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Modelling advanced technology for the industrialization of countries constructions with a mixed method

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Abstract

Many developing and newly industrialized countries lack the technical and management capabilities to carry out large and/or complex infrastructure projects. Therefore, a series of initiatives related to international technology transfer (technology transfer) has been started in the construction industry and others as well, in an effort to speed up countries' infrastructural development, economy and living standards. However, these initiatives have not been transferred to increase immediate capabilities and competitiveness in companies of hosting companies, and this has led them to be dependent stably on foreign companies. The demand for high-quality and affordable buildings has increased along with the evolution of society. Construction companies have proved that an Industrial House-Building platform (IHB) strategy is an effective way to meet customers' requirements. We decided to apply a managerial perspective and consider the IHB platform as a technical solution when considering technology transfer in a construction context. The IHB platform strategy can help companies overcome the uncertainties associated with the technology transfer process. In addition, the platform strategy help through the transferability of IHB to different markets, which in turn provides unique opportunities for companies from other fields to enter the construction market.

Keywords: technology transfer, developing countries, industrial House-Building (IHB), construction industry, industrialization of construction, mixed method
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1 Introduction

The development of the construction industry is one of the manifestations of growth and development in countries. The highest share of fixed capital accumulation and employment is in the industry sector while hiring educated and efficient people in this sector is of great importance. some of the influential components of this industry include: Improving the manufactured materials quality/design and implementation methods, accelerating the construction process, making competition in technology advancement, making optimal use of labor and utilizing new construction

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technologies [54]. Technology can be defined as all knowledge, processes, tools, methods and systems used in manufacturing products and providing services. Technology includes three components that can be distinguished from each other while they are of the same importance. These components contain hardware, software and firmware. The fourth component that should be considered independently is technical information that has caused the technology improvement and is known as advanced technology in the construction industry. But what is important is our attitude toward the transfer of technology in this industry which must have economic and technical justification in order to ensure the benefits of its using [33].

Technology transfer is a process in which the selected and required technologies of the organization are obtained and then made available to the organization. This process should start with the selection of a technology and end with its acquirement, and this process should be considered in a proper and local way in order to ensure its proper transfer [25]. In most countries of the world Industrialization of buildings construction has become inevitably a strategic goal which is paid attention to. Also, today, the development of science and technology has led to the emergence of new technologies in the field of construction. Currently, more than 65 new construction systems and technologies have been approved in Iran.

Therefore, in the construction and housing sector, getting to know and utilizing them in accordance with the climatic and geographical conditions and construction requirements of different regions of the country is considered a technical and economic necessity. According to the housing macro vision document for the year 1405 (solar year), in order to respond to the need of constructing 12 million residential units in the country, the annual construction of more than one million residential units is necessary. Meanwhile, according to the results of our country's latest survey, the average annual housing construction in Iran was about 650 thousand units in the 90s. In this way, it is inevitable to change the methods of building houses and use industrial methods in order to respond to the existing needs. Industrialization does not necessarily mean to use machineries and/or production in the factory, in fact, it is the result of a change in attitude and action, the purpose of which is to reduce the production duration, increase the quality and value obtained, and reduce the waste. Currently, the amount of construction by industrial methods in the country is estimated to be less than 10% and we see the backwardness of the construction industry. The main objective of the present research is to provide an economic model and transfer advanced and new technology to industrialize the country's construction. The main goal of the research has been investigated in the form of the following three sub-goals:

1. Determining the components and sub-components of the economic model and the transfer of advanced and new technology to industrialize the country's construction.
2. Determining the relationships between the components and sub-components of the economic model and the transfer of advanced and new technology in the industrialization of the country's buildings.
3. Adaptation of the economic model and the transfer of advanced and new technology to industrialize the country's construction

In this regard, the aim of the current research is to answer this main question: how are the economic model as well as the transfer of advanced and new technology presented in the Industrialization of the country's buildings?

2 Literature review, theoretical background, and questions

Given that technology transfer has been identified as an important part of solutions to issues related to development, including intensive urbanization and climate change, still we see that very little construction research has focused on the said topic. Articles related to technology transfer should be reviewed to gain an understanding of how technology transfer relates to the construction field. However, as technology transfer has already been studied in many fields by different researchers, there are various definitions of technology transfer. Hence, a qualitative meta-analysis of current articles precedes the present study in this research. The information promisingly collected from the review of the articles shows the distinctive characteristics of the construction sector and helps form a research question to investigate the use of technology transfer in the construction field.

Technology transfer is defined as an active process during which technology is transferred from one unit to another [6, 12, 13]. Several researchers consider technology transfer to be a complicated process that requires time to evolve [1]. Over the past few years, technology transfer has been implemented in many fields of science [51], which, like many emerging fields, technology transfer is a fragmented discipline [78]. As a result, a wide range of terms is used to describe technology transfer. Mansfield [45] was one of the first economic researchers who studied technology transfer from an industrial perspective [67].

Economists viewed technology as a necessary input for economic development (e.g., [39]); Therefore, technology transfer is an important factor for developed and developing countries [46]. Economists have also emphasized that technology transfer should follow a geographic gradient (i.e., North-South technology transfer) and also be able to cross the development gap [58, 66]. Region-to-region dynamics [56] as well as technology transfer between different industries and economic sectors [21, 78] have been promoted. Moreover, economists state that technology transfer occurs at both the domestic and international levels, from a country-state perspective [35].

In the field of management, technology transfer is considered as a means to increase the competitive advantage and subsequently, the interests of a company [78]. In addition, technology is considered as a company-specific asset that includes both tangible and intangible components. Specific terminology of this particular field has overlapped to a certain extent with the field of economics because some management researchers were trained as economists (e.g., [67]). In addition to terms related to the field of economics, management researchers usually broadly discussed, inter-firm [72] and intra-firm [44] technology transfer, ways of technology transfer to a wholly owned subsidiary [5] or joint ventures [72] and marketing companies, production and R&D related to technology transfer [35]. In the light of globalization, management research also places great emphasis on international technology transfer, which describes the transfer of capabilities and skills to produce a specific product from a firm in one country to firms in other countries [8, 20] and recently [68]. This has led to the growth of research on technology transfer mechanisms (e.g., [6, 21] and various transfer processes) more than ever (e.g., [63]).

Anthropologists emphasize culture [29]; As such, they discuss the role of technology transfer in terms of cultural evolution [47] with particular emphasis on social progress [78]. This relatively broad view of technology transfer tends to focus on technical progress as changes in cultural and social patterns [78]. Therefore, anthropologists generally emphasize the adaptation and expansion of new technologies and how they affect the development of societies. For this reason, they use more general terms to describe technology transfer, for example, cross-cultural transfer (from a cultural perspective), group, community, and village programs (from an institutional perspective), as well as rural, urban, and regional areas (from geographical perspective). Hence, most anthropological research on technology transfer focuses on agricultural, medical, and educational innovations.

Sociologists are concerned with how technology transfer affects social welfare rather than economic performance [19]. They tend to associate technology with innovation [12], since most new ideas in recent decades have had technological innovations [57]. Regarding terminology, most sociologists discuss technology in terms of expansion, specifically, centralized and decentralized expansion [57] and the acquisition of innovation.

Finally, Kumar et al. [40] presented different motivations for technology transfer, which can be divided into six categories: economic; operational; strategic; social; Universal and personal. A closer look at each disciplinary perspective on technology transfer reveals important common variables that should be included in a conceptual model of technology transfer (Figure 1).

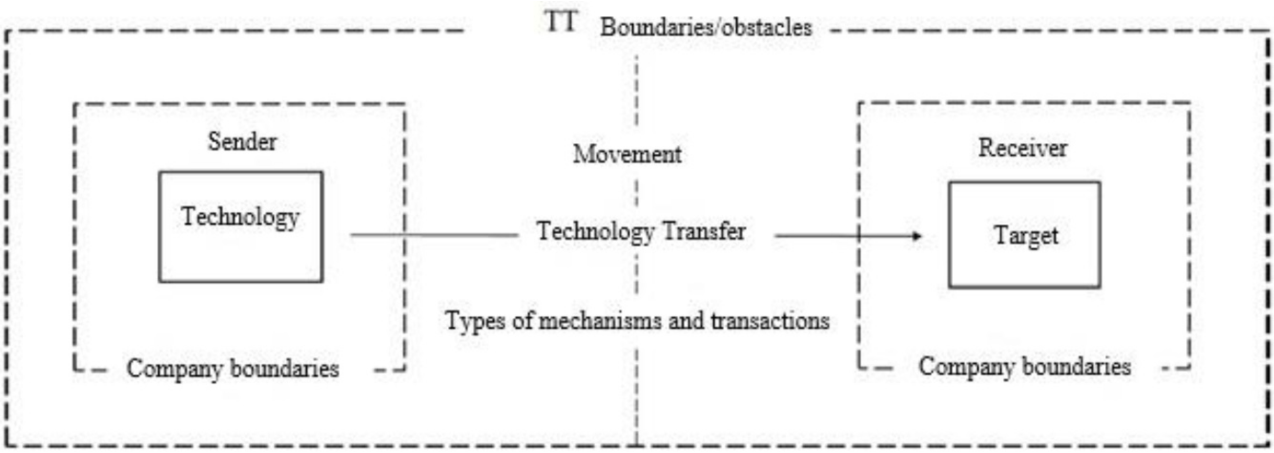


Figure 1: Conceptual model of technology transfer

First, there is always a transmitter/owner and a receiver of technology. Second, displacement must exist for both parties. Third, both sides will undoubtedly face certain barriers to technology transfer. Finally, technology transfer is moderated by various trades and mechanisms.

