resources	1. Knowledge interpretation 2. Testing 3. Knowledge dissemination	1. Assessment of knowledge 2. Organizational memory 3. Assessment of process of knowledge

Knowledge acquisition is to include external knowledge resources and internal resources. External resources are gained from companies’ environment. Whereas internal resources are gained from core of companies. Knowledge processing is process of adaptation of knowledge into companies. First step, companies process acquired knowledge. In second step, processed knowledge is tested by company. In final step, acquired and processed knowledge is disseminated company-wide. Knowledge recording is closing step. Therefore gained and progressed knowledge must be recorded to be lasting information in organizations.

Darroch [66] investigated knowledge management impact on innovation and firm performance. She separated knowledge management into three category namely is knowledge acquisition, knowledge dissemination, and responsiveness to knowledge. Contrary to what is stated above, responsiveness to knowledge means that emerging knowledge from external environment is interpreted and responded by companies. So that she could improve their capabilities. Her findings supported research question and she presented below Figure 3.12.

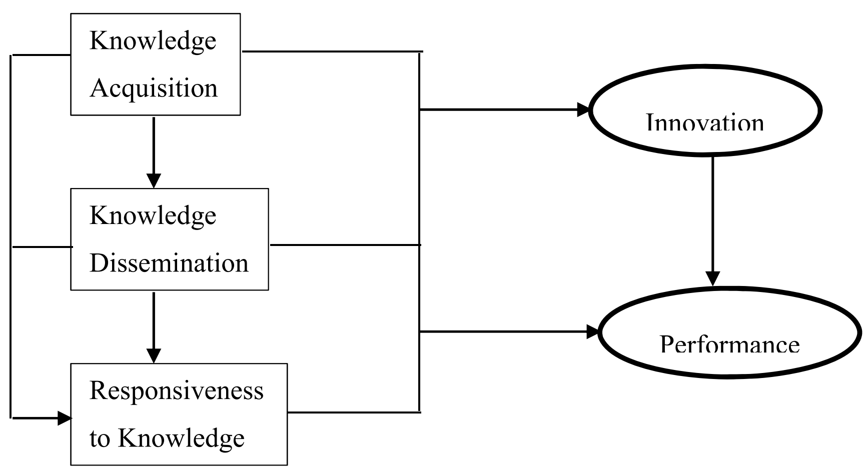


Figure 3.12 Knowledge Management Steps and Its Impacts on Innovation and Performance (Darroch [66])

Another important study about knowledge management and innovations belonged to Darroch, and McNaughton [67]. They specified that incremental innovations emerged from being market oriented and environment reactions. Radical innovations are affected from technological factors.

Nicolas and Cerdan [68] 9 investigated strategic knowledge management, which includes knowledge processes in order to be able to give strategic decisions, impact on innovation and performance. They found positive relationships between strategic knowledge management practice and innovation and performance. Their model is presented in Figure 3.13.

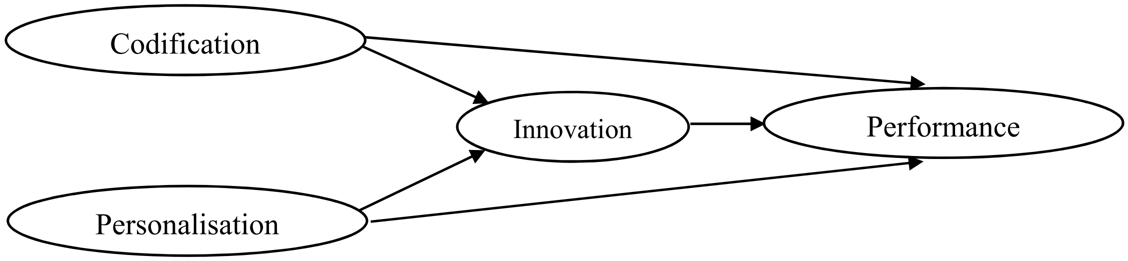


Figure 3.13 Strategic KM impact on Innovation and Performance (Nicolas and Cerdan [68])

Although KM is important in terms of innovations, KM in construction industry does not completely improve. According to Forcada et al. [69], although construction companies are aware of importance of KM in terms of themselves, they do not benefit from it according to being lack of systematic KM. They specified that the most important barrier in KM is organizational culture.

Another important study belongs to Kanapeckiene et al. [70]. They stated that in construction industry tacit knowledge is important rather than explicit knowledge. This can be originated from its fragmented structures. And project complexity increases knowledge demand in construction industry. Furthermore they offered Integrated KM Model in construction industry. They distinguished three levels. They are macro, meso, and micro level. Macro level is symbolized far environment. Meso level is types of construction companies. Micro level is related to firms' processes and works. This model presented in Figure 3.14.

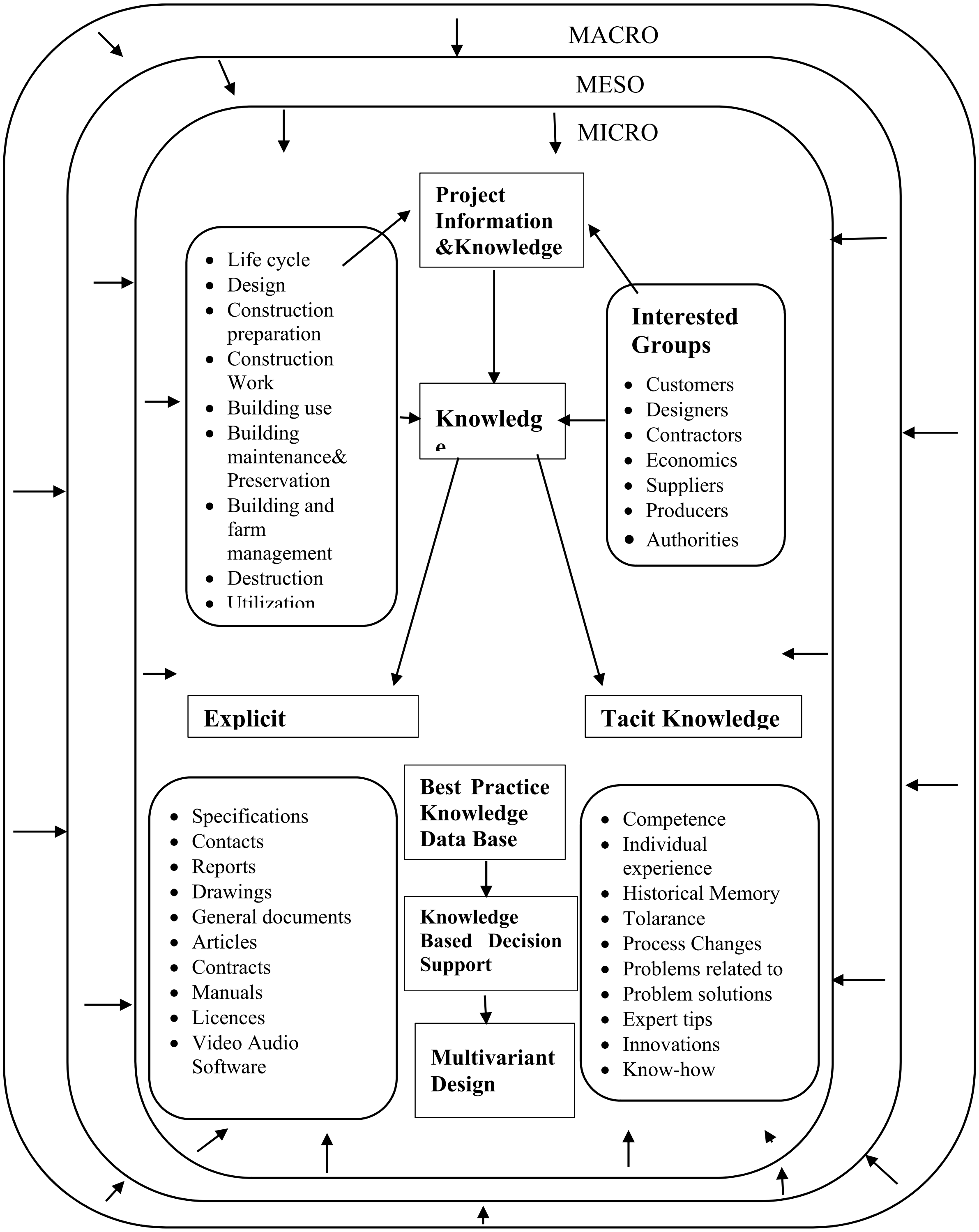


Figure 3.14 Integrated Knowledge Management Model for Construction Projects (Kanapeckiene et al. [70])

In the literature, Yang et al. [71] investigated information technologies impacts on project performance with intermediating role of knowledge management. Their model is presented in Figure 3.15. Results of study are given below;

- Knowledge management affects project performance,
- Effective knowledge management requires knowledge storage, documentation, and update, and
- Gained knowledge can be adapted to companies' work process or products or they can be used emerging of new technologies.

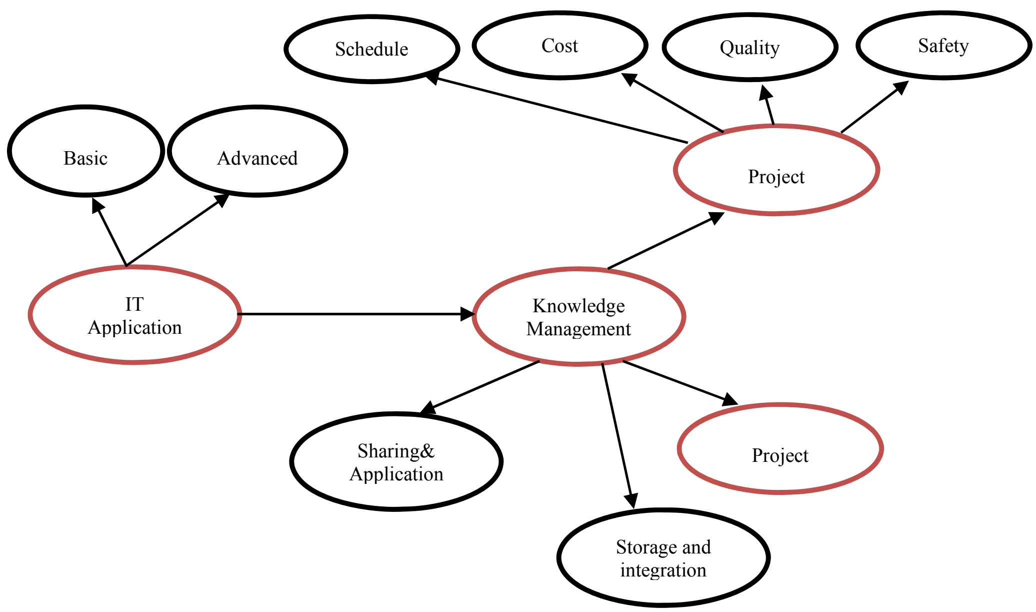


Figure 3.15 Intermediating role of Knowledge Management (Yang et al. [71])

In the light of the literature review, Figure 3.16 emerges. In this figure first step, which is knowledge management, has a positive impact on innovation. This information confirmed above literature findings. However, not only innovations reveal from KM, but also it can be gained single effort. After innovation phase is passed, firms want to use important innovations. This requires technology transfer mechanism. Innovations are transferred thanks to technology transfer mechanisms. Last phase is firms. Therefore process is completed.

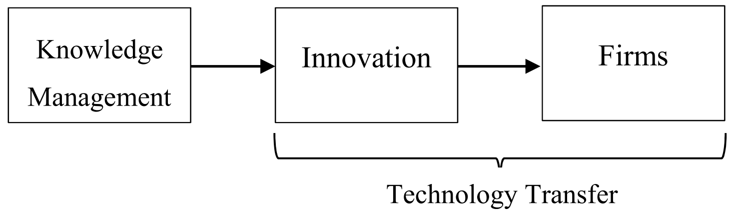


Figure 3.16 Relationships from KM to Firms

3.7.1 Sustainable Use of Technology Transfer in Construction Industry

Companies serve same customer or consumer groups in the same industry. This requires additional efforts for industry because of monopolizing of their customers/consumers. This creates competition between companies. This competition is formed cost, time, quality, and expertise.

After technology was used competition tool in business environment, R&D activities, innovations, and technology transfer activities have come into prominence in a dynamic environment. Therefore firms applied technology transfer activities more than before. This situation is valid for construction industry and they used it to be competition tool (Bygballe and Ingemansson [62]). Openly they differentiate from others by using it. In addition competition tools, they provides cost savings, time, and quality to product or process.

Expertise about specific case provides companies strong position in business environment. These expertise requires extra efforts in order to create or transfer knowledge. Nevertheless being able to gain knowledge does not mean what it will be used to be competitive tool. This requires knowledge capacity. Only if they have capacity, they can deploy it (Gambatese and Hallowell [48]).

As a consequent if processes progress properly, such activities can provide sustainability to construction companies.

3.8 Corporate Culture

Culture is a concept which defines organization dynamics. In other word they reveal organization character. So culture is multi-dimensional. For instance, when the clusters groups interact with firms, initially, they confront of organization climate (reflection of organization culture). Organizational culture and technology relationships are based on preparing suitable conditions for innovation and its diffusion in the company. Basically, this relationships can be judged with giving pay attention firms' R&D activities, worker support for their innovative ideas, and appropriateness of work conditions. Not only corporate culture handle, but also organization leaders and innovation champions are important factors at forming and managing innovation in the companies (Xiaolong et al. [53]).

3.9 Barriers of Technology Transfer in Construction Industry

Despite the fact that University-Industry relationship is important topic, some problems can be emerged along collaboration. These problems can be investigated in terms of academics, industry and policy. When it was investigated in terms of academics, according to promotion conditions, and reward systems these confront to academics to be blocking factor. Another problem is independent of academics which are affected from University-Industry relationships because they create pressure on academics. These concern can be associated academic disciplines because, whereas engineering disciplines support transfer policies, basic and social sciences concern about it. In addition to these, they will interfere their research area because of industrial problems urgency (Lee [7]).

In the literature another study about technical innovation in construction industry belongs to Gambatese and Hallowell [48]. Their findings about barriers were fear of change, reputation between clients and communication.

Pellicer et al. [55] stated that barriers of construction innovation are thought of it as product oriented and forgotten tool of competition. Another findings about barriers in the literature is clients' resistant and policy reality (Bygballe and Ingemansson [62]).

According to Aouad et al. [72] study, they specified sixteen bariers. They are namely "economic conditions, availability of financial resources, fragmented nature of construction business, unwillingness to change, lack of government role model, inappropriate legislation, risk in commercializing innovations, temporary nature of construction projects, extensive inter-organisational change required, lack of awareness, lack of qualified staff, lack of end-user involvement, lack of innovative investments/procedures/practices (R&D, training and education), adversarial approaches within the supply chain, lack of clear benefits, and belief that the industry is doing well without innovation".

Another study about barriers in construction innovation belong to Rigby et al. [43]. They investigated innovative project deliveries' barriers. They gained barriers from literature review. These barriers are presented in Table 3.8.

Table 3.8 AEC and IPD literature sources of risk (Rigby et al. [43])

Barriers	**Type**	**References**
Consistency of Installation	AEC	McCoy et al. [73]; Rigby et al. [43]
Product Lifecycle		McCoy et al. [73]; Rigby et al. [43]
Diffusion within/across builder firms		McCoy et al. [73]; Rigby et al. [43]
Market awareness		McCoy et al. [73]; Rigby et al. [43]
Complexity		McCoy et al. [73]; Rigby et al. [43]
Breadth of code compliance		McCoy et al. [73]; Rigby et al. [43]
Inefficiencies	Innovative Project Delivery	Rigby et al. [43]
Codes and Budgets		Rigby et al. [43]
Transparency		Rigby et al. [43]
Lack of Trust		Rigby et al. [43]
Too Much Conflict		Rigby et al. [43]
Frustrations with Defensive Behavior and Finger Pointing		Rigby et al. [43]
Desire to Improve Communication and Collaboration		Rigby et al. [43]
Increased Publicity on Alternative/Better Solutions		Rigby et al. [43]
Need for a Better Quality Product		Rigby et al. [43]

CHAPTER 4

FACTORS AND EXPLANATIONS

In this chapter, indicators of construction companies technology transfer and innovation success and its measures will be explained.