2.1 Technology transfer

There are two interpretations of technology transfer. In one interpretation, the meaning of technology transfer is the application and use of technology in a place other than the initial place of production. According to this definition, technology transfer is a process that causes the technology to flow from the source to its recipient.

In another interpretation, the meaning of technology transfer is absorption and acquisition of technology by the receiver of technology. In this view, moving a place is not just enough for transfer technology and the technology must actually be transferred to the recipient, so that they can acquire the ability to make a product or perform a process with the same initial quality as the transferor/transmitter. Technology transfer takes place in two ways: vertical transfer and horizontal transfer. In vertical transfer or transfer of research and development, technical information and findings of applied research are transferred to the stage of development and engineering design and then enter the production process with the commercialization of the technology [49].

In horizontal transfer, technology is transferred from one level of capability in one country to the same level of capability in another location/country. In this case, the higher the level of technology receiver is, the more the cost of technology transfer will decrease and its absorption will be more effective [4].

2.2 Domestic technology transfer

Industrialized construction is now well known and widely approved in Sweden. Over many years, the increase of demand for the company's products led to several decisions to speed up production, and reduce production bottlenecks. One of them was the decision to create a wholly owned subsidiary that would enable the complete manufacture and installation of bathroom enclosures compatible with existing volumetric elements. Set up of this subsidiary company in 2015, along with the subsequent strategic collaboration between the two companies, was the first major technology transfer event in the company's history. At the helm of the event's technology transfer it was one of the company's managers (later, one of the subsidiary's owners) who started the bathroom pod project to deal with the increased demand. the manager used a board of experts to identify and handle the issues related to the new product. In this way, knowledge and skills were collected from different departments and compiled to create a business model and the related processes for a prefabricated bathroom pod. When the opportunity arose, the manager started to build the bathroom enclosure, and this became a project of one of the owners of the subsidiary company. The manager could convince some of the production personnel to move from the main company to the subsidiary and continue production of bathroom. It is important to note that the subsidiary has access to the support operations (eg, finance, administration, planning affairs) of the company.

This is an example of the technology transfer of the company, as an investment, for the benefit of the company, which was used to handle production of the bathroom by the company, and the subsidiary was able to immediately start the efficient production of prefabricated bathroom pods to meet the contractual orders. The fact that the subsidiary had access to the company's resources helped refine processes and ensured continuity for both companies, as the target company depended on batches produced by the subsidiary. The owner and production manager of the subsidiary described the technology transfer event as follows: "This is to ensure that the focus is on the production of bathroom pod and guarantee that they get the bathroom pod."

2.3 Foreign technology transfer

Since the beginning of the cooperation, the parent company and the B company have benefited from establishing a firm relationship based on trust. From the first contact made in 2017 and also the first delivery in the fall of 2019, the company has considered long term collaboration as critical elements for success. "I believe you have to think of a long-term collaboration. There's a risk that you underestimate our work and effort that we go into for starting the business that we have. So you have to be patient and understand that it's going to take some time, but again, I repeat, do this as fast as you can. yet I think the main challenge is [subsidiary CEO].

The purpose of the studied foreign technology transfer was to send know-how to another company, and it means that a company is similar to the target company, only on a smaller scale. In particular, the Finnish company received the production system, including all necessary items for implementation (e.g., project coordination, planning and chain of supply management), the enterprise resource planning system (ERP), and leadership. This was critical to create a steady flow in the factory, with the subsidiary's CEO which stated, "Once we find a flow to work, then the whole system will work."

Also, the company supports the receiving company with providing the correct type of equipment and machinery for production equipment. In addition, the receiving company must clearly understand how to work on the construction site (e.g., assembly of volumetric elements, managing the construction site). Therefore, this company is responsible for ensuring that the receiving company has all the components as well as the ability to make them "fit" together. Based on this description, it can be assumed the whole company's culture has been transferred, but the subsidiary's CEO argues otherwise: "I wouldn't say that the culture we're trying to transfer replaces most of our way of working, methods and processes that are transferred". "So, we conclude, "In this context", when we talk about technology transfer and what it is, you have to go back and think it's long-term while it is the only key to success. I would like to point out that no one is the key to success, but success is based on them who are doing the whole job together."

2.4 Technology transfer in the construction industry

The construction industry is very vast and includes more than millions of people who are engaged in a wide variety of occupations, like engineers, technical personnel, skilled tradesmen, and professional operation monitoring. Construction, a high-risk industry that includes a set of activities related to construction, modification or repair. The construction industry, like all industries, has its own technical language. The common language of the entire industry includes a correct understanding of the language about structures, components and elements, getting familiar with specialized and technical language and creating a strategy for interpretation. Modern construction methods are a wide range of technologies, including prefabricated construction or on-site construction. While the distinction between construction and production has an obvious overlap or close connection [61].

Modern construction methods including a wide range of processes and technologies that include prefabrication, off-site assembly and various forms of supply chain specifications, define that they can control time frames and accuracy in forecasting expiration dates under controlled conditions and may explain restrictions limited to access to the site and also lower risk factors. Of course features such as specific objectives/ tasks/ beginning and ending time and resources being consumed for the construction of a project are defined. The purpose of construction is to make a difference in carrying out large and unique projects that require time, money, labor, equipment and materials and examples of all kinds of resources. Structure of the design cycle of materials, parts, information systems and management practices are to create a safe and healthy environment that facilitates and predicts future changes and possible adaptation to eliminate the recovery of all systems, parts, and materials [36].

The construction industry has been affected by a competition of prices for long. Considering the competitive conditions and variables such as demographic and climate changes, a long-term international competition in the construction industry and needs to numerous innovations and constant adaptation to customer needs. One of the main challenges in the construction industry is the renovation of existing commercial and residential buildings in terms of energy, time and cost efficiency. For example, almost 80% of existing buildings consume more than twice as much heat as new buildings. Therefore, there is a great need to use new materials and innovate technologies in energy management and insulation systems as well as optimal and renewable energy sources. Other challenges that the construction industry will face in the future include combining the functions and maintaining the value of different parts of the building, such as fulfilling the growing needs to design, creating safety-oriented structures due to the increase of environmental and tourist risks, saving energy and raw materials by producing special building materials, and universalizing of regulations despite being different in various regions. Innovation in construction, according to the conditions and regulations as well as common social trends and developments related to the supply and demand sector, requires all related stakeholders to get coordinated [49].

2.4.1 Challenges of technology transfer in the construction industry

Studies have shown that companies' different types have played an important role in the economic development of countries. however, these companies should survive big competitors in the market for more than a few years to overcome the problems caused by their size even through cooperation with similar companies to increase the penetration rate in the market and reduce financial risks or by using new technologies to affect their uneconomical size or by using the innovation that distinguishes them prominently from their larger competitors. In order to develop technology, small and medium companies should often use the process of technology transfer due to limited resources and relative inability to absorb costs and risks associated with technology development within the company [61].

Considering the potential capacity of construction companies for the country's economic development and also their innovative ability which has a great effect on long-term survival, it is very important to determine their primary obstacles in facing the development of new technologies and their acquisition, and to provide the designed tools and policies appropriate to overcome this challenge. In general, due to the market globalization and competitive developments, the demand for new technologies and innovations is increasing by market. Even large companies that have been able to survive in competitive markets for many years while enjoying a good market share, have realized that competition turns to an increasingly difficult principal in today's fast-paced business world, and that one must learn to monitor technological development activities and react quickly to changes related to business and regularly improve the production procedures in order to be able to survive and succeed in the market [41].

Rational investment on new technology enables economic enterprises to become leaders and fierce competitors within their respective industries. Among the countless technology benefits, we can mention increasing productivity and efficiency, improving production quality, reducing taxes, reducing long-term costs, and increasing competitiveness. Although companies can benefit from the advantages of new technologies, they all tend to invest in new technologies in order to overcome many obstacles and achieve different business goals [9].

For example, construction companies often use technology to compete more effectively with large companies, while large companies often want to use technology to improve efficiency and eliminate personnel layers. Although investing in new technologies, can ultimately be beneficial for the company, but it is also a challenging task, especially for construction companies that generally have less access to technological information and need financial and expert support for researches on technology. Due to the limited resources for small and medium companies and their inability to handle the costs and risks related to the development of local technologies, they are often involved in the technology transfer process to gain the advantages of new technologies and innovations. Technology transfer is the process of acquiring, simulating, publishing and developing technology that is done officially through contracts, royalties or partnerships and informal agreements. Construction companies that are involved in the process of technology transfer are able to receive the benefits of new technology through other organizations' research and development and avoid the costs and risks associated with the development of indigenous technologies or within the organization. Although, even in the technology transfer process, they face some problems caused by the lack of network communication between them and large research organizations and also the shortage of expert personnel to identify new technologies.