4.1 External Factors (General Environment)

As is known, companies are the smallest part of nation's economy. So they are exposed to a variety of difficulties which emerge from general conditions. These conditions do not affect firm directly. However, their shift impact affect firm's operation indirectly. These conditions are explained under eight conditions. These are: environmental (ecological) factors, governmental incentives on research and innovation, international relations, laws and regulations, macro economical fluctuations, political stability, sociocultural conflicts, technological advancements.

4.1.1 Environmental (Ecological) Factors

According to Bansal and Roth [74], reason of companies' ecological activities are to gain competitiveness, legitimation and ecological responsibilities. Their preliminary models showed that laws and regulations, requirements of stakeholders, economic advantages and ethic have an important role forming of companies' ecological decisions. They yielded like less utilization of resources, higher output, quality, low cost, increase of market position and marketshare and less waste in terms of companies. Legislations accelerates adaptation of companies to environmental precaustions. If this is not met by companies, this is resulted in fine, breaking of license agreement etc.

4.1.2 Governmental Incentives on Research and Innovation

Government use of a variety of mechanisms in order to promote research and innovation activities. Some of these mechanisms are tax incentives, product tax credits and direct investment. Another important mechanism is government-sponsored R&D consortia. Sakakibara [75] studied on government-sponsored R&D consortia in Japan. Outcomes of study showed that consortia has a positive impact on smaller firms than larger firms. Because they gain competitive advantage from this collaboration. However this consortia does not care to be important activities by participants in order to provide competitive position.

4.1.3 International Relations

International companies confront a lot of difficulties in foreign countries such as political risk, law and regulations, economy and stakeholders (Ülgen and Mirze [76]). For instance, foreign direct investment decisions of multinational enterprises are affected by host countries' "exchange rate", "quality of institutions" and "trade protection" (Blonigen, [77]). Friedman et al. [78] presented some parameters for investment of foreign multinational firms. These were transportation systems, infrastructure, large markets, labor force, demand and taxes. These parameters facilitate/impede realizing of companies' investment. After these variables are explained, Table 4.1 shows referances of variables.

4.1.4 Laws and Regulations

Laws and regulations are legislated by the government. Dynamic environment plays an important role consisting of laws and regulations (Ülgen and Mirze [76]). As every company, construction companies are affected by laws and regulations. El-Sayegh [79] specified a lot of risk parameters. One of them was "laws and regulations". This parameter shows up itself in "working hours" in construction industry. Another important example for laws and regulations is quality of productions. Government provides technical regulations for providing "quality of products". In addition to this, government's environmental and financial regulations impact construction industry (Pries and Janszen [80]).

4.1.5 Macro Economical Fluctuations

The revenue gained by the companies shared by stakeholders. So various economy parameters should take into account for sustainability of companies such as, economic period (crisis period, summer etc.), finance politics, inflation, national income, production cost (labor workforce salary, natural resources, capital and entrepreneurship) and balance of international payments (Ülgen and Mirze [76]). Arditi et al [81] found that “insufficient profits”, “industry weakness”, “poor growth prospects” and “high interest rate” to be macroeconomic are important in order to create successful business in construction industry. Another important indicator is “economic period” in construction industry. Like in all industries, construction industry affects being negative in regression. This condition causes to low profit for construction firms (Platt and Platt [82]; Arditi et al [81]).

4.1.6 Political Stability

Every countries have specific political factors which are used by central competent and local authorities. Every nation do not have same political management structure. While some of these structures facilitates business activities, some of them impedes. Sometimes the political factors can be used in a positive way by company owners, if they have close relationships between politicians and owners (Ülgen and Mirze [76]). For construction industry, El-Sayegh [79] specified project risk factors. These factors were divided into two part which is internal risks and external risks. Political factors were shown in under the external factors. Political factors are explained to be political instability and war risk. Moreover Bing et al. [83] distinguished PPP (public/private partnership) and PFI (private finance initiative) looking at levels which are macro, micro and meso level. When they explained macro level, they specified that macro level involves national or international risks and these risks included political risks, economic conditions, social conditions etc.

4.1.7 Sociocultural Conflicts

This arises from public’s life style, attitude, cultural differences, form of react to cases, diversity of behavior etc. (Ülgen and Mirze [76]). These diversity are formed company’s organization via organization personnel. So that organizations’ work style change according to their personnel. For instance, construction firms, which have same resources and ability, have got different business process and methods in different countries.

4.1.8 Technological Advancements

Technological advancements provide improvement in product and its process (Ülgen and Mirze [76]). Nation's economic levels play an important role formation of technological advancements. In addition to nation's level, advancement in different industries can affect positive other industries. Arditi et al [81] studied on construction equipment industry. Their findings showed that construction equipment industries' innovation is formed by buyer's requirements. Moreover other industries' advancements enabled advancement in construction industry.

4.2 External Factors (Business Environment)

Business environment involve various actors who companies have close relationships. These actors are company's competitors, customers and suppliers. Furthermore this environment includes market characteristics. In this context, boundary of market, client power, demand, market structure, severity of competition between companies, supplier power, and threat of new entrepreneurs will be considered.

4.2.1 Boundary of Market

Boundary of market specifies companies' competitive conditions. It consideres product structure and companies' location. In product structure, companies decide their scope of service. They decide which products will sell to customers and also they decide which companies are their rivalry. Another important issue is companies' location. It specifies companies' competitors in the same environment. Thus companies are formed their strategies (Ülgen and Mirze [76]).

4.2.2 Client Power

Companies produce product and service for gaining income from customers. So their products acceptances from customers are important to sustainability of companies (Ülgen and Mirze [76]). Client organizations help creating new knowledge Gann [84]. In design&build projects, clients should explain obviously their requirements to constructor (Ashley et al. [85]; Chan et al. [86]). So client's need is important for project success(Chan [88], Belassi et al. [89], Müller and Turner [90], Bryde and Robinson [91], Pinto and Prescott [92]). When innovation formation is investigated in terms of clients in construction industry, they have an important role (Arditi et al. [81], Blayse and Manley [45]).

4.2.3 Demand

Mochtar and Arditi [93] specifies owner's decision of pricing strategy. In this context, they found that pricing strategy of owners is changed depend on made a proposal. Therefore it is important for both construction industry and innovation.

4.2.4 Market Structure

Market structure can be investigated under the three title. These are number of competitors, balance of power at market and various difficulties (Ülgen and Mirze [76]). Ball et al. [94] specifies that entry new companies are easy in construction industry. Although there are potential risks, low cost is important for customers rather than other parameters. Moreover, lack of technology demand and low cost demand by customer facilitate entry into or exit from sector (Chiang et al. [95]).

4.2.5 Severity of Competition Between Companies

Severity of competition between companies states that companies who sell services and products in the same market have intense competition. This causes to increase severity of competition between companies. This increment emerges with numerous same firm, growth rate of market and firms which are banned exit from market (Ülgen and Mirze [76]). As being in most countries, construction industry has severity of competition between companies with low profit and high risk (Mochtar and Arditi [93]). So price based competitiveness prevails in construction industry.

4.2.6 Supplier Power

This parameter affects bargain power of companies with suppliers. If companies have more power than suppliers, they put across their proposal to suppliers. At market, number of suppliers, cost of passing to another suppliers and substitutes are important to consisting of this conditions (Ülgen and Mirze [76]). Same conditions is valid for construction industry. For instance, Bing et al. [83] state that "competitive procurement process" has a positive impact on PPP/PFI project and they provide rising project value. Betts and Ofori [96] state that construction companies have a chance in order that every country have different suppliers. Furthermore companies demand is vast amount of order. These condition increase impact of construction firms on suppliers.

4.2.7 Threat of New Entrepreneurs

Attractive industry presents advantage in order to enter new entrepreneurships. This case affects unfavorable existing companies in industry. When determining of industries' attractiveness, growth rate market, severity of competition between companies, uncertainties, demand etc. should be considered by new companies. Bing et al. [83] specifies that risk distribution related to uncertainty, growth of economic conditions, laws and regulations, financial market and procurement systems are identified to be positive factors in order to occur PPP/PFI. Betts and Ofori [96] state that new firms can enter easily with minimal investment into construction industry. However technological advancements impede entry of new entrepreneurs.

4.3 Resources and Capabilities

A companies' resources and capabilities can be investigated in company's brand, corporate identity, image in society, know-how and experience and learning capacity leadership, organizational culture, and technological secrets.

4.3.1 Brand, Corporate Identity

Brands constitute trust between companies and customer. Service-based companies sell invisible and intangible products to customers. Their products consist of cost, social and safety risk. Therefore strong brands are important for quelling. Customers' buying decisions are affected from brand's image (Berry [97]). Consequently, consumer's perception to product, service and companies are changed with brand (Cretu and Brodie [98]). Furthermore brand recognition provide flexibility to business problems (Jones et al. [99]).

Riel and Balmer [100] have explained corporate identity to be "clarifying the concept" and they have distinguished three title accordingly literature. These are graphic design, integrated communication and interdisciplinary. Graphic design reflects firm's name, logos, buildings etc. Integrated communication enables connection amongst stakeholders. Interdisciplinary emphasizes important of mix of communication, symbolism and behavior.

Image be a reflection of organization on society. Image generally is affected by organization's action or event (Berg [101];Gioia et al. [102]). "Organizational image is sum of impressions which are consisted on persons by organization". These impressions form attitudes and behaviors to organization (Erkmen [103]).

4.3.2 Know-how, Experience and Learning Capacity

Know-how is used competitive advantage tools by companies. Moreover know-how enables responding to changing market conditions (Helfat [104]). Hall's [105] investigation showed that company reputation, product reputation and know-how of employee are key performance indicators success of company. Sometimes it cannot be possible companies' single efforts. So companies collaborate with another companies. Simonin [106] stated that companies benefit from collaborative know-how and partners' experience. Kangari [107] and Assaf and Al-Hejji [108] specified that lack of experience causes to business failure in construction industry. Another importance of experience is in contractor's activities. While contractors cope with external factors, their management competence and experience impede probable conflicts, quality problems, cost problem etc. (Baloi and Price [109]).

4.3.3 Leadership

Leadership is one of the skills of project manager. Edum-Fotwe and McCaffer [110] distinguish managerial leadership into three categories. These are project leadership, technical leadership and team leadership. These provide achievement of project' vision and strategy leadership affect organization performance. Furthermore it compounds project participants. So manager's leadership should be compatible with organization. Their findings showed that project success is affected leadership and different type of project requires different leadership style.

4.3.4 Organizational Culture

Organization culture composes of shared items upon which organization members develop common attributes. Strength of culture can be defined with organizational history, group members' stability and intense of experience of group (Schein [111]). Relationship between organizational culture and technology is divided two parts by

Cabrera et al. [112]. These are; technology should be compatible with culture and culture is reshaped by technology.

4.3.5 Technological Secrets

Discovered knowledge which consists of industrial- commercial process is saved from rivals. Generally, this comes into prominence in chemical industry in order to save their formula (Teece [113]).

4.4 Strategic Decisions

In construction industry, strategic decisions of construction companies affect innovations and technology transfer activities positively or negatively. There are limited studies about this impact. One of them belongs to Seaden et al. [13]. They considered four different decision groups. They were namely “marketing, expanded product range, human resources and technological practices and development of competencies”. According to Manley et al. [45], strategic decisions were distinguished into five categories. These were “worker, knowledge, marketing, technology and relationship strategies”. According to our study, nine different strategies were considered. Their names and definitions are given below.

4.4.1 Client Selection Strategies

Before managers perform project, they specify target customer groups. According to these groups, they formed project properties. In this process, customer demand and acquisitions have an impact on forming of project.

4.4.2 Cost Leadership Strategies

Although cost leadership causes less profit margins and requires high capital investment for firms, it provides strong position to firms comparing with other firms. According to this strategy, firms should have considerable market share. Global competition and technological advances play a critical role in these strategies. While cost leadership provides competitive advantages, technology facilitates cost leadership (Porter [114]).

4.4.3 Differentiation Strategies

Firms' services and products should be unique in terms of customer perception. This strategy can take various forms which can be observed in firm's design, tangible assets, services, style of working etc.. Furthermore, this strategy have defensive extent against to Porter's five competitive forces, because they have strong position to customer, supplier related to their uniqueness. In contrast to these, it can require high invest into such as research and development activities and perfectionist approaches (Porter [114]).

According to Budayan [115] differentiation can be examined into two group which are price differentiation and non-pricing differentiation. Price differentiation was not handled because it was handled in cost leadership. When non-pricing differentiation strategy it is hadled stated that construction companies can make a difference in productivity, time, quality, innovation and image. In conclusion it is found that non-pricing differentiation provides competitive advantage to construction industry.

4.4.4 Human Resources Strategies

Human resource is one of companies' resources. Wright et al. [116] stated that sustainable competitive advantage is provided by rare, inimitable, and non-substitutable properties. Their findings showed that if companies manage their human capital successfully, human resources can meet them and provide sustainable competitive advantage. As is mentioned in Chapter 3, human resources are used transfer of new technologies to companies.

4.4.5 Investment Strategies

When construction companies make a decision for project, they choose their strategies by looking which project provides benefits in the long term or short term. Besides, these decisions are formed according to either financial or combination of financial and non-financial acquirements. Construction companies benefit from feasibility studies in order to choose project. If results of feasibility study meet companies' revenue expectations, they are accepted by companies. In these studies, some predictions are made by manager. These predictions are formed by past experience. This reveals that project contains some uncertainties (Mohamed and McCowan [117]).

4.4.6 Market Selection Strategies

In market selection strategies, companies specified which geographical area and region they give service. In addition to these, market selection strategies can involve customer group firms determined particular group and their requirements are struggled to meet. When firms commercialize innovations, they must specify target market and customer groups. According to chosen strategies, they must implement market orientation (Slater and Mohr [118]).

4.4.7 Subcontractor Selection Strategies

Subcontractor selection strategies begin with determined elector groups. However, required requirements should be specified. These requirements can be "cost, quality, time, experience, source sufficiency, safety, management capability, sufficiency of performance, sufficiency of technology, reference and personnel quality". According to these requirements, one of them or some of them is chosen (Rençber and Kazan [119]). Project budget and planning must be specified in agreement. According to constraints, subcontractors are chosen. However, if innovative solutions take place or promote in projects, types of contract is chosen according to it (Rigby et al. [43]).

4.4.8 Supplier Selection Strategies

While supplier is chosen, prices, reliability of products, technical support come into prominence. In addition to these factors, quantity, quantity and delivery and supply capability are just as important as others. As is concerned above, suppliers have an important role in problem solving and innovations. Therefore, companies must be chosen suppliers who have compatibility with companies' strategic aims.

4.4.9 Strategical Diversification (Horizontal, Vertical, and Combined)

With diversification strategies, companies want to strengthen in their industry. Therefore they considered horizontal and vertical strategies. Horizontal strategies are used for adding complementary activities, products, or services to their companies. However vertical strategies are used for adding direct activities, products, or services to their companies.

4.5 Project Management Competencies

Project management competencies are important to form technology transfer activities and innovation practice. In contrast to these, some of them necessitates technology transfer activities and innovations. Therefore, some management practices are given in order to measure their impact on innovations and technology transfer.

4.5.1 Cost management

"In order to complete project in confirmed budget, it includes planning of cost management, cost estimation, determine project budget and cost controlling" (PMIBOK [56]). Complexity of project (Kuyala et al. [120]), "project sector", "nature of project", "procurement methods", "nature of projects", "tendering method" and "project size" affect project budget (Shehu et al. [121]). Therefore such determinants should be taken into consideration in cost management.