2.5 Summary of background and research gaps

According to the endogenous growth theories, the most important factors influencing economic growth are including knowledge, innovation and technology. On the other hand, there is an idea saying that with the increase in economic growth, more facilities and financial resources are available to entrepreneurs, which in turn can expand inventions and innovation. In fact, there may be a circular flow between technology transfer and economic growth. So that technology transfers increases economic growth, and economic growth can lead to an increase in technology transfer. Despite the importance of technology transfer in the process of economic growth, few empirical studies have been conducted in this field, especially in developing countries. According to the statistics, the construction industry and construction projects are the largest industry in the country in terms of involved manpower supply. The rapid growth of population and growing demands, the need to reduce the delivery time of construction projects, reducing the duration of the investors' capital return, etc. have caused the need for transformation in the traditional methods of the construction industry to increase day by day. Taking advantage of construction technologies in accordance with the growth of each society, using technology in other industries and the implementation abilities of that society is different. These are the needs that sometimes lead to innovations or technology transfer. The vast extent of dilapidated structures with many problems and the lack of clear strategies regarding planning and management of planning and implementation in the renovation of these types of structures have caused the grounds for the implementation of laws and approvals are not made available, even if they are few; meanwhile the dilapidated urban structures will become the most important challenge of the city of Tehran progressively. In the first place, the issues related to earthquake and crisis management and their social, economic dimensions and the upgradable physical / functional/spatial qualities in the next phase, make the need for special approaches to their renovation inevitable.

Technology transfer is typically defined as high-level human resources of science, engineering, and technology areas that influence the development of skills and technology and innovation in the receiving country [2]. This technology usually includes the development of a country through the promotion of research and innovation, which are the main motivation of each province's competitiveness. Technology transfer includes the use and application of a foreign technology to improve the status of a country through bilateral trade agreements. According to the research conducted by Bozeman [12], technology transfer involves the transfer of knowledge, technology, and skills from one organization to another. This is a sign that is related to the transfer of not only products, but it is also effective for the transfer of knowledge and skills used in product development.

Technology transfer by [48], they examined the concept of technology transfer, where the term technology means the transfer of skills, values and capital from one country to another. The use of technology by the host country is the main goal of this country. Manfield [45] examined technology transfer in terms of both horizontal and vertical technology position. Manfield [45] defined vertical technology as know- how derived from fundamental research in applied research from development to production. On the other hand, Manfield [45], stated that technology transfer occurs from one place, context and organization to another organization or country. Ramanathan [55] stated that the necessary coordinated investment in technology transfer involves internal transfer of technology, while vertical transfer involves external transfer.

In addition, technology transfer will be considered as the transmission of management processes from one phase to another in its life cycle. Ramanathan [55] further explained that this is critical in strengthening the existing frameworks in technology integration for the implementation of various economic and development projects. Therefore, technology can be transferred to any stage of its development. The method used in technology transfer typically depends on a number of factors, such as the department, arrangement, and appropriate transfer method. Carl [17] argues that according to existing literature, there are two methods of technology transfer. The first method involves moving from one country to another.

Also, the conducted research shows that many investigators have conducted studies on the application of technology in the construction industry, most of them are descriptive or applied, meanwhile they focus on a specific technology. Still, none of the reviewed researches performed to present the economic model and transfer of advanced/new technology for the industrialization of the country's construction, do not show that the results can improve the process of technology transfer in the construction industry of the country and/or have high economic advantages.

2.6 Technology transfer: A survey of international construction companies

Technology transfer is defined in different ways. Dichter et al. [24] provided the following comprehensive definition: "The process by which knowledge is somehow transferred from an individual or an organization/company owning it to another individual or organization/company arranging to receive it (transferee/Receiver)".

Technology transfer develops the technical capability of the construction industry, which is very important and is in line with the interests of many developing countries [60]. International construction companies are a well-known platform for technology transfer in foreign contracts in developing countries. The most specific tool is providing training to local employees in the design and construction stages. In addition, these companies are more concerned about competing projects with projects that have consumed their time and budget and may have not employees with the required training skills. Ofori [52] discussed some of the problems experienced in construction technology transfer. These include:

1. unwillingness of transferors to cultivate potential competitors;
2. Time, cost and management implications of transfer in a project;
3. lack of understanding of what needs to be transferred;
4. Recipients/ transferees and customers' suspicions about the usefulness of transferred technologies;
5. The uselessness of the previous transfer;
6. Difficulty of measuring effectiveness.

Considering the background, this paper presents research findings on the experiences of UK and US consultants, contractors and their role in technology transfer.

2.6.1 New international and industrial construction companies

Most construction companies use foreign contracts to bring some stability to the cyclical nature of the industry and to act as a backstop to domestic revenues [15, 34, 65]. Being present in several countries means that there is a better chance of survival when one region is in an economic downturn and others may experience a huge boom. Construction companies in developing countries technically need more help than developed countries, but there is always suspicion about the motives of these countries with regard to the interests of the local community [14].

The main role of activists in the transfer of construction technology is related to architects, consultants and contractors. The World Bank has a policy of supporting and strengthening local capabilities by promoting knowledge transfer - how to use international consulting firms [77]. It also promotes the use of joint ventures, but does not specify why KM knowledge transfer has not been successful to date [77].

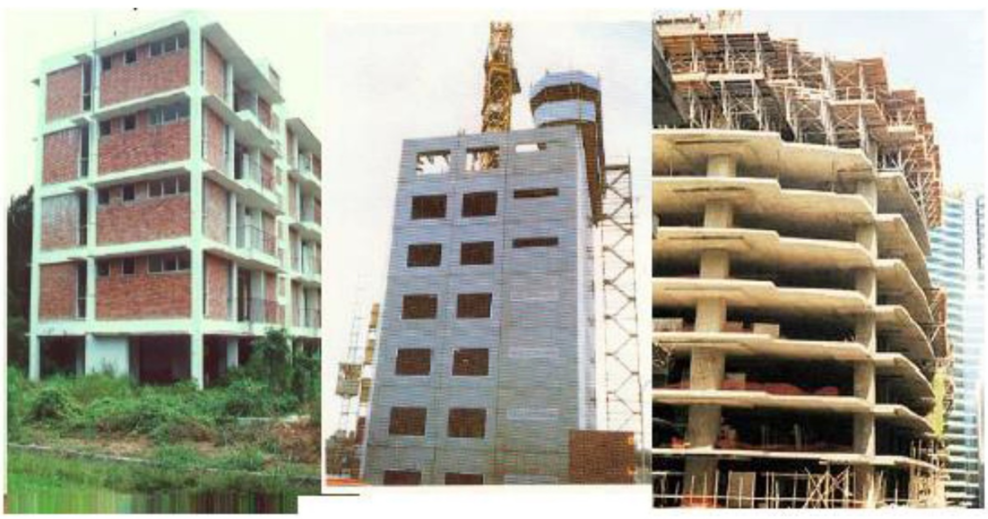
2.7 Investigation of technology transfer in the design and construction of bearing masonry units

Bearing or structural construction method is a construction method in which the elements of a structure are built by the builder. For bearing wall system, masonry walls are used to support the building loads applied from the roof, upper walls and concrete floor slabs as well as lateral loads such as wind and soil pressure. Due to its technical and economic advantages, this system is widely used in Western countries. The construction of residential buildings is something more than bearing brickwork or bricklaying without a frame. For a long time, this method has been used to preserve land and bridges, and it has also found new applications in the construction of larger buildings such as those used for sports, education, production and maintenance purposes.

Bearing construction method is not a new construction method. This method has been used since the beginning of civilization, mostly by clay and stone cuttings. Early construction was basically based on rules of thumb, so the structures found, were all large and massive. With the development of new materials, innovative design philosophies and theories, which in turn led to the development of new standards and codes of practice, today's masonry structures become taller and higher, more delicate and narrower; compared to concrete and steel structures.

2.7.1 Bearing masonry construction

There are basically three structural systems for buildings construction; frame system, flat concrete board system and bearing system (bearing a load) (or shear wall). A building can be made of any of the systems or a combination of all. For the frame system, beams and columns are used to support the building loads and provide the necessary stability of the building (Figure 2-a). The masonry method is only used for filling, i.e., slabs or walls that do not carry any structural load. In this country, most of the buildings are made of reinforced concrete frame and in very few buildings they use steel frames. For residential buildings, the first frame system is better. Bricks are sometimes used for columns. For load-bearing or shear wall systems, the building loads are carried by the walls, in other words, there are no columns (Figure 2-b). Therefore, the walls have a dual function; apart from acting as blades, they also act as structural elements in providing support and stability to the buildings. Common bearing walls are made using precast concrete or reinforced concrete (RC). RC retaining walls are technically shear walls that are used for main walls and lifting beams in tall buildings. For residential or other low-rise buildings, RC walls are usually pre-formed and then erected on site - commonly known as prefabricated buildings. In the flat concrete slab system, the concrete slab is placed on a column and there are no beams. To prevent the "staples" from breaking, the concrete slab near the column is typically thick.



(a) frame system **b) bearing/shear wall system** **(c) flat concrete slab system**

Figure 2: structural systems of buildings

In general, there are 3 types of structural masonry construction named simple, reinforced and pre-stressed [26].

2.7.2 Simple construction

Plain or unreinforced masonry is the simplest type of construction because it does not involve any steel reinforcement (Figure 3). They rely solely on construction strength to support the building loads. Since the masonry method is very strong in compression but weak in tension, unreinforced masonry is naturally designed for zero tensile stress. This bearing wall-based construction is generally used in medium and high-rise buildings in areas with low seismic activity.

For extensive and limited constructions such as bridges and doors, tensile and bending pressures are eliminated by forming beams or walls in the shape of an arch.

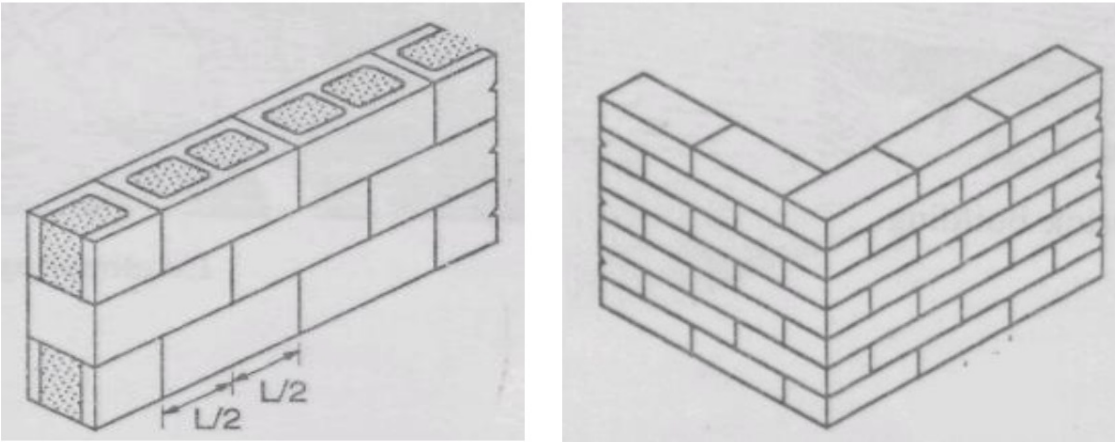


Figure 3: Examples of simple masonry construction

2.7.3 Reinforced construction

Like concrete, steel reinforcement power is added to the masonry structure to provide tensile and bending strength and improve compression strength (Figure 4). This allows for a narrower column and wall, which in turn allow for taller and more load-bearing masonry buildings. In addition, building elements such as beams and stairs can be made using a construction method that was not possible before. This construction method is preferred over simple construction in earthquake-prone areas. For reinforced brickwork, steel reinforcements are usually placed between two layers of units and covered in composite form using grout. For blockwork, reinforcing forces are mainly placed inside the cores, which are filled with grout.

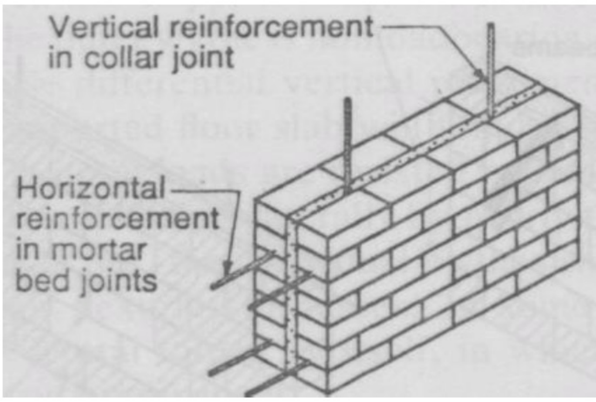


Figure 4: General plan of reinforced masonry construction

2.7.4 Pre-stressed construction

The initial pre-stressed form was in the form of placing a heavy sculpture on a column to increase its resistance against lateral pressure. Today, the pre-stressed method is used by steel bars with high resistance or foundations embedded inside the building (Figure 5). Steel bars or piles are placed in appropriate locations in an unreinforced masonry element and then braced against the end plates to compress the element. In almost all construction applications, the steel is centrally located in the element, so the compressive stresses induced on its cross section are uniform. The advantage of pre-stressing is that any subsequent tensile stresses that tend to develop are suppressed prior to compression. Pre-stressed building elements are designed to be stress-free under service loads. If there are small cracks in the load, when the load is removed, the steel closes them before re-compression. Other advantages are that pre-stressed bars can be inserted before or after masonry construction and they do not require grout injection, provided they and the anchorage are protected against corrosion. The pre-stressed method allows walls, columns, and beams to be constructed using the masonry method because it has a higher load-bearing capacity as well as providing adequate resistance to dynamic response compared to conventional reinforced masonry are improved. Common applications are in the construction of diaphragm walls for sports complexes, land and Water retention structures.

(a) Prestressed masonry diaphragm walls

Figure 5: Examples of pre-stressed masonry construction

2.8 Facilitating the technology transfer in buildings construction

The implementation of technology in the construction sector has got a significant growth in the last decade. There are two mechanisms for acquiring technology, "production and import" [3]. Production refers to the development of new technology through the application of knowledge to produce goods and services [53], while import refers to the process of taking technology from others and developing skills to obtain, implement and manage it [3]. Li-Hua [42] presented results on a research about the appropriateness and effectiveness of technology transfer (technology transfer) and concluded that knowledge and technology transfer should go hand in hand. Effective technology transfer does not happen without knowledge transfer. Li-Hua [42] also concluded that if there is a large gap between two countries in terms of economic development, technology transfer is not easily achieved. Ofori [53] discussed internationalization, barriers to technology transfer between developed and developing countries, and finally ways to overcome those barriers. Ofori [53] emphasized the need for future studies on internationalization. Whitla et al. [76] investigated the extensive usage of global strategies by English construction companies using a two-stage case study. This study showed that most international companies do not use integrated global strategies in an effective way. Stewart and Waroonkun [62] presented a technology transfer performance measurement framework with eight different perspectives. Waroonkun and Stewart [74, 75] proposed a model for international technology transfer with four factors including government influence, transferee characteristics, transferor characteristics, and making relationships. The results of the analysis showed that establishing a relationship between the transferor and transferee is the most important decision-making factor for creating value in the host construction sector. Devapriya and Ganesan [23] used subcontracting in the construction sector in Sri Lanka as a means to analyze the effectiveness of internal technology transfer. The authors concluded that internationally managed projects, design and construction systems should facilitate internal technology transfer.

Carrillo [18] presented the results of a survey for consultants and contractors in England and the United States to determine the areas of construction technology transfer that most benefit local communities and also decide the most effective way to improve technology transfer, the main barriers of experiences and how to overcome them. He concluded that the requirements of transferors for an effective technology transfer must be clearly defined. Carrillo [18] examined 12 joint ventures between UK contractors and some other contractors in developing countries plus their technology transfer experiences. One of the main obstacles identified by them was the lack of motivation for technology transfer. Cushman et al. [22] discussed the three main barriers to technology transfer in the US construction industry as to establishing codes, conservatism, and organizational determinism. The strong preference of the Chinese government for joint ventures in other areas of technology transfer is discussed by Tsang [69]. Tsang also raised issues related to the implementation of technology transfer in Sino-foreign joint ventures. Tsang [70] classified six factors that published in previous studies into three categories, namely resource constraints, resource requirements and resource protection, and used the resource-based perspective to explain a firm's choice about an international technology transfer mode.

2.9 Modeling the international transfer process in construction projects

While many existing models of technology transfer have been developed for the business and manufacturing sectors, the author is not aware of any comprehensive technology transfer models specifically developed to model international technology transfer in construction projects. Such a model must be developed through a process of justifying, grouping, communicating, and refining factors that have been established among a number of different industry sectors. Therefore, the purpose of this section is to review existing models developed in all industry sectors to develop a conceptual model of technology transfer which specifically designed for the construction sector [43, 44, 59, 70, 73]. The first discussed two models were particularly useful when formulating the overall structure of the conceptual model. And the next three models were valuable by identifying the main technology transfer factors that affect the technology transfer process and reviewing its production value. Each of these models and their limitations are presented in relation to the goals of this study. It should be noted that only complete models of technology transfer are examined in this section. Arguments for the inclusion of individual variables that underlie the activation of technology transfer and the following structures or factors, are presented in the next section.