4.5.2 Energy Management

Nowadays, governments promote energy saving policies, because they take advantages on commercial, competitive and environmental hazard reduction (Patterson [122]). "Energy management is the strategy of meeting energy demand when and where it is needed." Energy management process is constituted of four steps. First step possible energy savings are investigated. In second step determinated energy consumption assess and develops solutions in terms of energy saving. In third step these solution implement. However solutions can be assessed according to technical and financial. In final step, implemented solutions are monitored and solutions are evaluated whether success or not (Kannan and Boie [123]).

4.5.3 Health and Safety Management

Health and safety management is important for both companies and countries. It has a positive impact on labor productivity and performance. In the absence of this management, if work accident realizes, it causes to loss of money in company (Matias and Coelho [124]). However, innovations and technology transfers can be beneficial in order to troubleshoot regarding health and safety problems (Ozorhon [54]).

4.5.4 Knowledge Management

Nowadays, firms apply knowledge management in order to gain competitive advantages. Knowledge management is enabled with various process. These are;

- Knowledge creating,
- Knowledge recording,
- Knowledge mining and,
- Knowledge dissemination

Knowledge management deploys organization performance, competition, problem solving, innovation, cost efficiency in an organization. As is known, knowledge can be tacit or explicit. Although knowledge management aims that explicit knowledge is mined, is recorded and is disseminated in an organization, tacit knowledge is tried to convert to explicit knowledge (Gupta et al. [125]). In addition to these knowledge can be transferred from outside of organization. Also knowledge management confines both innovation management and technology management.

4.5.5 Procurement Management

Project procurement management comes into prominence in order to perform activities which are related to the project. Companies make a choice through make or buy decision is determined, essential services and materials are attained from outside project (Aartsengel and Kurtoglu [126], PMBOK [56]).

4.5.6 Quality Management

Generally, companies take care quality management because of competitive conditions in their industry. In quality management, various factors play an important role improvement of quality. Customer relationships are important factor because their needs form firms' quality performance. Supplier relationship, if only they don't choose based on bidding, they can contribute quality performance. Another important factor is organizational structure. If it incentives quality of work, firm' workers works in this direction. Workforce management provides to improve problem solving activities among workers and their solutions are considered. Top management support is consisted of emerging quality policies. If they are formed their strategies in this way, they can gain positive feedback (Flynn et al. [127]). When relationships between quality management and innovation are considered, study of Kim et al. [128] showed that quality management has a positive impact on innovation directly or indirectly. When they examined effect of quality management on innovation, they distinguish quality management to sub practice. Therefore they could search carefully. They found that process management have direct impact on radical product innovation, incremental product innovation, radical process innovation, incremental process innovation and administrative innovation in quality management.

4.5.7 Risk Management

Risk reveals from uncertainties and their probability on project outcomes (Chia [129]; Nieto-Morote and Ruz-Vila [130]). Risk management involves several processes. These are "planning of risk management", "identification of risk factors", "qualitative risk management analyses", "quantitative risk management analyses", "planning of risk respond", "control of risks" (PMBOK [56]). Planning of risk management is made in order to handle with project risk. Identification of risk factors include determining risk factors in project. In qualitative risk management analyses, interaction between risks and project are investigated. In addition to these, their probability and priority are determined. Quantitative risk management analyses probability of risks and their impacts are analyzed. In planning of risk respond, risk management scenarios develops. Control of risks are realized with implementation risk plan and their watching.

4.5.8 Time Management

Time management includes diverse tools and techniques. These tools and techniques provide effective utilization of project resources. Therefore time management has an impact on project economic performance (Shash and Al-abdullatif [131], Abbasi and Al-Mharmah [132], Sawalhi and Enshassi [133]). Besides, time is one of the iron triangle which is project performance dimension.

4.5.9 Value Management

Value management can be described to be "best value-for-money" briefly. This management area makes progress with technological advances, sectorial competition and clients' needs and demands (Shen and Liu [134]).

4.6 Indicators of Construction Companies Technology Transfer and Innovation Success

In the literature, many indicators are presented related to success factors of technology transfer and innovation. These factors are aligned below. As a result, their impact are going to be researched.

4.6.1 Completion of Project on Time

Ozorhon et al. [3] and Ozorhon [54] who make a case study about technology transfer showed that innovations enable to finish project in less time.

4.6.2 Competitive Advantage Among Rivals

Innovations is important in terms of competitiveness of firms. Some innovation perspectives bring competitive advantages to firms. These properties are specified to be hard to copy, being amenable to market expectations, pioneer at innovation, and utilization capacity of innovation (Lengnick-Hall [135]). Lim et al. [136] researched relationship between construction industry and competitive advantage in terms of innovation. Their findings showed that it is beneficial for competitive advantages. Moreover, it has an impact on increasing of market share and new market.

4.6.3 Completion of Project Budget

Ozorhon et al. [3] and Ozorhon [54] who make a case study about technology transfer showed that innovations enable to finish project in less cost.

4.6.4 Financial Indicators

In order to measure innovation at firm level, some indicators are utilized. One of them is innovation expenditure on number of outputs. Other one is innovation revenue to profit and personnel. For measuring of innovation, financial performance and market performance are considered (Tidd [137]).

4.6.5 Higher Perceived Value

In other words can be defined to be quality which gain being output of innovation (Ozorhon [3], Ozorhon[54]).

4.6.6 Learning and Development

As is known, FDI is important technology transfer for developing countries. They contribute learning and development of local firms. However, this is depend on capacity of firms (Fu et al. [138]).

4.6.7 Productivity

Hall et al. [139] investigated innovation impact on productivity in SMEs. They distinguished innovation to be product innovation and process innovation. After that, they investigated their impact on productivity separately. They found that product innovation supports labor productivity. However process innovation necessitates investment. As a result, they state that innovation contributes productivity (Hall et al. [139], Crespi and Zuniga, [140]).

4.6.8 Reputation/Company Image

Image or reputation of company are formed perception of costumer. Therefore some companies lead their strategies related to desire of customer. Reputation perception for production innovation lead consumer to innovative firms (Henard and Dacin [141]). In addition to these, their participation to forming innovation affects products positively. Another study which was made by Ozorhon et al. [54] stated that image is one of the outputs of innovation.

4.6.9 Satisfaction of Customer/Consumer

Firms try to meet customer demands and preference in order to attain more proportion. So they apply innovation. Innovations are used both new and meeting of customer demand. However, Simon and Yaya [142] who investigated innovation impact on customer satisfaction found that marketing innovation is important than product and process innovation on customer satisfaction. In contrast to Sımon and Yaya [142], Zhang et al. [143] stated that innovation affects brand and value equity. So customer value is affected by innovation in specific to sport shoes sector.

4.7 Indicators of Success in Terms of Construction Industry

Innovation and technology transfer can contribute nations' economic growth and competitiveness (Ozorhon [54], Lee [7]). One of the important part of economy is construction industry. Therefore construction industry' activities affect economy directly. In this section some of determinant of construction industry is given below. Given premises are utilized for measuring construction industry.

4.7.1 Development Level of Building Materials Sector

Building material industry is related to construction industry. When urbanization raises, utilization of construction material increases (Connolly [144]; Colten [145]; Fry [146]). In building material industry, increased demands to materials show that construction facilities raise. In other words one of indicators of construction is building material industry. However it needs to be regional building materials industry in order to support nation's construction industry and economy. In this issue, when relationship between construction material industry and innovation is interrogated, it has not direct relationship in order to processed by construction industry. However If network system is set, user-driven innovation can be provided. As a result, this lead to innovation, effectiveness, efficiency, etc. (Wandahl et al. [147]).

4.7.2 Employment

Construction facilities require intensive workforce. Therefore it plays an important role proportion of national employment (Ofori [41]; Ibrahim et al. [148]). According to these, proportion of employment in construction industry is viewed and collected data. Moreover these data gives information about continuity of industry.

4.7.3 Increase on Number of Multinational Firms

International construction firms serve both in their countries and in foreign countries. This event contributes export of countries. Not only innovations provides profit to firms, but also they bring firms social benefits. In construction industry, firms evolve about TQM, re-engineering, review of process and productivity in time. This evolution enables western firms being international market player. After they gain position in the market, they have to save their position. Therefore they take a precautions such as differentiation strategies, value offering and new products to consumer (Porter [149]; Seaden and Manseau [36]).

4.7.4 Turnover and Production

Construction turnover and production indices involves construction, building construction, dwelling or non-dwelling construction, other structures, highway and railroad, demolition of structure and mobilization of construction site and electrical, mechanical sytems[150]. These indeces gives us information about overall position of construction industry.

4.7.5 Material and Workmanship Prices

Construction industry is worker intensive industry. Therefore workmanship prices have direct effect in shaping of industrial activities. In addition to this material prices have the same effect on industrial activities. Therefore, this variable is taken into consideration under the indicators of construction industry.

Table 4.1 References list

EXTERNAL FACTORS (General Environment)	**References**
Environmental (ecological) factors	Bansal and Roth [74]
Governmental incentives on research and innovation	Shakibara [75]
International relations	Ülgen and Mirze [76], Friedman et al [77]
Laws and Regulations	Ülgen and Mirze [76], El-Sayegh [79], Pries and Janszen [80]
Macro Economical fluctuations	Ülgen and Mirze [76], Arditi et al [81], Platt and Platt [82]
Political Stability	Ülgen and Mirze [76], El-Sayegh [79], Bing et al. [83]
Sociocultural conflicts	Ülgen and Mirze [76]
Technological advancements	Ülgen and Mirze [76], Arditi et al [81]
EXTERNAL FACTORS (Business Environment)	
Boundary of market	Ülgen and Mirze [76]
Client power	Arditi et al [81], Ülgen and Mirze [76], Gann [84], Ashley et al. [85]; Chan et al. [86], Chua et al. [87], Chan et al. [88], Belassi and Tukel [90], Müller and Turner [91], Bryde and Robinson [92], Pinto and Prescott [46]
Demand	Mochtar and Arditi [93]
Market structure	Ülgen and Mirze [76], Ball et al. [94], Chiang et al. [95]

Table 4.1 References list (Cont'd)

EXTERNAL FACTORS (Business Environment)	
Severity of competition between companies	Ülgen and Mirze [76], Mochtar and Arditi [93]
Supplier power	Ülgen and Mirze [76], Bing et al. [83], Ofori [96]
Threat of new entrepreneurs	Bing et al. [83], Betts and Ofori [96]
RESOURCES AND CAPABILITIES	**References**
Brand, Corporate identity, Image in society	Berry [97], Cretu and Brodie [98], Jones et al. [99], Riel and Balmer [100], Berg [101]; Gioia et al. [102], Erkmen [103]
Know-how, experience and learning capacity	Helfat [104], Hall [105], Simonin [106], Kangari [107], Assaf and Al-Hejji [108], Baloi and Price [109]
Leadership	Edum-Fotwe and McCaffer [110]
Organizational culture	Schein [111], Cabrera et al. [112]
Technological secrets	Teece [113]
STRATEGIC DECISIONS	
Client selection strategies	
Cost leadership strategies	Porter [114]
Differentiation strategies	Porter [114], Budayan [115]
Human Resources strategies	Wright et al. [116]
Investment strategies	Mohamed and McCowan [117]
Market selection strategies	Slater and Mohr [118]
Subcontractor selection strategies	Rençber and Kazan [119], Rigby et al. [44]
Supplier selection strategies	
PROJECT MANAGEMENT COMPETENCIES	
Cost management	PMIBOK [56], Kuyala et al. [120], Shehu et al. [121]
Energy management	Patterson [122], Kannan and Boie [123]
Health and safety management	Matias and Coelho [124], Ozorhon [54]
Knowledge management	Gupta et al. [125]
Procurement management	PMIBOK [56]
Quality management	Flynn et al. [127], Kim et al. [128]
Risk management	Chia [129]; Nieto-Morote and Ruz-Vila [130], PMIBOK [57]
Time management	Shash and Al-abdullatif [131], Abbasi and Al-Mharmah [132], Sawalhi and Enshassi [133]
Value management	Shen and Liu [134]

Table 4.1 References list (Cont'd)

INDICATORS OF CONSTRUCTION COMPANIES TECHNOLOGY TRANSFER AND INNOVATION SUCCESS	
Completion of project on time	Ozorhon [3,54]
Competitive advantage among rivals	Lengnick-Hall [135], Lim et al. [136]
Completion of project on budget	Ozorhon [3,54]
Financial indicators	Tidd [137]
Higher perceived value	Ozorhon [3,54]
Learning and development	Fu et al. [138]
Productivity	Hall et al. [139],Crespi and Zuniga[140], Budayan [115]
Reputation/Company image	Ozorhon [3,54] [3,54, 141]
Satisfaction of customer/consumer	Simon and Yaya [142], Zhang et al. [143]
INDICATORS OF SUCCESS OF CONSTRUCTION INDUSTRY	
Development level of building materials sector	Connolly [144];Colten [145];Fry [146], Wandahl et al. [147]
Employment	Ofori [41]; Kim et al. [128]
Material and workmanship prices	
Increase on number of multinational firms	Porter [149]; Seaden and Manseau [36]
Turnover and production	TUIK [150]

CHAPTER 5

DATA COLLECTION AND ANALYSIS

In this chapter data collection and analysis stages and method will be explained. After examination the descriptive statistics regarding the caracteristics of the respondent companies, literature related to structural equation modeling (SEM) will be given and the SEM analysis results conducted with the collected datawill be explained.

5.1 Descriptive Statistics

In order to characteristics of the respondent companies. Descriptive statistical analysis were peformed. The mean, standard deviation, standard error, median, sample variance, kurtosis, skewness, range, minimum, maximum values were given in Appendix B.

5.1.1 General Information about the Respondent Companies

Within the context of the research collected fifty two questionnaires were with face-to-face interviews. General information about companies will be presented in next parts.

5.1.1.1 Number of Years of Experience

The distribution of the number of years of experiece of the companies are presented in Figure 5.1.

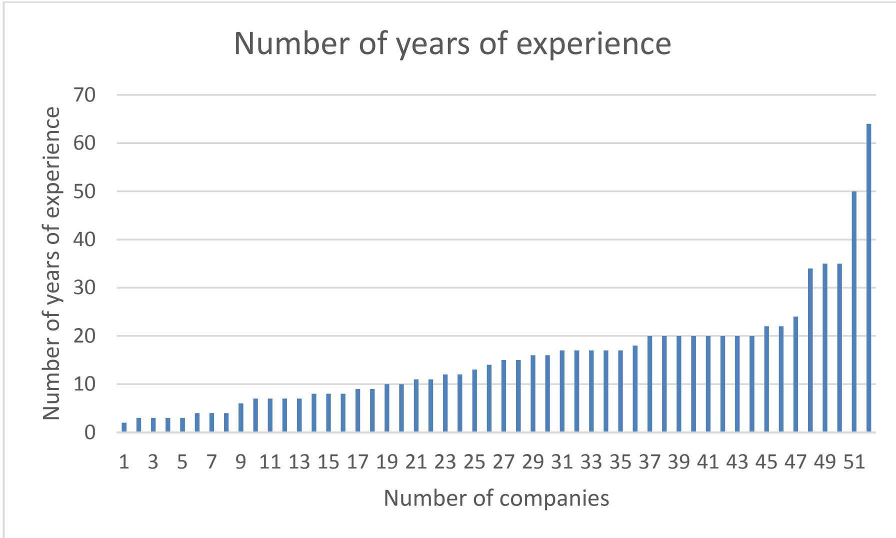


Figure 5.1 Number of year experience of respondents

5.1.1.2 Specified Fields of Experience

The respondent companies are specialized mainly on buildings 85%, waterworks 15%, transportation 21%, industrial 23% and infrastructure 17%. Analysis of specified fields of experience shows that some of companies operate in a few specialized area. Figure 5.2 depicts rate of areas.