Malik [44] developed a technology transfer model for intra-organizational technology transfer. The "data-scattering analogy" was adapted to Malik's (2002) model, in which the technology should be transmitted as a radio transmission message. This message is transferred from a sender (transferor) to a receiver (transferee). The strength of this transmitted message is influenced by two factors that function to aid and, more likely, to inhibit. While this model comprehensively examines the interactive nature of communication processes within a single organization, there are various considerations regarding the transfer of technology to a foreign operator. For example, the intra-firm model does not accurately address the issues related to the purpose of transfer so that protect its nuclear technology from competitors and also avoid the possibility of differentiating project goals. This model may not distort empirical supporting evidence because it is based on the response of only one manufacturing firm. To access a more reliable model, testing should be done with several different companies from a wide range of different industries. In addition, effective factors have been identified, but their impact on outcomes requires more detailed investigation. In addition, these factors can probably be categorized into transmitter and receiver elements for helping and inhibiting, most of which represent the personal characteristics of the technology supplier and receiver, respectively.

Calantone et al. [16] developed an adaptive marketing framework for international technology transfer based on concepts developed by Boddewyn's adaptive marketing research [10, 11]. Their study attempts to apply the comparative marketing principles outlined by Boddewyn to the context of international technology transfer and also includes other empirical studies. This framework presents a system consisting of 5 elements, namely, environment, supporters, structure, process and functions. This framework is designed so that it establishes the interaction between elements and environmental variables (for example, economic policies). For example, if the process is highly unsuccessful, economic policies may be introduced that discourage participation in technology transfer programs. These factors will again affect the transfer process of a continuous cycle of international technology transfer development. While this framework seeks to explain the feedback of international technology transfer factors, it could not unify indicators to identify the outcomes of technology transfer initiatives. In addition, the design of the model is very complex and has not been empirically verified using a statistical analysis method. Also, this model includes a number of factors that can be adapted for use in the field of construction, the model as a whole is widely related to the marketing and logistics sector. However, there are several important factors that have been identified to use this framework to generate a conceptual model for international technology transfer in construction projects.

According to the aforementioned principles, in order to achieve the objectives of the research, the following questions have been raised and examined:

The main question

How would be the presentation of the economic model and the transfer of advanced and new technology in order to industrialize the country's construction?

The main question:

1. What are the components and sub-components of the economic model and the transfer of advanced and new technology in order to industrialize the country's construction?
2. What are the relationships between the components and sub-components of the economic model and the transfer of advanced and new technology to industrialize the country's construction?

3. How do the economic model and transfer of advanced and new technology match in order to industrialize the country's construction?

3 Data and Methodology

The current research is mixed research of a guided and sequential type. In this project, the researcher determines a measurement tool through qualitative research and determines the main aspects of the phenomenon under investigation by analyzing qualitative data, and then with the help of the qualitative method tries to examine the goals and questions. Therefore, in this research, a mixed research method (qualitative and quantitative) will be used with time priority and greater weight of data and qualitative method than quantitative data. Thus, first, qualitative methods will be used to identify the components and indicators of the model, and then quantitative methods will be used to discover the cause and effect relationships and approve the findings. In fact, this method is a combination of quantitative and qualitative methods. Therefore, according to the goals it pursues, the present research is a part of applied researches, and in terms of the process of doing the work, it is a part of descriptive and survey research of an exploratory type, which has been done in two qualitative and quantitative phases. The statistical population for the qualitative section consists of experts familiar with the research topic (university professors and activists in the requested field of study). the statistical sample in this section includes 10 professors and experts of technology transfer and 10 experts and managers of the construction industry that were chosen as a purposeful sampling method. 20 people were selected as the volume of the society (3.1). The volume of the selected sample was determined based on the theoretical saturation matrix, in which the 20 people were interviewed and no new findings were counted. The required criteria to be considered in selecting participants for our study are as follows:

$$n = \frac{Z^2pq}{d^2} \tag{3.1}$$

In this Z formula, the confidence level of the statistical population is based on the assumption of normality of the distribution, which in this research, the confidence level is 95% ($Z = 1.96$); d is also the allowed error value (error value) which is set at 0.05 in this research ($d = 0.05$); p and q are also considered equal to 0.5 ($p = q = 0.5$).

- Having at least 10 years of managerial work experience for construction industry managers
- Having at least a bachelor's degree for managers graduated from technology transfer
- Having a PhD for professors graduated from technology transfer management

The statistical population of this department includes all the managers of companies that import new construction technologies, having post-graduate degrees and above, and their number is equal to 344 people by simple random sampling method and according to Morgan's table, 182 people as the volume sample was selected. For the measurement tool, first, the research framework (primary components and indicators) was prepared from a library studies, and then an open - end questionnaire was extracted from it and given to the section for the statistical sample of the qualitative dept in order to answer and collect opinions about the components and indicators of the current research. After confirming and finalizing the indicators and components according to the priorities, a closed questionnaire was prepared and given to the section for statistical sample of the quantitative dept of the research. In terms of qualitative analysis, the content analysis technique was used in order to identify the dimensions of the model. structural equations were used in this technique.

4 Findings

4.1 Sample size adequacy test

Variables are more suitable for model analysis that are at the level of distance measurement, but in some cases rank and nominal variables are also used. It should be mentioned that the researcher can include any number of variables related to the research problem in the analysis provided that the variables are measured with the correct method and the reliability coefficient of the variables is acceptable. Regarding the size of the sample volume, it is generally used a large amount of data in the structural equations. The minimum sample size should not be less than 50. The larger size of the sample volume is, the higher the accuracy of the model analysis is. As a general rule, the number of samples should be about 4 or 5 times the number of variables used. This ratio is somewhat moderate. If the KMO value is less than 0.5, the data will not be suitable for structural equations, and if its value is between 0.5 and 0.69, structural equations can be used with more restraint. But if its value is greater than 0.7, the correlations between the data will be suitable for model analysis. The output of this test can be seen in Table 1. Meanwhile the value of KMO index is equal to 0.873 and the number of samples is sufficient for analysis. Also, the significance value of Bartlett's test is less than 0.05, which shows the desired analysis is suitable for identifying the structure of the model.

$$KMO = \frac{\sum^n \sum_{i \neq j}^n r_{ij}^2}{\sum^n \sum_{i \neq j}^n r_{ij}^2 + \sum^n \sum_{i \neq j}^n a_{ij}^2} \tag{4.1}$$

As can be seen in the formula above, in the denominator of the sum of the non-diagonal correlations of the reagents, the sum of the non-diagonal correlations of the reagents plus the sum of the partial non-diagonal correlations of the reagents are included in the denominator. Therefore, the smaller the current correlations are, the larger the KMO index will be and vice versa. The closer the KMO index is to 1, the better "sampling adequacy" there has been in selecting the predictors (manifest variables). The cut-off point of the KMO index for "sampling adequacy" is 0.6, which means that if the KMO index is higher than 0.6, the criterion of "sampling adequacy" has been estimated, and if it is lower than 0.6, it means that the criterion of "sampling adequacy" has not been estimated.

Table 1: Measurement of sample adequacy

	Test statistics	**test**
0.873	Measuring sample adequacy	(KMO)
12143.4532	Chi-square approximation	Bartlett's test
181	Degrees of freedom	
0.000	SIG	

4.2 Results of qualitative analysis and Delphi method (third round)

The components of the research have been identified by the qualitative analysis method. In this section, the respondent should express his opinion about the effect of each of these factors by choosing one of the available options. These options were presented in the form of a Likert spectrum, including "very little effect: 1., "little effect: 2", "moderate effect: 3", "high effect: 4" and "very high effect: 5". Kendall's correlation coefficient in the answers of this round is equal to 0.944, which shows the experts greatly agreed on the subject, and considering that coefficient of agreement of this round is not much different from coefficient of agreement of the second round, it can be said that the agreed coefficient between the experts is 0.94.

Table 2: Delphi method

Subcomponents	**Number of responses**	**Average of responses**	**Standard deviation of responses**
Organization recognition	20	3.56	0.45
Technology requirements	20	3.43	0.34
Royalties purchase	20	3.55	0.65
Recruitment and exchange of human resources	20	3.65	0.67
Long coexistence of technical and managerial staff	20	4.23	0.71
Technology acquisition	20	4.11	0.65
Organization and proper organizational structure	20	4.32	0.40
Gaining experiences from other countries	20	3.98	0.74
The country's capacity to absorb technology	20	3.45	0.47
Market share	20	3.65	0.54
Competition status	20	3.46	0.61

Development of technology strategy	20	3.21	0.48
Technological capabilities	20	3.78	0.46
Market access	20	3.23	0.43
Dependence on technology	20	3.55	0.67
Technological competitive advantage	20	3.24	0.43
Technology transfer culture	20	3.56	0.46
Market elasticity	20	3.44	0.45
Technology life curve	20	4.21	0.65
Localization of technology	20	4.34	0.74
Industry ability	20	3.54	0.89
Training of technology specialists	20	3.56	0.58
Mutual investment	20	3.21	0.73
Adaptability	20	3.67	0.83
Government support for technology transfer	20	4.32	0.74
Compilation of long-term science and technology document	20	4.34	0.93
Flexibility	20	3.54	0.64
How to use technology	20	3.23	0.71
Relative competence of technology	20	3.54	0.65
Compilation of the road map and transfer map	20	3.78	0.45
Effective and efficient management	20	3.23	0.38
Make small changes	20	3.67	0.39
Technology improvement	20	3.24	0.88
Innovation	20	3.65	0.73
Technology knowledge transfer	20	3.54	0.45
Learning	20	3.23	0.63
Cooperation with scientific centers	20	3.65	0.54
Reverse Engineering	20	3.78	0.76
Relationship between research goals and technological needs	20	3.54	0.67
Outsourcing	20	3.21	0.45
Development of technical specifications	20	3.67	0.33
Commercialization of research results	20	3.24	0.56
Updating	20	3.54	0.67
Definition of the terms of the contract	20	3.23	0.63
Organizational interactions	20	3.56	0.72
Laws	20	3.34	0.45
Defining the purpose of cooperation	20	3.65	0.42
Long-term and confidential partnerships	20	4.12	0.56
Cooperation with the supplier	20	3.43	0.71
Office of Technology Transfer	20	3.42	0.33
Sending troops abroad for training and gaining practical experience	20	3.54	0.71
Consortium formation	20	3.25	0.43
Subcontracts and second hand	20	3.11	0.78
Preservation of documents	20	4.23	0.37
Commitment to project transfer	20	4.54	0.45
Strengthen the communication	20	4.33	0.65
Technology pricing	20	3.21	0.34
Cooperation and coordination	20	3.45	0.61
Negotiation and Technology evaluation	20	3.65	0.45
Use of technology	20	3.21	0.78
Willingness and ability of the transferor	20	3.76	0.43
Taking ownership of technology	20	2.45	0.23
Merge	20		0.81

Franchising purchase	20	3.24	0.43
Establishing a joint business unit	20	3.67	0.54
Strategic agreement	20	3.89	0.32
Union	20	3.42	0.72
Intellectual Property	20	3.62	0.34
Acquisition of technology	20	3.54	0.32
Technology risk management	20	3.67	0.66
Technology source control	20	3.24	0.81
Communication with the beneficiaries of technology transfer	20	4.11	0.77
Technology maintenance and repairs	20	2.81	0.34

4.3 Examination of divergent validity (diagnostic) for the dimensions of the research model

One of the methods of measuring this validity is the Fornell-Locker test. Table 3 shows the results obtained for the dimensions of the research model. The following table shows that the constructs are completely separated, that is, the principal diameter values for each hidden variable are greater than the correlation of that dimension with other reflective hidden dimensions in the model.

$$AVE = \frac{\sum \lambda_i^2}{n} \tag{4.2}$$

Average Variance Extracted or AVE stands for Average Variance Extracted. This index was introduced by Fornell and Larcker in [28]. Convergent validity is checked based on the external model and by calculating the average variance extracted (AVE). The AVE measure represents the average variance shared between each construct with its indicators. In simpler terms, AVE shows the degree of correlation of a structure with its indicators, the higher the correlation, the better the fit. Fornell and Larcker believe that convergent validity exists when AVE is greater than 0.5.

Table 3: Fornell Locker index to check the diagnostic or divergent validity index

Row	Dimensions	1	2	3	4	5	6
1	Awareness of technological needs	1					
2	Market status	0.831	1				
3	Industry policies	0.764	0.886	1			
4	Research and Development	0.774	0.868	0.879	1		
5	Contracts	0.839	0.888	0.900	0.892	1	
6	Technology Protection	0.659	0.576	0.740	0.650	0.630	1

4.4 Checking the quality of the model

Redundancy index and coefficient of determination are used to check the quality of the model. Positive numbers indicate good model quality. The main criterion for structural model evaluation is the coefficient of determination. This index shows how many percent of dependent variable changes are made by independent variables. Table 4 shows that 88.7 percent of model changes are predicted by independent variables (model dimensions). If the redundancy index is greater than zero, the observed values are well reconstructed and the model is able to predict. In the above research, this index is above zero regarding the economic model and the transfer of advanced and new technology to industrialize the buildings.

$$GOF = \sqrt{\overline{R^2} * \overline{Communality}} \tag{4.3}$$

Table 4: checking quality indicators of the model

Model	determination coefficient	Redundancy
Economic model and transfer of advanced and new technology in building industrialization	0.887	0.566

4.5 Quantification of the model

In this section, considering how the conceptual model was determined, the size of the sample volume is appropriate, and all the identified dimensions are effective on the said model, the model will be quantified using partial square technique and bootstrapping t-test. The results are described in Figures 6 and 7. The results of the above figure show that all the obtained coefficients for the dimensions of the model are positive and all the obtained t values are greater than 1.96 in the Z table, we can conclude that the model is meaningful and the obtained results can be relied upon. According to the figures, it can be said that the causal accuracy relationships in the research model are confirmed and the model is also suitable.

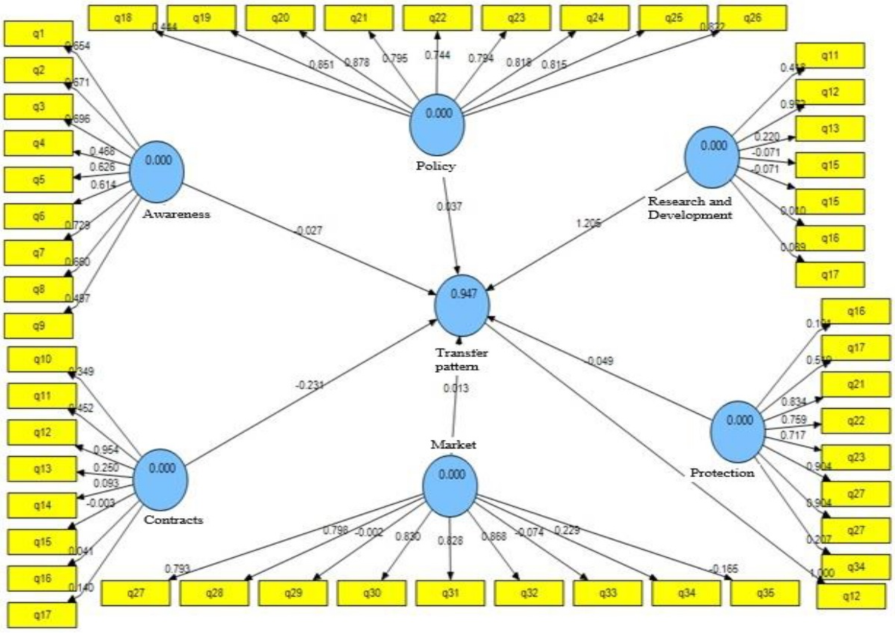


Figure 6: Causal accuracy relationships between model variables in standard estimation mode

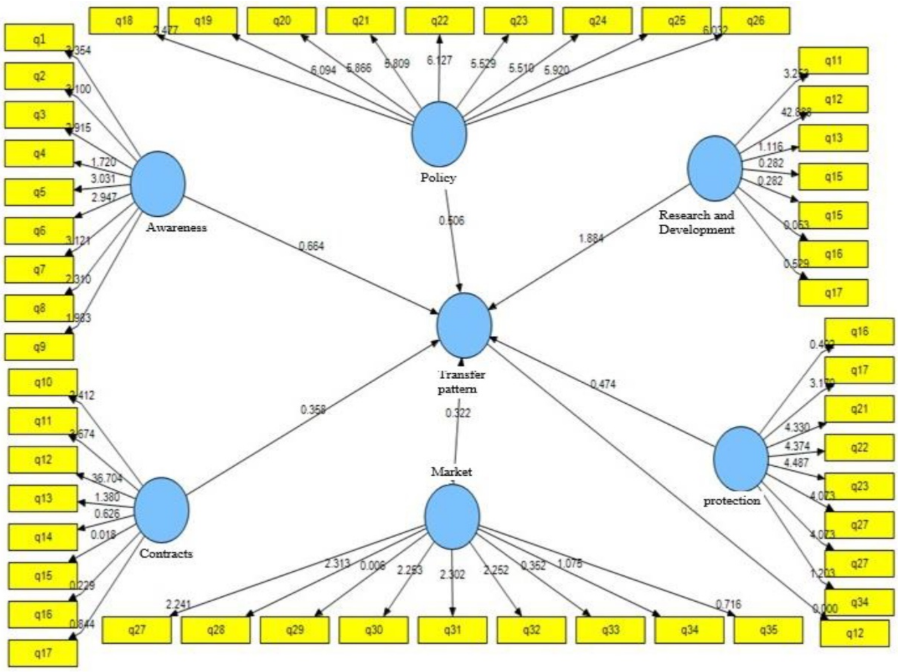


Figure 7: Causal relationships between model variables in the state of significant estimation

4.6 Model fit

In the following, to fit the model we use some of the goodness of fit indicators including: GFI, AGFI and RMSEA, the values obtained shown in table 5 stating that the results of the model are reliable.

$$RMSEA = \sqrt{\frac{X^2 - df_{model}}{(N-1) * df_{model}}} \tag{4.4}$$

$$GFI = 1 - \frac{F_M}{F_{IND}} \tag{4.5}$$

$$AGFI = 1 - (1 - GFI)\frac{dl_{IND}}{dl_M} \tag{4.6}$$

$$CFI = 1 - \frac{\max(X^2_{model} - df_{model}, 0)}{\max(X^2_{null} - df_{null}, X^2_{model} - df_{model}, 0)} \tag{4.7}$$

$$IFI = \frac{X^2_{null} - X^2_{model}}{X^2_{null} - df_{model}} \tag{4.8}$$

$$NFI = \frac{(X^2_{null} - X^2_{model})}{X^2_{null}} \tag{4.9}$$

$$NNFI = \frac{(X^2_{null} - \frac{df_{null}}{df_{model}} * X^2_{model})}{X^2_{null} - df_{null}} \tag{4.10}$$

Because the GFI and AGFI indices are both estimated more than the target, this statistic is greater than the 0.90 criterion. Also, the chi square ratio to the degree of freedom (χ^2/df) shows a suitable value. Also, the RMSEA error criterion is estimated to be 0.03, which was smaller than the permissible limit of 0.08. Based on the estimates presented, it can be concluded that the model tested in the target society had a relatively good and acceptable fit. Therefore, the results of the research model show that the model used in the current research had a good fit.