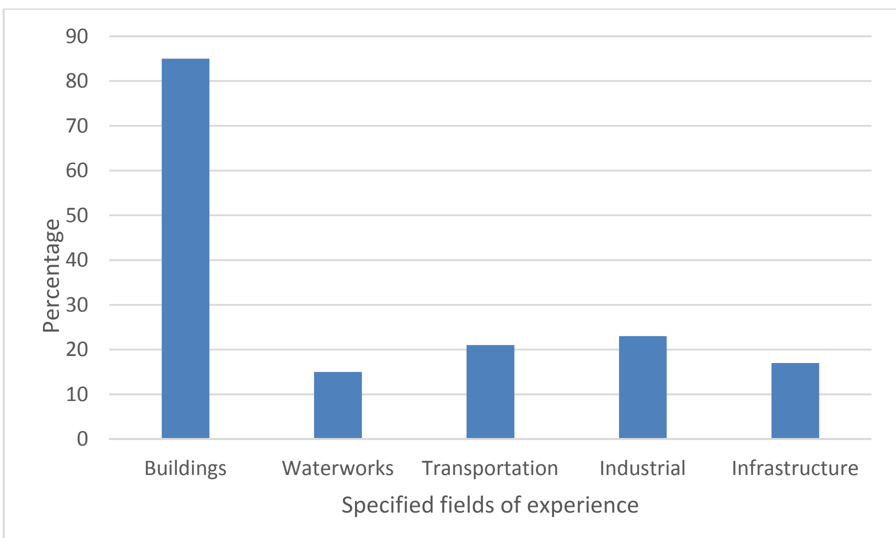


Figure 5.2 Distribution of companies in terms of specialized fields of experience

5.1.1.3 The Turnover of the Companies

The distribution of domestic and international turnovers of the companies are presented in Figure 5.3 and Figure 5.4 respectively.

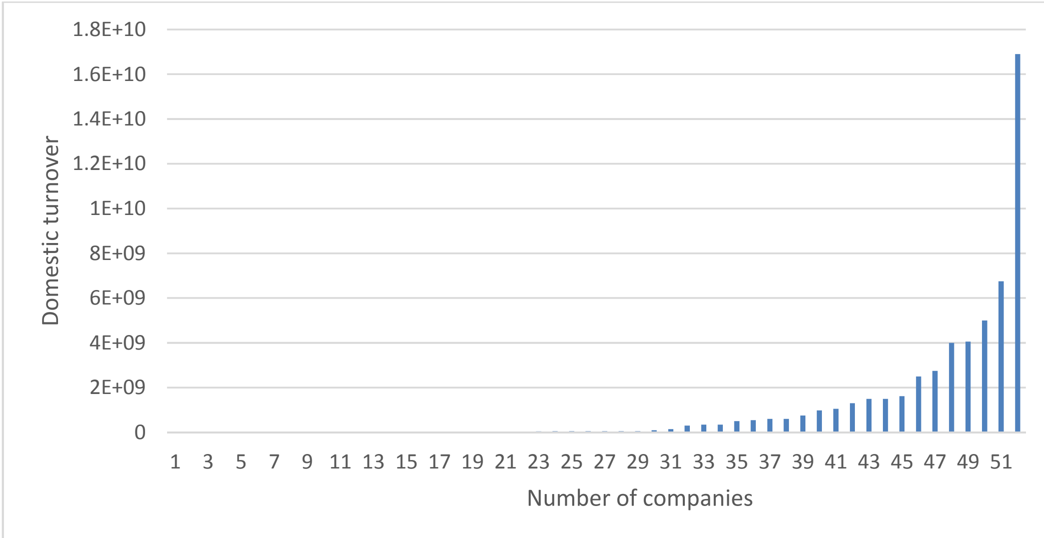


Figure 5.3 Distribution of companies in terms of domestic turnnnover

Figure 5.4 Distribution of companies in terms of international turnover

5.2 Questionnaire

Questionnaire was implemented in order to make statistical analysis quantitatively. Also information was gained by questionnaires. In the literature, various questionnaire implementation methods have been developed. In this study, face to face interview method was used. This method provides more healthy results and feedback rate when comparing with other methods.

In the preparation of questionnaires, three things should be considered. These are understandable questions and factors, contribution of experts, and honesty of the responder [151].

As it was mentioned in the above paragraph, questionnaire phase is quite important to get a straight answer. So Figure 5.5 was followed. First phase, initial consideration, is considered for target population according to content of the study. Moreover sampling method is choosen in this phase such as face to face, e-mail etc. Second, question content, phrasing and response format, is made for clarifying the necessity of questions. Third, equalities, is made for collecting population descriptive statistics. Fourth, confidentiality, is important to be guaranted by the collected data from respondents.

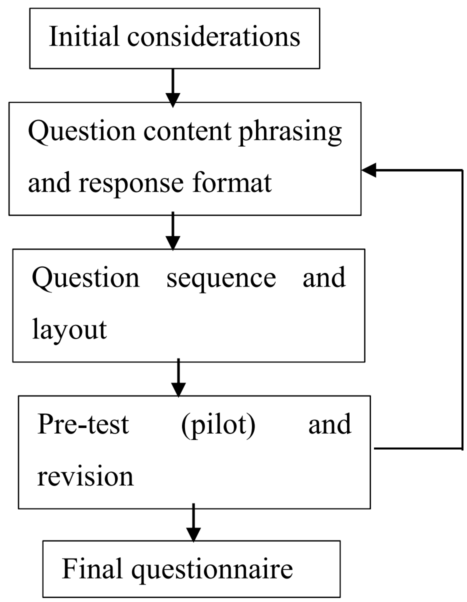


Figure 5.5 Array of Questionnaire Arrangements [152]

Questionnaire was created according the hypothesis set at the beginning of study. These hypothesis consist model attributes. Basically, questionnaire is structured to construct a technology transfer assessment model for construction industry. According to modeling, structural equation modeling method was used. Therefore 1-5 likert scale was used. In the questionnaire, both significance level and implementation level were questioned.

When questionnaire was implied, significance and implementation level were wanted to assess by considering technology transfer and innovation. Questionnaire is to consist of seven questions. Respondents evaluated subfactors of all factors by considering indicators of innovation and technology transfer. Sample of questionnaire is presented in Appendix A.

5.2.1 Pilot Study

As you know, pilot study is made for testing quality and efficiency of questionnaire. Therefore first of all, pilot study was employed. Pilot study was implemented to two experts in the managerial level of two different construction companies (from Turkish Contractors Assosiation). The pilot study was implemented by coming together with respondents. In this study, questions of questionnaire were rearranged according to respondents' suggestions. As a result of their answer and assessment, development of the questionnaire was completed. Also some subfactors were extracted from questionnaire. After necessary arrangements were made, questionnaire was implemented to other construction companies' engineer and manager.

5.3 Method

Structural Equation Modeling (SEM) was used to analyze the data collected from the respondents. In this part a detailed explanation of SEM is given.

5.3.1 Structural Equation Modeling

This method includes many types of statistical analysis methods. Generally, via these statistical analysis, emerged models according to the literature is tested. In this processes, first of all measurement model iss revealed. After analyzing measurement model, analysis of structural model begins.

Basically, researcher searches fit between their models and survey results. Best-known specialty of SEM is to convert unobserved variables to measurable variables. To be statistical specialty, it combines a measurement model (confirmatory factor analysis) and a structural model (regression or path analysis).

5.3.2 Key Concepts and Terms in SEM

A review of terminology and graphical is essential for understanding of structure of SEM and reveal of the analysis results.

5.3.2.1 Definition of the Terms

Observed variables: it states measurable variables statistically. They are depicted with rectangular shapes in SEM.

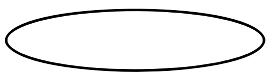
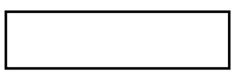
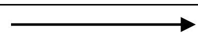
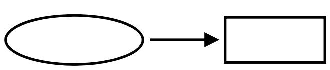
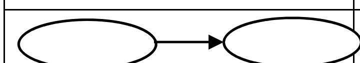
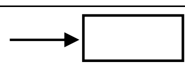
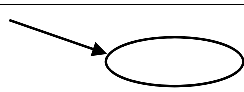
Unobserved variables: it is used for unmeasurable variables. These are measured by observed variables. In SEM, they are symbolized with circle or ellipse (ovals).

Exogenous: If variable is independent, they are defined as exogenous variables.

Endogenous: If variable is dependent, they are defined as endogenous variables.

Following Table 5.1 is to define some concept about SEM.

Table 5.1 SEM Symbolic notations (Byrne [153])

Shape	Definition
	Circles are used for latent factors.
	Rectangular is used for representing observed variables.
	Single-headed arrows are used for show causal relationship.
	Double-headed arrows are used for show covariance between variables.
	"Path coefficient for regression of an observed variable onto an unobserved latent factor"
	"Path coefficient for regression of one factor onto another factor"
	"Measurement error associated with an observed variable"
	"Residual error in the prediction of an unobserved factor"

5.3.3 Regression, Path, and Structural Equation Models

As is mentioned above, SEM have a structure that is conducive to show latent factors with observed variables. This is distinctive property when it compares with other methods. However regression and path modeling only include observed variables. In these models, errors only are showed with dependent variable in regression and endogenous variables in path models. Other variables have not got error. Path models also have the same notation related SEM like circle, arrow etc.

5.3.4 Measurement Model

The measurement model is the first phase of SEM. The measurement models include latent factors and their related indicators (observed variables). Exploratory and confirmatory factor analysis can be used in the measurement model in SEM. However confirmatory factor analysis is used commonly in order that relationships between observed and latent factors are revealed from literature. If researcher wants to use the exploratory factor analysis, they have to connect all observed variables to all latent factors. As a result of analysis, indicators are specified according to their high factor loads. Straight arrows, two headed arrows, errors, latent factors and observed variables (indicators) are used in the measurement models. The straight arrows are used two place. They are placed between latent factors and their indicators and between errors and their observed variables respectively. Two –headed variables are used between latent factors if there is a correlation between latent factors. If there is an unexplained variance between indicator and latent factor, this is stated with errors. In this models, while observed variables are symbolized with rectangular shapes, latent factors are symbolized with ovals. While meaningful of t-test is looked for in straight arrow relationship, this is not only enough for accepting of model. Also goodness of fit statistics are used.

5.3.5 Confirmatory Factor Analysis

CFA is a method that is used for calculate the loadings of measured variables on factors. Basically, prior literature review emerges factors' indicators. In the light of specifying indicators, it is investigated whether their load is satisfactory or not. In CFA, researcher make a selection according to their literature review. This constrains necessary factors and indicators (Kim and Charles [154]).

According to DeCoster [155], CFA is consist of six basic phase.

1. Define the factor model: In this phase, researcher measure model which they want to confirm.
2. Collect measurements: Variables must be specify on the same units such as 1 to 5 Likert scale.
3. Obtain the correlation matrix: Correlation between variables are found.
4. Fit the model to the data: Factor loadings are estimated. However, before specifying the factor loadings, researcher should choose method. Maximum likelihood estimation is very common in this process.

5. Evaluate model adequacy: After fourth phase, the factor loadings are chosen according to the difference between correlation matrix and observed matrix. A minimum difference is aimed in the process. After the factor loadings are chosen, consistency of model and data is investigated. When this is investigated, the goodness-of-fit test is used generally. In this process, the null hypothesis means that the data and model explain each other. Other hypothesis is that there is a significant difference among them.

The factor loadings are used for defining relationship between the variables and factors. They are correlation coefficients. If the correlation coefficient squares, percent of variance is gained. The percent of variance helps to identify which indicator is explained by factor.

As a result of CFA, standardized factor loading have to be higher than 0,70. And this is not valid by itself. Also t-test has to be meaningful.

5.3.6 Structural Model

In this phase, cause and effect relation is investigated. However, before testing, merged measurement model is tested together. Afterwards, relationships between the latent factors are investigated whether it has got expected results or not.

Goodness-of-fitness statistics are used in order to make last evaluation about structural model. These statistics provide an information whether data supports or not.

5.3.7 Model fit Indices

As is mentioned above, goodness-of-fitness statistics is essential for the last assessment. In the literature, a lot of indices are found. Some of them is presented in Table 5.2.

Table 5.2 Commonly Used Goodness of Fit Indices

Type of fit indices	Acceptable Fit	Good fit	Very good fit	Explanation
Chi-square	$2<\frac{\chi^2}{df}\leq 5$	$\frac{\chi^2}{df}\leq 2$	$\frac{\chi^2}{df}=0$	In Chi Square testing, χ^2value has to be meaningless. Because of this, if they is meaningful, this means that they have different covariance matrix.
GFI (Goodness of fitness index)	0,95>GFI>0,9	GFI>0,95		
AGFI (Adjusted Goodness of Fit Index)	0,95>AGFI>0,9	AGFI>0,95		Value of AGFI is changed between zero and one or more. If it takes a negative value, it defines what sample size is very low.
CFI (Comparative Fit Index)	0,95>CFI>0,9	CFI>0,95		
RMSEA (Root Mean Square Residual)	0,05≤RMSEA<0,08	RMSEA<0,05		
RMR (Root Mean Square Residual)	0,05≤RMR<0,08	RMR<0,05		When value of RMR approaches to zero, model shows good fitness.
SRMR (Standardized Root Mean Square Residual)	0,05≤SRMR<0,08	SRMR <0,05		When value of RMR approaches to zero, model shows good fitness.

5.3.8 Phase of Structural Equation Modeling

It comprise of three phase. They are namely identification of model, model estimation, model testing, and fitness of model.

5.3.8.1 Identification of Model

Researcher has to attribute their research on sound footing. In other words, they have to gain their variables from theoretical research. In structural equation modeling, it comprises of two models. These are namely measurement model and structural model. While the measurement model shows relationships between observed models and latent factors, structural model only show relationships among latent factors. When model is identified, straight arrows and two headed arrows are used. Straight arrows show regression structure, while two headed arrows are used for correlations.

5.3.8.2 Model Estimation

After model is identified, it is passed to model estimation phase. In this phase, lots of methods are found in the literature. Some of these is maximum likelihood, ordinary least squares, two stage least squares, generalized least squares, weighted Least Squares etc. Maximum likelihood method provides increasing of maximization of data which is taken from survey results. Maximum likelihood estimation method, in comparision with other methods, requires less number of sample.

Another important subject is robust statistic in estimation methods. If data has non-normality distribution and small sample size, robust methodology is used. In our study, while some of latent factors are normal distribution, others have non-normality distribution. However, three models have non-normality distribution. So robust methodology is used intensively in our study. Robust methodology is determined according to loking at estimated z-score. The score must be ± 1,96 in a 0,05 confidence interval.

5.3.8.3 Model Testing and Fitness of Model

In this phase, it is investigated fitness between model and data. In our study, fitness of model is assessed by looking at the non-normed fit index (NNFI), comparative fit index (CFI; Bentler [156]), the root mean square error of approximation (RMSEA; Steiger [157]) with its 90% confidence interval, and the model chi-square.

5.4 Analysis of the Innovational Measurement Models

In order to structure the casual relationship between the 52 variables, seven latent factors were specified. They are namely, “external factors (general environment)”, “external factors (business environment)”, “resources and capabilities”, “strategic decisions”, “project management competencies”, “indicators of construction companies technology transfer and innovation success”, and “indicators of success of construction industry”. The data was obtained from the 52 construction companies and they were analyzed with the SEM software package called EQS 6.2. First of all, validity of the measurement model is presented.

5.4.1 Validity of the Innovation Measures and the Indicators

Construct validity is comprised of several subdimensions. These are namely “content validity”, “scale reliability”, “convergent validity”, and “discriminant validity”.

5.4.1.1 Content Validity Testing of Innovation Measures

Content validity is used for to extent which observed variables belongs to its latent factors. It does not require statistically analysis. It fulfills by making deeply literature reviews. Literature review was performed in order to fulfill the validity.