Table 5: Statistics related to fit goodness

Goodness indices	**symbol**	**Criterion**	**Research values**	**Goodness result**
Chi-square division by degree of freedom	χ^2/df	≤ 3	1.34	Fit goodness
The root mean square of the estimation error	RMSEA	≤ 0.08	0.03	Fit goodness
Fit goodness index	GFI	≥ 0.9	0.94	Fit goodness
Adjusted fit goodness index	AGFI	≥ 0.9	0.91	Fit goodness
Comparative goodness index	CFI	≥ 0.9	0.95	Fit goodness
Incremental goodness index	IFI	≥ 0.9	0.93	Fit goodness
Norm goodness index	NFI	≥ 0.9	0.92	Fit goodness
Non-normative goodness index	NNFI	≥ 0.9	0.96	Fit goodness

5 Discussion

Looking at the technology transfer carried out in Iran over the past years, it can be seen that the technology transfer process is very inadequate. Sometimes technology applicants do not have a precise and correct understanding of what they want and do not know their true and real needs, sometimes they move in search of their ideals or look for technologies that have not been invented yet or vice versa they are glad that their life is over and they have no economic justification. In the next step, instead of choosing the right technology, they look for the most expensive and modern technologies, which are very unlikely to be even acquired. The most important part of technology transfer is its absorption and localization and innovation, which should be analyzed deeply and scientifically. There is a significant gap between the technological level of advanced countries and the third world. To reduce this gap, technology transfer is an undeniable necessity. Technology transfer is possible with different methods, the important factors determining the technology transfer method are prominently a combination of the technology transferor's desire to supply technology and technical knowledge, and the technology transferee ability to acquire and absorb technology. In the meantime, it is very important and vital to have a criterion and a definition that indicates the effective transfer of technology. It is possible that both the technology transferor and the technology transferee have the intention to transfer technology in the best possible way, but in practice, the technology transfer method may be carried out in such a way that it cannot meet the intended results, therefore, it is necessary to choose accuracy and expertise in choosing the best technology transfer method in the acquisition phase. Another issue is the adaptation and absorption of the transferred technology, which must be adapted to the conditions and environmental characteristics of the recipient, and finally, it is the development and diffusion of technology, which requires collective determination and national self-confidence, and of course, the creation of the necessary infrastructures by the government. In today's world, there is a direct relationship between the development of technology and the economic, social, political and cultural progress of a country. It can be said that technology is a fundamental factor for creating wealth, ability and knowledge of countries and is considered a powerful tool in national development. It is for this reason that, at the international level, technological economic war has replaced military wars. Therefore, adopting technology development strategies in various sectors of each country economy, is one of the necessities of economic reconstruction and development of that country, and without it, it is impossible to achieve goals such as economic self-sufficiency, national development, and improvement of living standards.

By an increase in the progress of science and technology in all fields, especially construction technology, it is necessary to address this issue. Construction as an industry is based on the adoption of innovation and technology. The quantitative and qualitative needs of the building during the past decades show that the best solutions for achieving housing construction goals are the use of new methods in building construction. In order to increase innovation in constructions, first the necessary foundations must be created in organizations and the environment. In addition, the organizational structure, strategy and management methods, the attraction of professional employees, and the environmental conditions appropriate to new technologies; must be provided in order to pave the ground for innovation and creativity. Factors such as organizational and national culture and changing the executive technical system are necessary to strengthen innovation in this industry.

In order to have an optimal usage of new technologies in buildings construction, there should be considered some solutions to match these methods with the cultural and social characteristics of societies. There will be a wide range of materials and innovative methods and design for buildings to respond to new conditions. To achieve these goals, there is an early need for key measures such as financial support to help create testing procedure infrastructure and construction mechanisms and lower cost with higher quality materials and advanced products to create sustainable business models, to reduce barriers to create a fair market, energy efficient construction materials, researches and to find new innovative materials with international researchers to help product and infrastructure development, provide innovative products and a deep renovation with a long-term vision so that to prevent extra capacity and also to promote zero energy buildings.

Technology transfer is an important and fundamental category in improving the technology level of a country and finally moving towards sustainable development. Of course, this requires attention to research centers and also economic and political support for such activities. There are many important factors that determine the method of technology transfer including a combination of the desire for technology transferor to supply technology and technical knowledge, as well as the ability of the transferee of technology to acquire and absorb technology. The importance of choosing technology transfer methods made many developing countries to try different types of technology transfer methods in order to choose the most suitable ones.

Generally, in the construction industry of developing countries they can learn valuable lessons from the successful experience of some industrialized and newly industrialized countries, especially East Asian and Latin American countries, regarding technological and industrial development. The successful experiences of these countries have shown that the extensive transfer of suitable and modern technologies to these countries enables them to increase their productivity and as a result has led to the rapid industrial development of these countries. For example, countries such as South Korea, Taiwan, Brazil and Mexico are more likely to be promoted as newly industrialized countries in East Asia and Latin America through the import and transfer of foreign technology. In general, the situational factors of these countries can be divided into internal and external factors. Within these countries, the national determination to develop technology is at the forefront of all planning and actions, and all the platforms and structures necessary to realize this, have been already prepared.

Due to the saturation of the investment space in advanced countries outside, western investors and international companies have been interested in joint cooperation and making investments in these countries. Although these countries can be distinguished from other countries due to some characteristics and macro-economic indicators such as per capita income, economic volume, primary resources and their industrialization process, examination of their success factors can be useful for other countries that are trying to follow the development model. in some cases, the probability of failure in technology transfer can be minimized with: providing an effective management, making close cooperation between research centers and industries, giving special attention to research and development activities, providing an effective government support.

Looking at the technology transfer carried out in Iranian construction industry over the past years, it can be seen that the technology transfer process is done in a very incomplete way. Sometimes the technology applicants do not have a precise understanding of what they want to have, meanwhile they do not know their true needs, sometimes they go to follow their ideals or look for technologies that have not been invented yet or vice versa they are glad with technologies which are already over and have no economic justification. In the next stage, instead of choosing the right technology, they look for the most expensive and modern technologies, which are very unlikely to get absorbed or even acquired. In the current environment, which is full of dynamics and change, one of the important categories that can lead us to achieve goals of our organization and society in an effective way, is effective technology changes / technology transfer with special principles, methods, stages and processes.

Regarding the comparison of the findings Ebrahimzadeh [27] showed that, by examining the state of construction and also using modern technologies in the country, the use of these technologies in our country has not contributed much and traditional methods are rather used in construction industry. this is while a great progress achieved in the world in the field of new construction technologies. [33] stated that the purpose of industrialization of buildings is to increase the speed of production, increase the share of factory production, reduce the share of components, change the production procedure into installation and assembly. Among the results and effects of this process we can refer to the following: to make a new style, prepare a resistant construction, make substantial materials savings, reduce energy consumption during construction and operation, reduce construction duration and consequently reduce the costs of construction of the building.

Poladkhai et al. [54] stated that the transfer of new technologies and industrial methods from industrially developed countries to developing countries requires to create a technical infrastructure while training the specialists to create a class of industrial workers in the country. of course, this is a process which needs a good amount of time. To industrialize the traditional buildings which can be upgraded is only possible by using new technologies which is of course, an effective step in the localization of industrial technologies. Noguchi et al. [50] expressed that improvement of the scientific and specialized level of the country's engineering community and their getting to familiar with new construction technologies and materials, as well as reviewing the implementation of buildings by industrial methods rather than traditional methods, and the use of new technologies and compatibility of these methods with Iranian architecture and countries climate, are suitable solutions for the practical use of these new systems.

Dong [25] stated that today consequences of cities emphasize the need for researches on how to reduce the effects caused by it and how to use methods to reduce pollution and anomalies caused by human existence. Today man realize that their survival can only be summed up in reconciliation and respecting the nature, and as a result, they try to compensate for the damages and protect their environment, so he has got a special approach to the natural environment and the culture of using it and its lovers, especially man has become interested in nature. Considering the need for sustainability and survival in society, one question arises: what new technologies can be used to sustain usage of clean energy sources in architecture and building construction?