Table 5.3 Results of content validity testing

EXTERNAL FACTORS (General Environment)	**EXTERNAL FACTORS (Business Environment)**
Environmental (ecological) factors	Boundary of market
Governmental incentives on research and innovation	Client power
International relations	Demand
Laws and Regulations	Market structure
Macro Economical fluctuations	Severity of competition between companies
Political Stability	Supplier power
Sociocultural conflicts	Threat of new entrepreneurs
Technological advancements	**STRATEGIC DECISIONS**
RESOURCES AND CAPABILITIES	Client selection strategies
Brand, Corporate identity, Image in society	Cost leadership strategies
Know-how, experience and learning capacity	Differentiation strategies
Leadership	Human Resources strategies
Organizational culture	Investment strategies
Technological secrets	Market selection strategies
PROJECT MANAGEMENT COMPETENCIES	Subcontractor selection strategies
Cost management	Supplier selection strategies
Energy management	Strategical diversification (horizontal, vertical and combined)
Health and safety management	**INDICATORS OF CONSTRUCTION COMPANIES TECHNOLOGY TRANSFER AND INNOVATION SUCCESS**
Knowledge management	Completion of project on time
Procurement management	Competitive advantage among rivals
Quality management	Completion of project on budget
Risk management	Financial indicators
Time management	Higher perceived value
Value management	Learning and development
INDICATORS OF SUCCESS OF CONSTRUCTION INDUSTRY	Satisfaction of customer/consumer
Development level of building materials sector	Productivity
Employment	Reputation/Company image
Material and workmanship prices	
Increase on number of multinational firms	
Turnover and production	

After an in-depth literatüre review was performed, pilot study was performed. Together with industry proffessional, latent factors and observed variables were eleminated. Latent factors and their observed variables are presented in Table 5.3. Now emperical tests such as “scale reliability”, “convergent”, and “discriminant validity” will be given.

5.4.1.2 Scale Reliability Testing of Innovation Measures

Scale reliability is measured with Cronbach’s alpha value. Internal consistency is measured with this value. In other words, this value represents the extent to which observed variable indicates their corresponding latent factors. This value must be 0,7 in minimal conditions (Nunally, 1978). Cronbach’s alpha value of our latent factors are presented Table 5.4.

Table 5.4 Cronbachs alpha coefficients of the latent factors

Latent factors	**Cronbach’s alpha values**
External Factors (General Environment)	0.834
External Factors (Business Environment)	0.852
Resources and Capabilities	0.752
Strategıc Decisions	0.909
Project Management Competencies	0.886
Indicators of Success in Terms of Technology Transfer and Innovation	0.891
indicators of construction companies technology transfer and innovation success	0.718

5.4.1.3 Convergent Validity Testing of Performance Measures

Convergent validity is used to measure correlations between the latent factors and corresponding observed variables. In order to fulfill convergent validity, observed variables must be statistically significant (Dunn et al. [158]). Therefore meausrement model of all latent factors were assessed by looking whether they are significant at α=0,05 or not. Factor loadings of study is presented in Table 5.5.

Table 5.5 Latent and observed variables of the model with factor loadings

	MODEL VARIABLES	Factor loadings
F1	**RESOURCES AND CAPABILITIES**	
V1	Know-how, experience and learning capacity	0,789
V2	Leadership	0,851
V3	Brand, Corporate identity, Image in society	0,634
V4	Technological secrets	0,381
V5	Organizational culture	0,488
F2	**PROJECT MANAGEMENT COMPETENCIES**	
V6	Energy management	0,401
V7	Knowledge management	0,739
V8	Value management	0,713
V9	Health and safety management	0,804
V10	Quality management	0,795
V11	Cost management	0,562
V12	Risk management	0,758
V13	Procurement management	0,908
V14	Time management	0,589
F3	**STRATEGIC DECISIONS**	
V15	Subcontractor selection strategies	0,821
V16	Differentiation strategies	0,693
V17	Human Resources strategies	0,625
V18	Cost leadership strategies	0,795
V19	Client selection strategies	0,529
V20	Market selection strategies	0,765
V21	Strategical diversification (horizontal, vertical and combined)	0,649
V22	Supplier selection strategies	0,846
V23	Investment strategies	0,821

Table 5.5 Latent and observed variables of the model with factor loadings (Cont'd)

	MODEL VARIABLES	Factor loadings
F4	**EXTERNAL FACTORS (General Environment)**	
V24	Governmental incentives on research and innovation	0,646
V25	Environmental (ecological) factors	0,753
V26	Macro Economical fluctuations	0,749
V27	Political Stability	0,583
V28	Sociocultural conflicts	0,601
V29	Technological advancements	0,513
V30	International relations	0,578
V31	Laws and Regulations	0,581
F5	**EXTERNAL FACTORS (Business Environment)**	
V32	Client power	0,783
V33	Boundary of market	0,304
V34	Demand	0,729
V35	Market structure	0,705
V36	Severity of competition between companies	0,634
V37	Supplier power	0,571
V38	Threat of new entrepreneurs	0,956
F6	**INDICATORS OF CONSTRUCTION COMPANIES TECHNOLOGY TRANSFER AND INNOVATION SUCCESS**	
V39	Higher perceived value	0,605
V40	Completion of project on budget	0,770
V41	Completion of project on time	0,769
V42	Competitive advantage among rivals	0,784
V43	Reputation/Company image	0,779
V44	Productivity	0,718
V45	Financial indicators	0,567
V46	Learning and development	0,672
V47	Satisfaction of customer/consumer	0,595

Table 5.5 Latent and observed variables of the model with factor loadings (Cont'd)

	MODEL VARIABLES	Factor loadings
F7	**INDICATORS OF SUCCESS OF CONSTRUCTION INDUSTRY**	
V48	Material and workmanship prices	0,632
V49	Turnover and production	0,578
V50	Employment	0,773
V51	Development level of building materials sector	0,519
V53	Increase on number of multinational firms	0,419

5.4.1.4 Discriminant Validity Testing of Innovation Measures

Discriminant validity is used to measure whether observed variable belongs to its corresponding latent factors or not. Low correlations between variables indicate the presence of discriminant validity. In order to fulfill conditions, value of correlations must be below 0,90 (Hair et al. [159]). If value is higher than 0,90, variables have the same constructs. According to intercorrelations between observed variables, there was no multicollinearity between variables. Necessary information about correlations are presented in Table 5.6-Table 5.12.

Table 5.6 Intercorrelations for the variables of "Resources and Capabilities"

F1	V1	V2	V3	V4	V5
V1	1	0,675	0,467	0,268	0,441
V2	0,675	1	0,566	0,338	0,347
V3	0,467	0,566	1	0,177	0,334
V4	0,268	0,338	0,177	1	0,331
V5	0,441	0,347	0,334	0,331	1

Table 5.7 Intercorrelations for the variables of "Project Management Competencies"

F2	V6	V7	V8	V9	V10	V11	V12	V13	V14
V6	1	0,226	0,236	0,404	0,371	0,084	0,363	0,347	0,229
V7	0,226	1	0,704	0,499	0,591	0,518	0,589	0,660	0,326
V8	0,236	0,704	1	0,498	0,604	0,362	0,498	0,624	0,476
V9	0,404	0,499	0,498	1	0,688	0,392	0,583	0,783	0,410
V10	0,371	0,591	0,604	0,688	1	0,498	0,633	0,687	0,340
V11	0,084	0,518	0,362	0,392	0,498	1	0,505	0,480	0,324
V12	0,363	0,589	0,498	0,583	0,633	0,505	1	0,664	0,484
V13	0,347	0,660	0,624	0,783	0,687	0,480	0,664	1	0,623
V14	0,229	0,326	0,476	0,410	0,340	0,324	0,484	0,623	1

Table 5.8 Intercorrelations for the variables of "Strategic Decisions"

F3	V15	V16	V17	V18	V19	V20	V21	V22	V23
V15	1	0,493	0,549	0,632	0,423	0,577	0,479	0,755	0,709
V16	0,493	1	0,492	0,689	0,417	0513	0,568	0,527	0,513
V17	0,549	0,492	1	0,595	0,443	0,504	0,376	0,433	0,431
V18	0,632	0,689	0,595	1	0,373	0,587	0,591	0,619	0,617
V19	0,423	0,417	0,443	0,373	1	0,528	0,366	0,435	0,327
V20	0,577	0,513	0,504	0,587	0,528	1	0,463	0,662	0,656
V21	0,479	0,568	0,376	0,591	0,366	0,463	1	0,512	0,517
V22	0,755	0,527	0,433	0,619	0,435	0,662	0,512	1	0,758
V23	0,709	0,513	0,431	0,617	0,327	0,656	0,517	0,758	1

Table 5.9 Intercorrelations for the variables of “External Factors (General Environment)”

F4	**V24**	**V25**	**V26**	**V27**	**V28**	**V29**	**V30**	**V31**
V24	1	0,484	0,559	0,321	0,408	0278	0,366	0,320
V25	0,484	1	0,532	0,356	0,553	0,369	0,525	0,406
V26	0,559	0,532	1	0,464	0,371	0,492	0,255	0,554
V27	0,321	0,356	0,464	1	0,399	0,252	0,494	0,353
V28	0,408	0,553	0,371	0,399	1	0,284	0,416	0,183
V29	0,278	0,369	0,492	0,252	0,284	1	0,203	0,354
V30	0,366	0,525	0,255	0,494	0,416	0,203	1	0,358
V31	0,320	0,406	0,554	0,353	0,183	0,354	0,358	1

Table 5.10 Intercorrelations for the variables of “External Factors (Business Environment)”

F5	**V32**	**V33**	**V34**	**V35**	**V36**	**V37**	**V38**
V32	1	0,176	0,567	0,554	0,454	0,480	0,753
V33	0,176	1	0,297	0,522	0,168	0,279	0,247
V34	0,567	0,297	1	0,512	0,407	0,264	0,712
V35	0,554	0,522	0,512	1	0,498	0,534	0,650
V36	0,454	0,168	0,407	0,498	1	0,298	0,621
V37	0,480	0,279	0,264	0,534	0,298	1	0,548
V38	0,753	0,247	0,712	0,65	0,621	0,548	1

Table 5.11 Intercorrelations for the variables of “Indicators Of Construction Companies Technology Transfer And Innovation Success”

F6	V39	V40	V41	V42	V43	V44	V45	V46	V47
V39	1	0,475	0,507	0,562	0,300	0,421	0,381	0,512	0,276
V40	0,475	1	0,666	0,583	0,686	0,481	0,373	0,432	0,475
V41	0,507	0,66	1	0,566	0,625	0,493	0,468	0,467	0,418
V42	0,562	0,583	0,566	1	0,600	0,577	0,411	0,567	0,471
V43	0,300	0,686	0,625	0,600	1	0,580	0,443	0,447	0,502
V44	0,421	0461	0,493	0,577	0,580	1	0,468	0,527	0,429
V45	0,381	0,373	0,468	0,411	0,443	0,468	1	0,368	0,352
V46	0,512	0,432	0,467	0,567	0,447	0,627	0,368	1	0,419
V47	0,276	0,475	0,418	0,471	0,502	0,429	0,352	0,419	1

Table 5.12 Intercorrelations for the variables of “Indıcators of Success of Constructıon Industry”

F7	V48	V49	V50	V51	V52
V48	1	0,475	0,474	0,277	0,203
V49	0,475	1	0,439	0,211	0,165
V50	0,474	0,439	1	0,425	0,332
V51	0,277	0,211	0,425	1	0,384
V52	0,203	0,165	0,332	0,384	1

5.5 Analysis of the Structural Innovation Model with SEM

In this study, SEM was choosen because a lot of interdependency is available in the same model. Analysis of the models consist of three phases. First of all model is specified. Secondly, estimation and identification of the model is performed. Finally, model is assessed bu using fit indice value.

5.5.1 Specification of the Model

Result of literature review and expert interviews, five variables that impact innovation performance in construction industry were identified. Model is distinguished in three models according to the statistical results. Three models are presented in Figure 5.6-Figure 5.8.

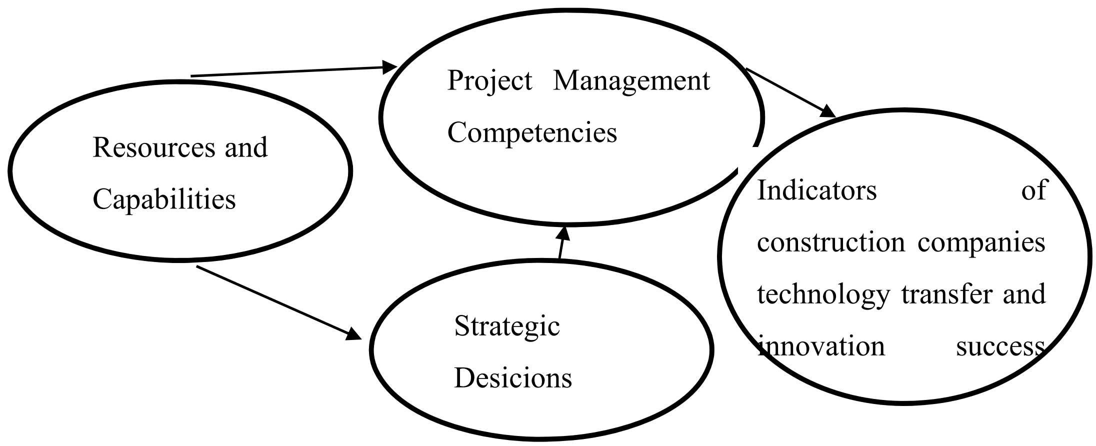


Figure 5.6 Model 1- Casual relationships between the latent factors of the model

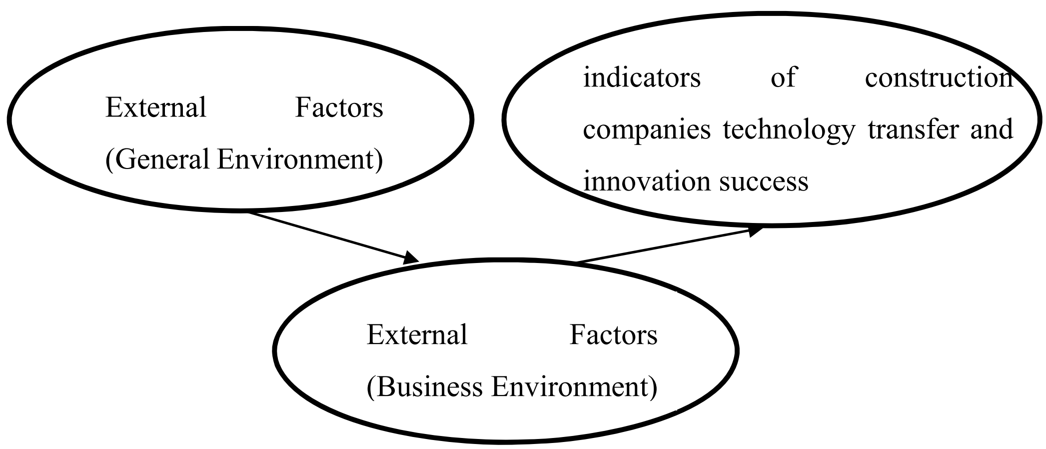


Figure 5.7 Model 2- Casual relationships between the latent factors of the model

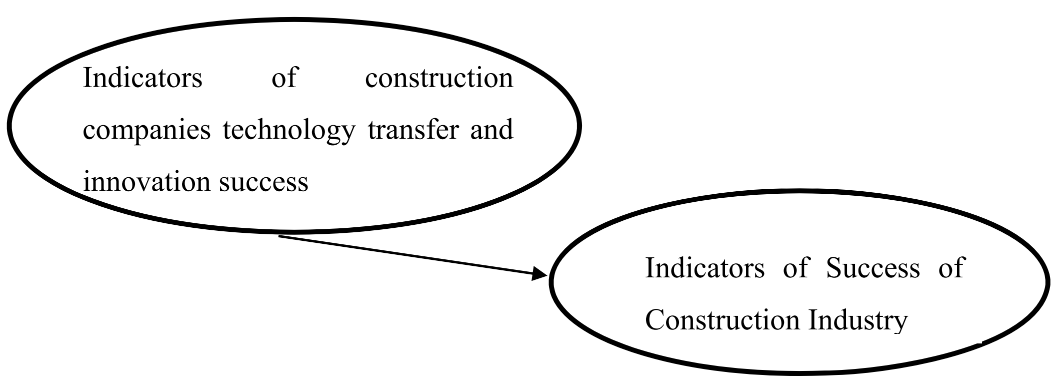


Figure 5.8 Model 3- Casual relationships between the latent factors of the model

In first model, “indicators of construction companies technology transfer and innovation success” is affected by “resources and capabilities”, “project management competencies” and “strategic decisions”.In second model, “external factors (general environment)” and “external factors (business environment)” affect “indicators of construction companies technology transfer and innovation success”. Final model is to show relationship between “indicators of construction companies technology transfer and innovation success” and 1indicators of success of construction industry”.

Although models are presented with patterns, they have equations among them. The relationships are used to analyze this structure.

First model is specified by the following direct path equations:

- indicators of construction companies technology transfer and innovation success = path coefficient 1* Project management competencies+error term 1
- Project management competencies= path coefficient 2* Strategic Decisions+Path coefficient 3*Resources and capabilities+error term 2
- Strategic Decisions=Path coefficient 4*Resources and capabilities+ error term 3

Second model is specified by the following direct path equations:

- indicators of construction companies technology transfer and innovation success = path coefficient 5* External Factors (Business Environment)+error terms 4
- External Factors (Business Environment)= path coefficient 6* External Factors (General Environment)+error terms 5

Last model is specified by the following direct path equations:

- indicators of construction companies technology transfer and innovation success = path coefficient7* Indicators od success in terms of technology transfer and innovation+error terms 6

5.5.2 Estimation and Identification of the Model

Every parameter of model is estimated via computer program. However they have to fulfill conditions in order to being able to specify being model. Lots of method are used in the literature. Some of them maximum likelihood (ML), generalized least squares (GLS), asymptotically distribution free (ADF) estimator, and robust statistics.

Maximum likelihood estimation seeks universe value which is derived from sample. Maximum likelihood method assumes that data has normal distribution. If data has non-normality distribution, it can be benefited from robust methodology. However as it was mentioned before, Mardia's coefficient must be considered.

5.5.3 Evaluation of the Model Fit

In this phase fitness between model and data is investigated. Model fit is determined by looking at non-normed fit index (NNFI), comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the ratio of chi-square per degree of freedom. Measurement model fit indices are presented in Table 5.13- Table 5.19

Table 5.13 Model fit indices for "Resources and capabilities"

Fit indices	**Allowable range**	**Overall**
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,996
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,998
RMSEA	<0,1	0,023
χ^2/degree of freedom	<3	1,0258

Table 5.14 Model fit indices for "Project management and competencies"

Fit indices	**Allowable range**	**Overall**
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,938
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,953
RMSEA	<0,1	0,082
χ^2/degree of freedom	<3	1,3418

Table 5.15 Model fit indices for "Strategic decisions"

Fit indices	**Allowable range**	**Overall**
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,983
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,987
RMSEA	<0,1	0,044
χ^2/degree of freedom	<3	1,100

Table 5.16 Model fit indices for “External Factors (General Environment)”

Fit indices	Allowable range	Overall
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,923
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,645
RMSEA	<0,1	0,079
χ^2/degree of freedom	<3	1,3193

Table 5.17 Model fit indices for “External Factors (Business Environment)”

Fit indices	Allowable range	Overall
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,943
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,962
RMSEA	<0,1	0,096
χ^2/degree of freedom	<3	1,4691

Table 5.18 Model fit indices for “indicators of construction companies technology transfer and innovation success”

Fit indices	Allowable range	Overall
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,973
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,980
RMSEA	<0,1	0,048
χ^2/degree of freedom	<3	1,118

Table 5.19 Model fit indices for “Indıcators of Success of Constructıon Industry”

Fit indices	Allowable range	Overall
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,969
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,985
RMSEA	<0,1	0,050
χ^2/degree of freedom	<3	1,1258

When reliability tests, fit indices and factor loadings were assessed, all of them was in the recommended ranges. After these statistics were obtained, evaluation of structure models were performed according to the same constraints. According to trials of model, models were specified. Until the final model was specified, 140 trials were performed. As a result of trials, model was distinguished into three models.

First model with path coefficients is presented in Figure 5.9. Afterwards path coefficient figure, fit indices for the first model is presented in Table 5.20.

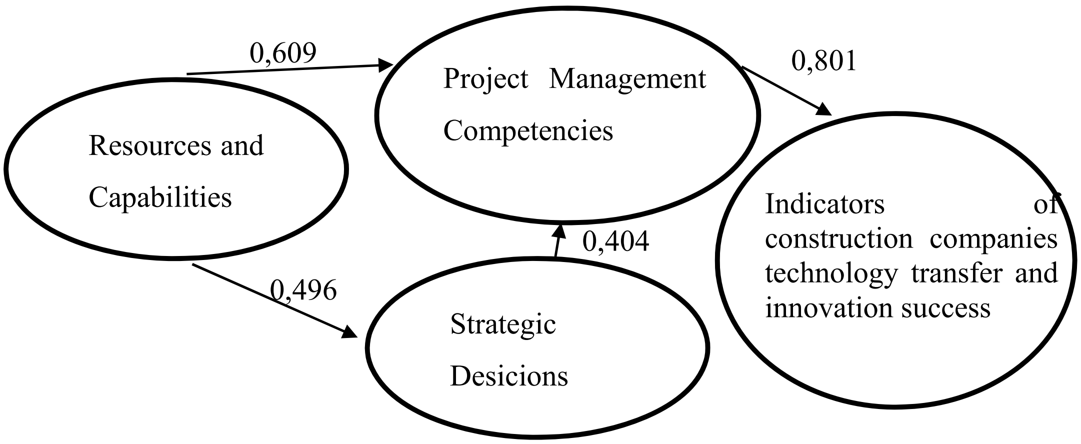


Figure 5.9First model with path coefficient

Table 5.20 Fit indices for the first model

Fit indices	**Allowable range**	**Overall**
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,758
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,775
RMSEA	<0,1	0,097
χ^2/degree of freedom	<3	1,4765

Second model with path coefficients is presented in Figure 5.10. Afterwards path coefficient figure, fit indices for the first model is presented in Table 5.21.

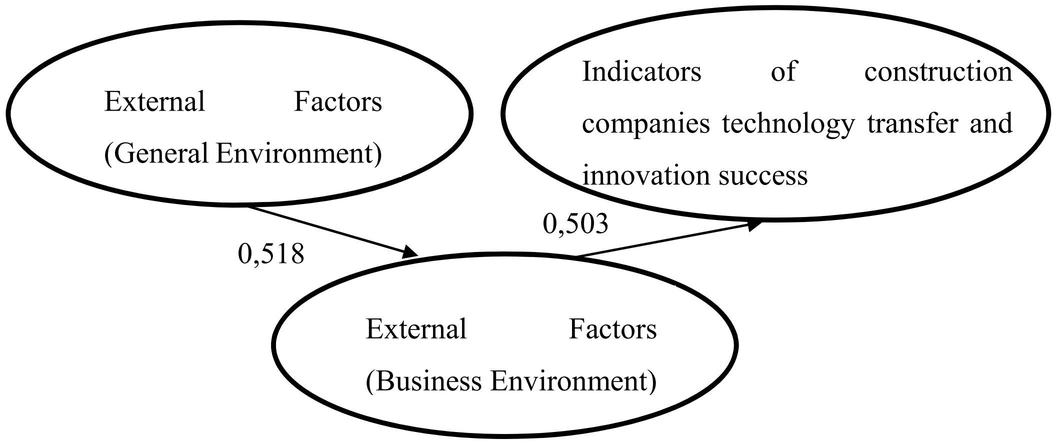


Figure 5.10 Second model with path coefficient

Table 5.21 Fit indices for the second model

Fit indices	Allowable range	Overall
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,794
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,814
RMSEA	<0,1	0,092
χ^2/degree of freedom	<3	1,431

Last model with path coefficients is presented in Figure 5.11. After path coefficient fit indices for the first model is presented in Table 5.22.

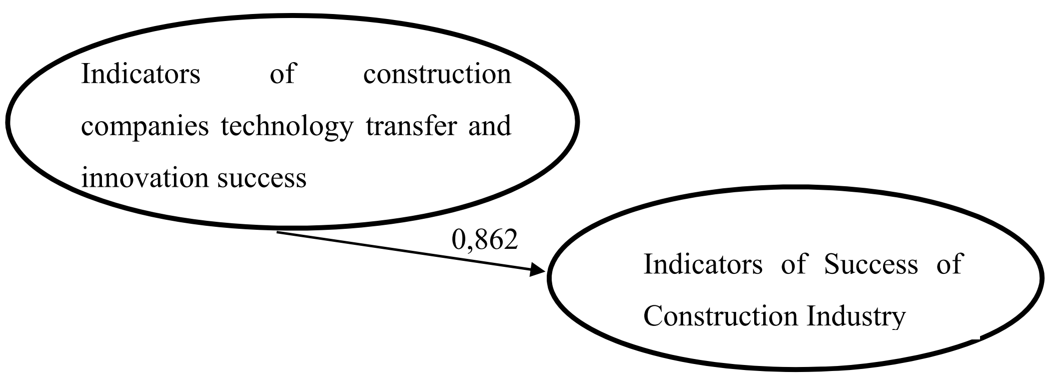


Figure 5.11 Last model with path coefficient

Table 5.22 Fit indices for the last model

Fit indices	**Allowable range**	**Overall**
Non-normed fit index (NNFI)	0 (no fit)-1(perfect fit)	0,848
Comparative fit index (CFI)	0 (no fit)-1(perfect fit)	0,873
RMSEA	<0,1	0,090
χ^2/degree of freedom	<3	1,4088

5.6 Overall view of the Analysis Results

Collected data from 52 construction companies were analyzed in order to reveal innovation model. According to revealing innovation model, SEM methodology was performed. Therefore SEM software programme (EQS 6.2) was used. Values of all of structure models and measurement models were at allowable range. Furthermore, all values of regression coefficient and path coefficients were significant at α=0,05.

CHAPTER 6

RESULTS AND DISCUSSION

In this chapter major findings of the research will be discussed on the basis of previous research.

6.1 Impact of Company Innovation and Technology Transfer Efforts

Since construction industry is a captial intensive sector, it causes paticipation of new competitors easily into sector. Moreover, the problems faced in the projects need new solution methods. Another important criteria in tending to innovation and technology transfer efforts is technological advancement in other sectors. In the light of the issues, innovation and technology transfer activities enable diferantiation in companies. Therefore “indicators of construction companies technology transfer and innovation success” was taken to be major subject.

“Indicators of construction companies technology transfer and innovation success” subject shows why construction companies want to make innovation and technology transfer efforts. In other words it is to present reason of efforts. Therefore accepted indicators in literature were choosen and it eliminated according to the pilot study and discussions. Considered variables are “higher perceived value (quality)”, “completion of project on budget”, “completion of project on time”, “competitive advantage among rivals”, “reputation/company image”, “productivity”, “financial indicators”, “learning and development”, and “satisfaction of customer/consumer”.

As a result of SEM analysis, factor loadings of measurement model relative to “indicators of construction companies technology transfer and innovation success”were found to be 0,605 for “higher perceived value (quality)”, 0,770 for “completion of project on budget”, 0,769 for “completion of project on time”, 0,784 for “competitive advantage among rivals”, 0,779 for “reputation/company image”, 0,718 for “productivity”, 0,567 for “financial indicators”, 0,672 for “learning and development” and 0,595 for “satisfaction of customer/consumer”. As is seen, “competitive advantage among rivals” has the largest score on realization of innovation and technology transfer at construction companies. “Reputation/company image”, “completion of project on budget”, “completion of project on time”, “productivity”, “learning and development”, “higher perceived value (quality)”, “satisfaction of customer/consumer” and “financial indicators were followed “competitive advantage among rivals” respectively. The findings of the analysis generally shows that, competition in construction sector and connected factors to it are to affect innovation and technology transfer activities in construction companies. However this findings shows that tangible earns such as “reputation/company image”, “learning and development” come into prominence in construction companies.

In order to present three models, now “indicators of construction companies technology transfer and innovation success” of three models will be discussed. Three models of factor loadings are given in Table 6.1.

Table 6.1 Factor loadings of three models of indicators of construction companies technology transfer and innovation success

Indicators of construction companies technology transfer and innovation success	**Factor loadings**		
	Model 1	**Model 2**	**Model 3**
Higher perceived value	0,638	0,605	0,621
Completion of project on budget	0,746	0,756	0,740
Completion of project on time	0,730	0,757	0,749
Competitive advantage among rivals	0,793	0,783	0,791
Reputation/Company image	0,745	0,772	0,753
Productivity	0,756	0,741	0,747
Financial indicators	0,532	0,575	0,589
Learning and development	0,724	0,689	0,710
Satisfaction of customer/consumer	0,584	0,588	0,567

Analysis of variables show that all of variables have significant impact in technology transfer and innovation. Results of analysis emphasized that “competitive advantage among rivals” have the highest impact in realization of innovation and technology transfer activities.

6.2 Model 1- Internal Capabilities Impact on Innovation and Technology Transfer

In the first model, internal capabilities effects were considered such as "Project management competencies", "strategic decisions" and "resources and capabilities" on "indicators of construction companies technology transfer and innovation success". Now, first model results will be given according to SEM analysis. Related model is presented in Figure 6.1.

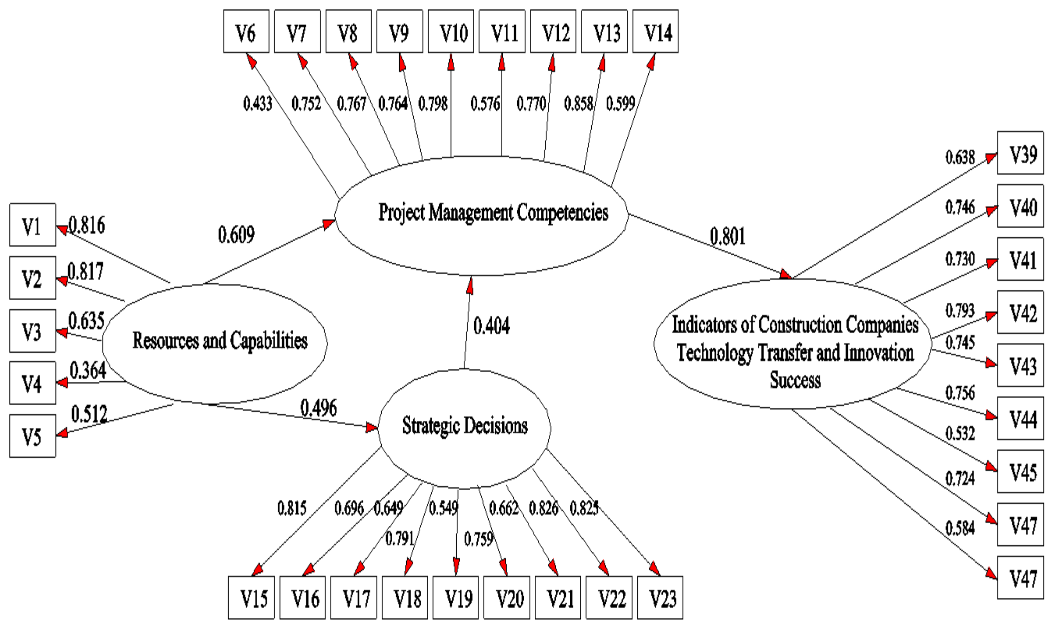


Figure 6.1 Model 1- Internal capabilities impact on innovation and technology transfer

6.2.1 Effect of Project Management Competencies on Innovation and Technology Transfer in Construction Companies

In the first model, "project management competencies" were found to have a direct influence on performance. The importance of project management competencies was emphasized in the literature. According to the study of Keegan and Turner [5], strict project management methods cause to impede innovational activities in construction industry. Another study which support indirect effect of Project management on innovation belongs to Gann and Salter [46]. They stated that work load of contractor and operators consists of pressure on delivery time, budget and quality.

According to the analysis of model 1, factor loadings of the variables were found to be as 0,433 for "energy management", 0,752 for "knowledge management", 0,767 for "value management", 0,764 for "health and safety management", 0,798 for "quality management", 0,576 for "cost management", 0,770 for "risk management", 0,858 for "procurement management", and 0,599 for "time management".