Frank et al. [30] stated that architecture and building are connected and integrated with technology. Meanwhile, the role of architects in creating new link between architecture and technique as one of the foundations of modern architecture has been very effective. Stouti and Leinger [64] stated that training by companies which provide technology in field of construction industry will make construction companies importing technology, better use of the capabilities of imported technology. Therefore, according to results of this research, paying attention to the needs of technology, market, policy making, research and development, contracts and protection of technology play an important role in economic and technology transfer in a proper way.

6 Conclusion

This study identified a specific tangible construction product, IHB, to enable research to find out how technology is transferred within the construction sector. Although Waroonkun and Stewart [74, 75] discussed technology transfer in construction projects, their study focused on how a project can be transferred. In contrast, the present study examines a project as a prototype, rather than a product [32, 38] and adopts the view that each project creates a unique building. Furthermore, Kirchberger and Pohl [37] argued that technologies should be integrated into products if they are sold to generate value for society and profit for the company. Therefore, from our perspective, Waroonkun and Steward's [74, 75] research focused more on knowledge sharing than technology transfer. As they explain, "technology transfer is defined as when various types of construction-related knowledge (e.g., design, construction process, use of materials, use of equipment, etc.) are transferred from the foreign/international company to the national/domestic company"

Technology transfer in the field of construction has also been discussed in the context of developing countries (e.g., [7, 23, 31, 53]). The previous research looked at how cooperation with foreign construction companies can be possible. this brought significant benefits to less developed countries. Developing countries benefit from training, project formulation, design and implementation, and shifting towards more sustainable construction. However, researches conducted in the context of developing countries [7, 23, 52, 74] focused on knowledge and skill transfer, construction techniques, organizational technology and management systems within the country, this research focuses on the transfer of a tangible product between firms.

This study was carried out with the aim of identifying how technology transfer occurs in the field of construction. The study approached this managerial issue through a qualitative analysis of technology transfer articles and a case study of an IHB company. Qualitative meta-analysis showed that globally, the accepted definition of technology includes three structures: product, process and knowledge. Surprisingly, these are the same structures that make up an IHB platform. Therefore, an IHB platform should be considered as a technology that can be transferred between two construction companies or a construction company and a company from another industry. This could mean that technology transfer will be an important part of future business models as well as a way to gain a competitive advantage through market disruption. Therefore, technology transfer articles should focus more on how to apply product platforms in construction. Also, technology transfer can be an effective way for construction companies to move from the current economic model to a more efficient resource and build "buildings in the economic cycle" as preferred by the European Commission (2020).

The evidence of this study show that investment in product platforms can benefit technology transfer in construction. In addition, the empirical case study showed that successful technology transfer in the field of construction requires a strong relationship between the participating companies. This research is studied from a managerial perspective based on a single case (with two technology transfer events) and this is a clear limitation of this study. The single-case method was chosen due to the need for in-depth information on firm-specific decisions, which seems vital to reach a conclusion about firm strategies. However, as the present study covered a single case, future research should examine other types of construction companies - Northern European and International ones- to confirm our research findings. Apart from the managerial, cultural and social decision-making aspects that affect the transferability of the HIB platform, researchers of technology transfer can also adopt a socio-technical perspective in light of the increasing demand for sustainable housing construction. To provide further insight into technology transfer in the construction sector, we intend to study technology transfer from the perspective of the receiving fir/ transferee.

Based on our findings, construction companies interested in implementing an IHB platform strategy through technology transfer should consider the following guidelines:

1. Both companies have the motivation to participate in technology transfer.
2. The receiving company must establish a strong relationship based on trust with the technology transferor.
3. Every technology transfer project involves a long-term commitment.
4. The two parties involved must work across organizational boundaries, which includes preparing to sell part of the company to the transferor in order to set up a partnership.
5. Technology is a set of interconnected structures that must be rearranged generally. Innovative technologies have always had a disruptive role, which means that an increase in technology transfer in the construction sector can redefine the market through internationalization and also distinguish a list of companies which not previously associated with construction, and this surely makes the competition tighter.

Concepts at company level

The decision to expand an existing business is often financially driven. However, this research showed that the CEOs of a case company, its subsidiary and a foreign company seem to have another reason to participate in technology transfer. For these managers, the driving factor for technology transfer is not only better profits but also the improvement of employees and society. Even so, competition in the construction sector is primarily based on price, and it is surprising that social aspects have a large impact on how this particular company performs. The social structure of the Nordic countries, i.e., all of these countries, which are considered to be pro-welfare countries, may explain this finding. People consider an affordable and high-quality life as a basic right, and this feature may make the studied managers focus strongly on corporate responsibility. In addition, the target company is making bold decisions to achieve its strong market position, and managers are likely to seek a partner with similar values for expansion.

The topic covered in this research was carefully described by The topic covered in this research was carefully described by Uusitalo and Lavikka [71], which describes how the company has grown over the years. Similar to the present study, their findings emphasize that all parties involved in technology transfer must share the same vision and goals. It feels that the findings show there is no optimal way to perform technology transfer, as this process is very complex and dependent on the maturity of the transferred technology. Therefore, companies (both sender and receiver) must fully understand what is being conveyed with a predefined product more easily than with a vague concept. This feature makes technology transfer particularly challenging in the construction sector, as businesses in this sector rarely offer a defined product. This is because construction businesses are based on rare client, which is heavily influenced by local regulations and expected to provide unique solutions more than ever. Uusitalo and Lavikka [71], which describes how the company has grown over the years. Similar to the present study, their findings emphasize that all parties involved in technology transfer must share the same vision and goals. it feels that the findings show there is no optimal way to perform technology transfer, as this process is very complex and dependent on the maturity of the transferred technology. Therefore, companies (both sender and receiver) must fully understand what is being conveyed with a predefined product more easily than with a vague concept. This feature makes technology transfer particularly challenging in the construction sector, as businesses in this sector rarely offer a defined product. This is because construction businesses are based on rare client, which is heavily influenced by local regulations and expected to provide unique solutions more than ever.

For this reason, construction companies are not used to implementing technology transfer in both directions. Hence, if construction companies are to manage technology transfer successfully, they must build new capabilities. This may explain the low degree of digitization (for example, the use of building information modeling or building with the help of robots) in the construction sector. As shown in the empirical case study, technology transfer links the resources that construction companies may need for flexibility in order to gain a competitive advantage. As such, long-term commitments between companies are rare and will severely hinder technology transfer in this sector.

Concepts at Industry level

When we consider our findings at the industry level rather than the firm level, it appears that technology transfer would significantly affect the construction market. For example, companies in current foreign markets have the opportunity to make a major technical leap by investing in the IHB platform. Of course, this requires that these companies can successfully implement this technology. As mentioned in one of the interviews with the CEOs, in the next two decades this company is possible to implement for other construction companies in a shorter period, for example, 3-5 years. This will enable companies to effectively use the IHB platform to reach new markets and disrupt local construction markets to gain market share. Additionally, the maturity of the IHB platform means that companies from other industries (electronics, retail, etc.) can access the construction market. These companies have higher capabilities in other business areas, but not in homebuilding.

We can give an example in this respect: Amazon, as an American multinational technology company. This company is considered as one of the four big technology companies along with Google, Apple and Microsoft. Amazon recently invested in a home-building startup called Plant PreFab. This decision for the construction of prefab can be seen as a stepping stone for the company so that they can later invest in an IHB platform. Due to its extensive expertise in technical innovation and mass scale, Amazon - equipped with the IHB platform - may threaten existing construction companies, as it may compete on different levels (e.g. price, quality, and reliability). This type of competition can be positive for customers as a potential increase of competition, in order to lower prices.

The research recommendations

It is suggested:

1. that the managers may not only absorb the physical aspect of technology, i.e., hardware, but focus on the acquisition of technological capabilities in order to develop the construction industry based on technology transfer.
2. that the construction industry should increase its absorption capacity by focusing on training and targeted research and development activities in order to fully and effectively utilize the transferred technology.
3. that before the transfer of technology, the construction industry selects a team of experts to study and get to know the desired technology in order to facilitate and speed up the purposeful acquisition of the technology by explaining the technological needs of the industry to the technology provider and creating an efficient and effective interaction.
4. that the activities of the research and development unit of the construction industry should be carried out with the aim of indigenizing the transferred technology and in order to increase the technological capabilities of the construction industry.
5. to carry out the research to identify the obstacles to the implementation of the related recommendations.

6. to examine the current state of the economic model and the transfer of advanced and new technology for the country's building industrialization and compare it with the ideal state (i.e., the presented model in the research).
7. to offer psychopathology for not paying attention to the effectiveness of the economic model and the transfer of advanced and new technology in order to industrialize the country's buildings, according to the dimensions of the presented model.
8. to rank the factors affecting the economic model and transfer of advanced new technology in the industrialization of the country's building with methods such as AHP, Topsis, etc., in order to determine the priority of the investigated factors.

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