Regarding the allowable results of the analysis, it can be asserted that "procurement management" in a company can be efficient in the execution of all innovation and technology transfer processes. Secondly, "quality management" reveal being driving force on technology transfer and innovation in project management activities. These two variables approve nature of innovation and technology transfer in construction industry.

Technology transfer activities are related to procurement management activities directly. Therefore it may orginate from this reason. In the literature, Gann and Salter [46] stated that challenges depending on project can cause to procurement Technologies. This is to support to our findings from analysis.

Another high loading of the model is "quality management". Literature findings show us quality management activities which involve total quality management activities have a positive impact on innovations (Hoang et al. [160]). Another study about this impact was seen Bossink [161] study. Bossink stated that strategic quality management have a positive impact on innovation management.

6.2.2 Effect of Strategic Decisions on Innovation and Technology Transfer in Construction Industry

"Strategic decision" has no direct effect on innovation and technology transfer in construction industry, but via "project management competencies". Importance of strategic decisions on innovation and technology transfer activities in construction industry was investigated by Gambatese and Hallowell [48]. Another study which support importance of "strategic decisions" in construction innovation belongs to Barrett and Sexton [162]. They stated that business strategies can affect innovation in small, project-based construction firms. They considered strategy under the "upper management support". As a result of study, strategic decisions about innovation have facilitator role in construction industry. However, "project management competencies" and "strategic decisions" have a relationship. This relationship between business strategy and Project management can be two-way according to Srivannaboon and Milosevic [163]. Acoording to the analysis of SEM, "Strategic decisions" ,which were given above, affect "project management competencies". Its variables support both "project management competencies" and "indicators of innovation and technology transfer" via "project management competencies” indirectly. Furthermore results of analysis of SEM of first model were found effect of “resources and capabilities” on “strategic decisons”.

In the light of the SEM results, these findings are approved. According to the analysis of first model, “supplier selection strategies” were found to have the highest impact on “project management competencies”. Another variable “investment strategies” is close to the loadings of “project management competencies”. Factor loadings of the variables were found to be as 0,815 for “subcontroctor selection strategies”, 0,791 for “cost leadership strategies”, 0,759 for “market selection strategies”, 0,696 for “differentiation strategies”, 0,662 for “strategical diversification”, 0,649 for “human resources strategies”, and 0,549 for “client selection strategies”.

The highest score “supplier selection strategies” is supported by Schiele [164] study. Schiele stated that innovation is the way for surviving of companies. Therefore they need to puchase new technologies. At this point, innovative suppliers play an important role.

The second highest score is “investment strategies”. This finding can be supported by explanation of Seaden et al. [13]. They stated that “the focus of innovation is considered to be the business firm since that is where the benefits of the investment can be observed and measured”. This shows that “investment strategies” are related to innovation and technology transfer activities.

Another highest score is “cost leadership strategies” according to the analysis. Teece [113] stated that innovation can provide low cost to customer. This statement supports anture of cost leadership strategies impact on innovation according to the literature. And cost savings are seen in indicators of innovation and technology transfer activities indicators.

6.2.3 Effect of Resources and Capabilities on Innovation and Technology Transfer Indicators

In the literature, it stated that lack of resources and capabilitieshave an influnce according to innovation by Barrett and Sexton [162]. Therefore “know-how, experience and learning capacity”, “leadership”, “brand, corporate identity, image in society”, “technological secrets” and “organizational culture” are taken into consideration in this study.

According to the results, direct impact of “resources and capabilities” on innovation and technology transfer indicators were not found. In stead of this, the impact was seen via “project management competencies”. This issue was also explained by Brady et al. [165]. They stated that project management is responsible for companies resources. If the impact is compared to “strategic decisions”, results show that it has higher impact on “project management competencies” than “strategic decisions” according to the path analysis score (0,609-0,404).

Analysis of first model shows that “resorces and capabilities” have impact on both “project management compatencies” and “strategic decisions”. This impact were found to be as 0,609 for “impact of resources and capabilities on project management competencies” and 0,496 for “impact of resources and capabilities on strategic decisions”. As a result of analysis of “resources and capabilities”, factor loadings of the variables were found to be as 0,816 for “know-how, experience and learning capacity”, 0,817 for “leadership”, 0,635 for “brand, corporate identity, image in society”, 0,364 for “technological secrets” and 0,512 for “organizational culture”.

The highest score is “leadership” from analysis of model 1. This findings were supported by Sorros et al. [166] study. They stated that transformational leadership have an impact on organizational culture. Also organizational culture support to climate for organizational innovation. Furthermore another study mentioned about effect belongs to Bossink [161].

6.3 Model 2- External Factors Impact on Innovation and Technology Transfer Indicators

In second model, external factors were taken into consideration. In the literature, it was external factors’ effect on innovation was mentioned by Jurado et al. [167]. They considered manufacturing firms. Furthermore they stated that the effect of external factors can change according to the type of industry. Therefore second model for external factors effect on innovation and technology transfer were considered separetely from first model. Related model is given in Figure 6.2.

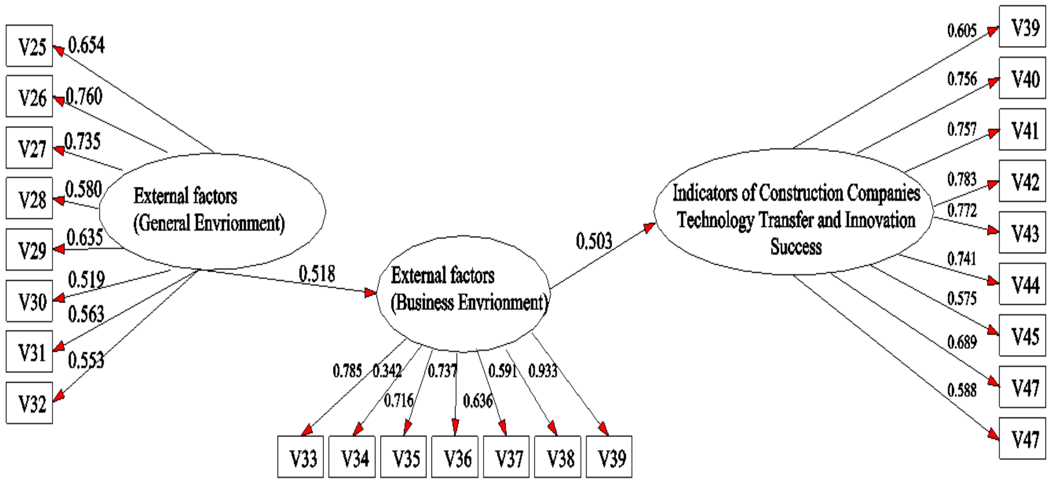


Figure 6.2 Model 2- External factors impact on innovation and technology transfer indicators

6.3.1 Effect of External Factors (General Environment) on Innovation and Technology Transfer Indicators

External factors (general environment) have no direct effect on the Indicators of construction companies technology transfer and innovation success. Instead of this, this impact is measured via external factors (business environment). This issue arises from statistical analysis in SEM or its variables. Path analysis of model 2 shows the path coefficient between external factors (general environment) and external factors (business environment) is 0,518.

Another result in SEM analysis is the variables factor loadings on external factors (general environment) in model 2. According to the analysis, factor loadings of the variables were found to be as 0,654 for "governmental incentives on research and innovation", 0,760 for "environmental (ecological) factors", 0,735 for "macro economical fluctuations", 0,580 for "political stability", 0,635 for "sociocultural conflicts", 0,519 for "technological advancements", 0,563 for "international relations" and 0,553 for "laws and regulations".

In the light of results, it was found that "environmental (ecological) factors" have the highest score on external factors (general environment). In the literature this result is supported by Jafe and Palmer's study [168]. They revealed that environmental regulations trigger innovational activities by companies.

The second highest score belongs to "macroeconomic fluctations". Audretsch and Acs [9] stated that small enterprises like startups have a positive impact on absorbtion of macroeconomic flactations. Therefore startups which are products of technology transfer and innovational activities can be used for blocking macroeconomic fulctuation efects. This reason can explain our results in terms of trigger effect between macroeconomic fluctations and innovation and tecnology transfer activities.

6.3.2 Effect of External Factors (Business Environment) on Innovation and Technology Transfer Indicators

According to the analysis, external factors (business environment) fed from external factors (general environment). Moreover it has a direct relationship with innovation and technology transfer indicators. Path analysis of model 2 shows that path coefficient between external factors (business environment) and innovation and technology transfer indicators is 0,503.

As is mentioned above, “client power”, “boundary of market”, “demand”, “market structure”, “severity of competition between companies”, “supplier power”, and “threat of new entrepreneurs” were taken into consideration in model. According to the analysis, factor loadings of the variables were found to be as 0,785 for “client power”, 0,342 for “boundary of market”, 0,716 for “demand”, 0,737 for “market structure”, 0,636 for “severity of competition between companies”, 0,591 for “supplier power”, and 0,933 “threat of new entrepreneurs”.

The highest score is “threat of new entrepreneurs”. This exerts pressure on companies in order to innovative or differantiation from other companies. One of the sollution for differantiation strategy can be realized ith technology transfer and innovation.

Another the important variable under the business environmet is “client power”. This result is supported by Winch study [169]. Winch specified that client is the one of the actor in innovation infrastructure in construction industry.

6.4 Model 3- Indicator of Innovation and Technology Transfer Impact on Indicators of Construction Industry

Innovation and technology transfer activities’ impact on construction industry has been investigated many times by researchers in the literature. Therefore relationship between innovation and technology transfer indicators and indicators of construction industry ere examined. However according to the small sample size and the data fluctation, indicators of innovation and technology transfer impact on indicators of construction industry were investigated in different model. The result of path analysis is shown in Figure 6.3.

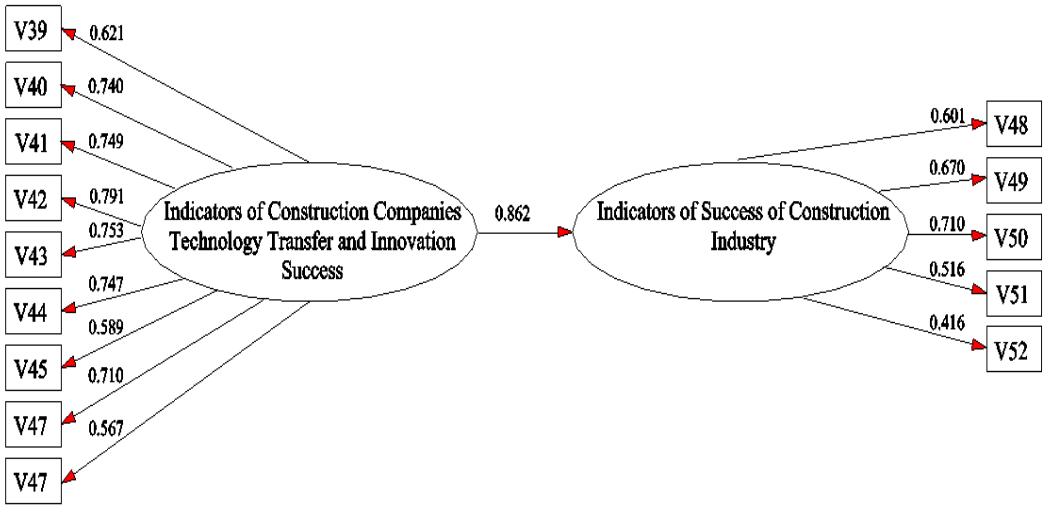


Figure 6.3 Model 3- Indicator of innovation and technology transfer impact on indicators of construction industry

6.4.1 Indicators of Construction Industry

Indicators of construction industry were evaluated in terms of five factors. These factors were choosen according to relationship between innovation and technology transfer efforts of companies and industry. Therefore "Indicators of construction companies technology transfer and innovation success" were designed including "material and workmanship prices", "turnover and production", "employment", "development level of building materials sector", and "ıncrease on number of multinational firms". The factor loadings of these variables were found to be as 0,601 for "material and workmanship prices", 0,670 for "turnover and production", 0,710 for "employment", 0,516 for "development level of building materials sector", and 0,416 for "increase on number of multinational firms". According to the analysis of data "employment" were found to be the highest variables. "Material and workmanship prices", "turnover and production", "development level of building materials sector", and "increase on number of multinational firms" were followed pecpectively. The findings of analysis show that innovation and technology transfer idicators are to be able to affect to measurement parameter of construction industry. The highest score belongs to "employment according to the analysis. In the literature, according to Reenen [170] study, they stated that there are relationship between employment and technological innovations. In other words, result of analysis is supported by literature.

According to the pair analysis of “Indicators of construction companies technology transfer and innovation success” and “indicators of success of construction industry”, path coefficient is 0,862. This shows that relationship between “indicators of construction companies technology transfer and innovation success” and “indicators of success of construction industry” is very strong.

CHAPTER 7

CONCLUSION

Increasing globalisation has a considerable effect on construction industry. This effect requires durability against competitiveness. One of the solution of this problem is innovative practices. These practices enable to differentiate innovative companies from others (Seaden and Manseau [36]). In the literature, study which emphasize technology transfer activities in construction industry belongs Ofori [2]. Ofori stated that technology which is developed by industrialized countries has a positive impact in developing countries. Furthermore this impact is more important when ratio of construction industry's GDP is taken into consideration. Therefore innovation and technology transfer activities in construction industry were considered.

According to the innovation and technology transfer issue, types of innovation and technology transfer were investigated from literature. As a result of literature review, necessary models and studies were given in previous chapters. Under favor of this literature review, indicators of innovation and technology transfer were specified. After determination of indicators of construction companies technology transfer and innovation success, it was argued how construction firms gain indicators. Therefore "resources and capabilities", "Project management competencies", "strategic decisions", and "external factors" were taken into consideration. Finally, construction industry indicators were analysed in order to measure effect of innovation and technology transfer on construction industry indicators.

Structural Equation Modeling was used as the analysisi method. This method is used because it enables to measure unobserved variable via observed variables. Besides these structures measure causual relationships.

In order to collect information about these seven latent factors and their 52 observed variables, a questinnaire was performed to 52 construction companies. In questionnaire, 1-5 Likert Scale was used.

Collected data analysed with SEM method in order to construct the assessment framework. However a single framework didn't reveal. Therefore assessment framework has been distinguished into three different models. These models measure effects of company's internal factor on indicators of innovation and technology transfer, external factor on indicators of innovation and technology transfer and indicators of innovation and technology transfer on indicators of construction industry. Although poor data exists at statistical analysis, results of analysis of models stayed allowable ranges.

Model 1 consists of "resources and capabilities", "strategic decisions", "Project management competencies" and "indicators of construction companies technology transfer and innovation success" as the latent factors. Analysis of model 1 showed that all variables have a significant role on forming of "indictors of innovation and technology transfer". "Competitive advantage", "productivity" and "completion project on budget" have the highest score respectively. If companies gain these, companies pay attention to processes of "procurement management", "quality management", "risk management", "supplier selection strategies", "investment strategies", "know-how, experience and learning capacity", "leadership" etc. Another interpretation about model is that variables of "resources and capabilities", and "strategic decisions" feed "project management competencies".

Model 2 consists of "external factors" and "indicators of construction companies technology transfer and innovation success" latent factors. However external factors were distinguished into two categories as general environment and business environment. Analysis of model shows that general factors affect "indictors of innovation and technology transfer" via business environment. Analysis of SEM shows that all variables are significant and model was within the allowable ranges.

Model 3 was consisted for measuring effect of "indicators of construction companies technology transfer and innovation success" on "indicators of construction industry". Analysis of model shows that strong relationship between "indictors of innovation and technology transfer" and "indicators of construction industry". Results explained that indicators of construction companies technology transfer and innovation success have positive impact on "material and workmanship prices", "turnover and production", "employment", "development level of building materials sector", and "ıncrease on number of multinational firms".

Combination of three model or assessment framework state that if construction companies want to achieve "indicators of construction companies technology transfer and innovation success", they should consider "resources and capabilities", "strategic decisions", "project management competencies" and "external factors". However all of these latent factors have not got direct relationship with "indictors of innovation and technology transfer". Some of them have enhancer impact on other latent factors. All latent factors and their variables have a relationship with "indicators of construction companies technology transfer and innovation success" directly or indirectly. Furthermore innovation and technology transfer impact on construction industry come out from analysis.

Another important finding is intersection of some key performance indicators and indicators innovation and technology transfer. According to Cox et al. [171], key performance criteria like on-time completion, cost resemble. Therefore innovation and technology transfer activities can be used activity which develop performance in construction companies. Another study about performance measurement for construction industry belongs to Isık [172] who specified four criteria for performance measurement. These are namely financial, learning and growth, internal business, and customer. According to similarity between output of innovation and techneology transfer and performance measurement, it can be said that innovation and technology transfer have supportive structure company performance.

As a consequence, innovation and technology transfer assessment framework developed in this study is aimed to increase innovation and technology transfer activities in construction industry. Moreover framework can be used as a tool when construction companies would like to perform innovation and technology transfer. When framework is used by company, it provides differentiation for the company. In other words, these activities provides competitive advantage to companies. However these advantages aren't limited to companies. Also they spark construction industry in the way of development. Therefore faster development and modernisation in construction industry can be reached throuhout innovation and technology transfer.

Consequently, under favor of created framework, not only construction companies specify necessary activities in order to make an innovation and technology transfer, but also they specify measures for indicators of innovation and technology transfer to perform successful innovation and technology transfer. Thus internal and external capabilities of companies are regulated by looking at these models in order to both increase indicator innovation and technology performance and construct structure is compability with innovation and technology transfer. These models should be used for an innovation and technology transfer assessment framework for the construction industry.

Suggestions for Further Research

The suggestions for future research can be split into three groups. While two of them include model development, one of them is related to innovation and technology transfer scorecard.

In the context of study, the questionnaire was performed only to contractor companies. However construction industry has a lot of subsectors. In order to emerge an innovation and technology transfer model, these questionnaires should be performed to stakeholders of construction industry.

A general model which consists both the internal and external factors may be constructed with more data. A general model will enable all factors to work together. By this way, comparison between external and internal factors can be prioritized.

The last suggestion is about the development of a scorecard. Scorecard can be used for rating companies' innovational and technological transfer activities which enables benchmarking among companies.

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APPENDIX A

SAMPLE OF QUESTIONNAIRE

A.1 GENERAL INFORMATION ABOUT THE RESPONDENTS

Please fill/mark in the blanks below.

1. Please mark related types of stakeholder.
   ☐ Contractor company ☐ Metarial supplier company ☐ Machine supplier company

2. Please indicate general information of your company.

COMPANY INFORMATION	
1. How many years are your company active in construction industry?	☐ 0-5 year ☐ 5-10 year ☐ 10-15 year ☐ 15> year
2. Please state your company's domestic turnover the last 5 years	
3. Please state your company's international turnover the last 5 years	
4. Please indicate countries in which your companies are active.	
5. Do you have R&D departmant in your company?	☐ Yes ☐ No
6. Please indicate numbers of R&D departmant staff's number.	Number of workers: ……..
7. Does your company have any patent? If you have, please indicate number.	☐ Yes ☐ No Number of patent: ……..
8. Does your company have any licensing agreement? If you have, please indicate number.	☐ Yes ☐ No Number of license: ……..
9. Have your company got any certification system such as ISO, OHSAS etc.?	☐ Yes ☐ No
10. Have your company ever realized collaboration with university/research institution? Please give an brief information about itç	☐ Yes ☐ No Explanation:

3. Please respond according to the your specialized area.

Contractor Companies		
1. Please state area of expertise of your companies.		
Building (Dwelling, turistic facilities, business center, social and cultural facilities, hospitals, military installation, universities, civic center etc.)	☐	
Transportation buildings (Highway, tunnel, bridge, railway, harbor, airport etc.)	☐	
Infrastructure systems (water and sanitation systems, pipelines etc.)	☐	
Water (Dam, irrigation facility etc.)	☐	
Industrial facilities	☐	
Other (Please indicate)		
2. Have your company ever realized any energy efficiency Project?	☐ Yes	☐ No
3. Does your company have any green building certification?	☐ Yes	☐ No
Material Supplier Companies		
1. Please state area of expertise of your companies.		
Ready mixed concrete	☐	
Asphalt	☐	
Sanitary system	☐	
Formwork systems	☐	
Prefabricated structural member	☐	
Steel structural member	☐	
Reinforcement	☐	
Paving materials	☐	
Isolation materials	☐	
Paint	☐	
Wood	☐	
Other		
Machine Supplier Companies		
1. Please state area of expertise of your companies.		
Lighting systems	☐	
Energy systems	☐	
Air-conditioning systems	☐	
Construction equipments	☐	
Construction tools	☐	
Work safety equipments	☐	
Other		

A.2 Questions of Survey

A.2.1 Importance level: Please indicate importance level variables which are given under the “resources and capabilities”.

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

Resources and Capabilities	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Know-how, experience and learning capacity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Leadership	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brand, Corporate identity, Image in society	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technological secrets	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Organizational culture	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.2 Importance level: Please indicate importance level variables which are given under the “project management competencies”.

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

Project Manajement Competencies	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Energy management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knowledge management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Value management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Health and safety management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Quality management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cost management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Risk management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Procurement management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Time management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.3 Importance level: Please indicate importance level variables which are given under the “Strategic Decisions”.

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

Strategic Decisions	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Subcontractor selection strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Differentiation strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Human Resources strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cost leadership strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Client selection strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Market selection strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Strategical diversification (horizontal, vertical and combined)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Supplier selection strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Investment strategies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.4 Importance level: Please indicate importance level variables which are given under the “External factors (General Environment)”.

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

External factors (General Environment)	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Governmental incentives on research and innovation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Environmental (ecological) factors	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Macro Economical fluctuations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Political Stability	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sociocultural conflicts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technological advancements	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
International relations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Laws and Regulations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.5 Importance level: Please indicate importance level variables which are given under the "External factors (Business Environment)".

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

External factors (Business Environment)	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Client power	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Boundary of market	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Demand	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Market structure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Severity of competition between companies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Supplier power	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threat of new entrepreneurs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.6 Importance level: Please indicate importance level variables which are given under the "indicators of success in terms of technology transfer and innovation".

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

Indicators of construction companies technology transfer and innovation success	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Higher perceived value	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Completion of project on budget	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Completion of project on time	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Competitive advantage among rivals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reputation/Company image	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Financial indicators	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Learning and development	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Satisfaction of customer/consumer	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

A.2.7 Importance level: Please indicate importance level variables which are given under the "indicators of success of construction industry".

Implementation level: Please rate implemantation level of these variables which are taken into consideration in your company. (N/A: it can not be evaluated)

Indicators of success of construction industry	Importance Level					Implementation Level					N/A
	1	2	3	4	5	1	2	3	4	5	
Material and workmanship prices	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Turnover and production	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Employment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Development level of building materials sector	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Increase on number of multinational firms	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Material and workmanship prices	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

APPENDIX B

DESCRIPTIVE STATISTICS

Table B.1 Descriptive statistics of general information on respondent companies

	Range	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Age (year)	62,00	2,00	64,00	758,00	15,4694	1,70037
Domestic Turnover	16899000000,00	1000000,00	16900000000,00	54658180000,00	1115473061,2245	388232643,60745
International Turnover	27000000000,00	,00	27000000000,00	75469320000,00	1540190204,0816	736483902,69183

Table B.1 Descriptive statistics of general information on respondent companies (Cont'd)

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Age (year)	11,90256	141,671	2,045	,340	5,749	,668
Domestic Turnover	2717628505,25218	7385504692559184900,000	4,533	,340	24,290	,668
International Turnover	5155387318,84282	26578018407285380000,000	3,934	,340	15,441	,668

Table B.2 Descriptive statistics of general information on respondent companies

	Range	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Total Turnover	33099000000,00	1000000,00	33100000000,00	130127500000,00	2655663265,3061	953018258,01591
Number of countries operated	6,00	1,00	7,00	100,00	2,0408	,23683
Number of R&D worker	20,00	,00	20,00	69,00	1,4082	,51336
Number of patent	10,00	,00	10,00	21,00	,4286	,22399
Number of license	14,00	,00	14,00	81,00	1,6531	,46525
Number of certificate	1,00	,00	1,00	33,00	,6735	,06769
Unıiversity-Industry relationship	1,00	,00	1,00	6,00	,1224	,04731

Table B.2 Descriptive statistics of general information on respondent companie(Cont'd)

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Total Turnover	6671127806,11138	44503946205472450000,000	3,514	,340	12,512	,668
Number of countries operated	1,65780	2,748	1,563	,340	1,508	,668
Number of R&D worker	3,59350	12,913	3,646	,340	15,394	,668
Number of patent	1,56791	2,458	5,158	,340	29,985	,668
Number of license	3,25673	10,606	2,199	,340	4,438	,668
Number of certificate	,47380	,224	-,763	,340	-1,479	,668
Unıiversity-Industry relationship	,33120	,110	2,377	,340	3,803	,668

Table B.3 Descriptive statistics of variables regarding "implementation level"

	Range	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
VAR00001	4.00	1.00	5.00	202.00	3.8846	.14954
VAR00002	4.00	1.00	5.00	188.00	3.6154	.15572
VAR00003	4.00	1.00	5.00	191.00	3.6731	.17308
VAR00004	4.00	1.00	5.00	128.00	2.4615	.19508
VAR00005	4.00	1.00	5.00	164.00	3.1538	.15385
VAR00006	4.00	1.00	5.00	141.00	2.7115	.17003
VAR00007	4.00	1.00	5.00	180.00	3.4615	.14651
VAR00008	4.00	1.00	5.00	177.00	3.4038	.15106
VAR00009	3.00	2.00	5.00	186.00	3.5769	.12982
VAR00010	3.00	2.00	5.00	183.00	3.5192	.12431

Table B.3 Descriptive statistics of variables regarding "implementation level"(Cont'd)

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
VAR00001	1.07838	1.163	-.738	.330	-.277	.650
VAR00002	1.12291	1.261	-.214	.330	-.647	.650
VAR00003	1.24808	1.558	-.538	.330	-.763	.650
VAR00004	1.40673	1.979	.345	.330	-1.351	.650
VAR00005	1.10940	1.231	.042	.330	-.661	.650
VAR00006	1.22613	1.503	.250	.330	-.760	.650
VAR00007	1.05647	1.116	-.518	.330	.005	.650
VAR00008	1.08934	1.187	.067	.330	-.905	.650
VAR00009	.93612	.876	-.083	.330	-.810	.650
VAR00010	.89641	.804	-.060	.330	-.680	.650

Table B.4 Descriptive statistics of variables regarding "implementation level"

	Range	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
VAR00021	4.00	1.00	5.00	152.00	2.9231	.16670
VAR00022	4.00	1.00	5.00	166.00	3.1923	.16256
VAR00023	4.00	1.00	5.00	155.00	2.9808	.16589
VAR00024	4.00	1.00	5.00	125.00	2.4038	.17425
VAR00025	4.00	1.00	5.00	126.00	2.4231	.14361
VAR00026	4.00	1.00	5.00	172.00	3.3077	.14925
VAR00027	4.00	1.00	5.00	167.00	3.2115	.17224
VAR00028	3.00	1.00	4.00	130.00	2.5000	.15656
VAR00029	4.00	1.00	5.00	172.00	3.3077	.14411
VAR00030	4.00	1.00	5.00	139.00	2.6731	.17088
VAR00031	4.00	1.00	5.00	160.00	3.0769	.13126
VAR00032	4.00	1.00	5.00	169.00	3.2500	.13969
VAR00033	4.00	1.00	5.00	170.00	3.2692	.14561
VAR00034	4.00	1.00	5.00	160.00	3.0769	.14749
VAR00035	4.00	1.00	5.00	181.00	3.4808	.13023
VAR00036	4.00	1.00	5.00	188.00	3.6154	.16049
VAR00037	5.00	1.00	6.00	173.00	3.3269	.16182
VAR00038	4.00	1.00	5.00	150.00	2.8846	.19545
VAR00039	3.00	2.00	5.00	176.00	3.3846	.11374
VAR00040	3.00	2.00	5.00	201.00	3.8654	.13739

Table B.4 Descriptive statistics of variables regarding "implementation level" (Cont'd)

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
VAR00021	1.20206	1.445	-.058	.330	-.545	.650
VAR00022	1.17220	1.374	.066	.330	-.891	.650
VAR00023	1.19624	1.431	-.248	.330	-.867	.650
VAR00024	1.25651	1.579	.350	.330	-1.151	.650
VAR00025	1.03557	1.072	.159	.330	-.635	.650
VAR00026	1.07628	1.158	-.557	.330	-.228	.650
VAR00027	1.24202	1.543	-.292	.330	-.859	.650
VAR00028	1.12894	1.275	-.085	.330	-1.376	.650
VAR00029	1.03920	1.080	-.443	.330	-.268	.650
VAR00030	1.23226	1.518	.008	.330	-1.025	.650
VAR00031	.94653	.896	-.158	.330	-.591	.650
VAR00032	1.00733	1.015	-.172	.330	-.443	.650
VAR00033	1.05003	1.103	-.149	.330	-.203	.650
VAR00034	1.06359	1.131	-.158	.330	-.930	.650
VAR00035	.93914	.882	-.238	.330	-.168	.650
VAR00036	1.15731	1.339	-.450	.330	-.706	.650
VAR00037	1.16688	1.362	.245	.330	-.842	.650
VAR00038	1.40941	1.986	.300	.330	-1.212	.650
VAR00039	.82018	.673	-.168	.330	-.582	.650
VAR00040	.99072	.982	-.223	.330	-1.175	.650

Table B.5 Descriptive statistics of variables regarding “implementation level”

	Range	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
VAR00041	4.00	1.00	5.00	205.00	3.9423	.13844
VAR00042	3.00	2.00	5.00	189.00	3.6346	.11979
VAR00043	3.00	2.00	5.00	202.00	3.8846	.12480
VAR00044	4.00	1.00	5.00	183.00	3.5192	.14658
VAR00045	4.00	1.00	5.00	174.00	3.3462	.15748
VAR00046	4.00	1.00	5.00	180.00	3.4615	.15403
VAR00047	3.00	2.00	5.00	200.00	3.8462	.12091
VAR00048	4.00	1.00	5.00	191.00	3.6731	.14459
VAR00049	4.00	1.00	5.00	192.00	3.6923	.14147
VAR00050	4.00	1.00	5.00	176.00	3.3846	.14044
VAR00051	4.00	1.00	5.00	147.00	2.8269	.14196
VAR00052	4.00	1.00	5.00	124.00	2.3846	.14828

Table B.5 Descriptive statistics of variables regarding “implementation level” (Cont’d)

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
VAR00041	.99830	.997	-.742	.330	.138	.650
VAR00042	.86385	.746	-.150	.330	-.545	.650
VAR00043	.89997	.810	-.269	.330	-.823	.650
VAR00044	1.05701	1.117	.051	.330	-.766	.650
VAR00045	1.13560	1.290	-.396	.330	-.435	.650
VAR00046	1.11076	1.234	-.212	.330	-.671	.650
VAR00047	.87188	.760	-.428	.330	-.364	.650
VAR00048	1.04264	1.087	-.590	.330	.062	.650
VAR00049	1.02016	1.041	-.951	.330	1.020	.650
VAR00050	1.01274	1.026	-.379	.330	-.288	.650
VAR00051	1.02366	1.048	-.323	.330	-.582	.650
VAR00052	1.06925	1.143	.263	.330	-.740	.650

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EDUCATION

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WORK EXPERIENCE

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PUBLISHMENTS

Conference Papers

1. Demirdöğen, G. and Işık, Z., (2014;). “Technology Transfer In Constructıon Industry”, 11th International Congress Advances in Civil Engineering, 21-25 October 2014, İstanbul.
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1. BAP / YTÜ (Araştırmacı) (2014-2015) An Innovational Technology Transfer Model for the Construction Industry (Araştırmacı)

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