

## A REVIEW OF TECHNOLOGY TRANSFER (TT) MODELS IN MANUFACTURING, IT, TOURISM AND CONSTRUCTION INDUSTRIES

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### ABSTRACT:

*Technology transfer (TT) in construction through construction project development has emerged as an important business and managerial concern to many developing countries including Malaysia. TT in construction is seen as effective mechanism to advance the flow of technological development by acquiring newer technology from abroad in response to a changing economic environment. This paper attempts to investigate and review different models of TT across industries: manufacturing, IT, tourism, and construction to capture the critical components for successful transaction, and the impacts of TT on organisational performances.*

*Based on the consideration of these models, important variables are captured. These are: types of technology (knowledge, tools and skills); numerous modes (channels) of TT; and project as a medium of transfer. These are needed for transaction process. The impacts of TT on organisational performance however, could be measured via the level of absorptive capacity, technological capabilities, barriers and benefits to the organisations/firms. The concept of TT could also include technology exchange (TE). It is a two-way flow which involves the transfer and exchange process of different components of technology in terms of knowledge, tools and skills. Technology may be transferred at any given time or on a given project which need not only be in one direction. The transferred and exchanged processes could occur simultaneously. Considering these variables, a further empirical research is needed for data elicitation.*

*Keywords: Absorptive Capacity, Malaysia, Technological Capabilities, Technology Exchange (TE), Technology Transfer (TT).*

### 1.0 INTRODUCTION

Technology transfer (TT) through the development of construction projects can be seen as an effective mechanism to enhance the local technological capabilities of an organisation and a country. It helps the diffusion process of newer technology abroad through technology importation to support indigenous innovation capabilities to meet socio-economic objectives and to compete globally (Saad et al. 2002; Putranto et al. 2003; Wie, 2003; Kumar et. al. 2007). Technology is a collection of physical processes that transform inputs into outputs with procedural techniques and organisational arrangements for carrying out the transformation (Bell et al. 1984; Putranto et al. 2003; Wie, 2003). In an operational context, technology could be defined as technical knowledge and could also be associated as a machine, an electrical or mechanical component, a chemical process, software code, a patent, a technique, communication, or a combination of different components. Therefore, transfer of technology from one entity to another, from one organisation to another or from one country to another is, simply identified as 'technology transfer'. It includes transfer of skills, technical know-how, machinery and other capital equipment (Wie, 2003). The concept of TT could also include technology exchange (TE). It is a two-way flow which involves

the transfer and exchange process of different components of technology in terms of knowledge, tools and skills (Kumaraswamy, 1994). Hence, technology transfer (TT) and technology exchange (TE) are goal oriented processes that is likely to enhance the local capabilities of an organisation and subsequently increase its performance (Autio and Laamanen, 1995).

Various models of technology transfer have been investigated from the literature and these models of TT could be seen from various industries such as: manufacturing, information technology (IT), tourism and construction industries (Waroonkun, 2007; Kumar et. al. 2007). The prime issues of these models are to enlighten the critical components that are needed to make a successful transaction and practical issues in the TT process. Thus, the aim of this paper is to review the existing technology transfer models from four industries (i.e., manufacturing, IT, tourism and construction) to capture two fundamental issues: critical components for successful transaction of TT process, and the impacts of TT on organisational performance, taking into consideration the technology exchange processes.

## **2.0 RESEARCH METHODOLOGY**

This study is purely based on literature review. It reviews the theoretical aspects of research work of TT models in manufacturing, IT, tourism, and construction industries. The decision to undertake literature review as the main methodology for the study arises from the desire to survey the latest knowledge in the field from the international experts and to capture as much of the issues relevant to TT. A rigorous literature review would provide breadth and scope to the study to be undertaken.

## **3.0 SYNTHESIS OF TECHNOLOGY TRANSFER (TT) MODELS**

Figure 1 to 7 present TT models in Manufacturing, IT, Tourism, and Construction industries. These models have been developed by various researchers (Kumar et al. 2007; Baark & Heeks, 1999; Kumar et al. 2004; Guan et al. 2006; Wie, 2003; Benda, 2005; Mansfield and Sasillo, 1990). These models are discussed in turn.

### **3.1 Technology Transfer (TT) Model in Manufacturing Industry**

Figure 1 presents TT model in manufacturing industry developed by Kumar et al. (2007). They viewed technology as a combination of four different components: technoware, humanware, infoware, and orgaware. Technoware is an object-embodied form of technology (machinery, various tools, structures and computing machines), humanware is human-embodied form to achieve the manufacturing goal and could be divided into two parts (contact human ware and support humanware). Orgaware on the other hand, refers to the support net of principles, practices, and arrangements that govern the effective use of technoware by humanware. Infoware represents the accumulated knowledge needed to realise the full potential of the technoware, humanware, and orgaware. As a result, in order to acquire technology, several modes (channels) are required to be employed such as: foreign direct investment, joint ventures, direct sale, licensing, turnkey projects, technical agreements, and cooperation. These will be obtained through the negotiation process.

Further, the success of the absorptive process of TT into the organisations or firms is through increasing the level of technological capabilities by the respective organisations (Saad et al. 2002).

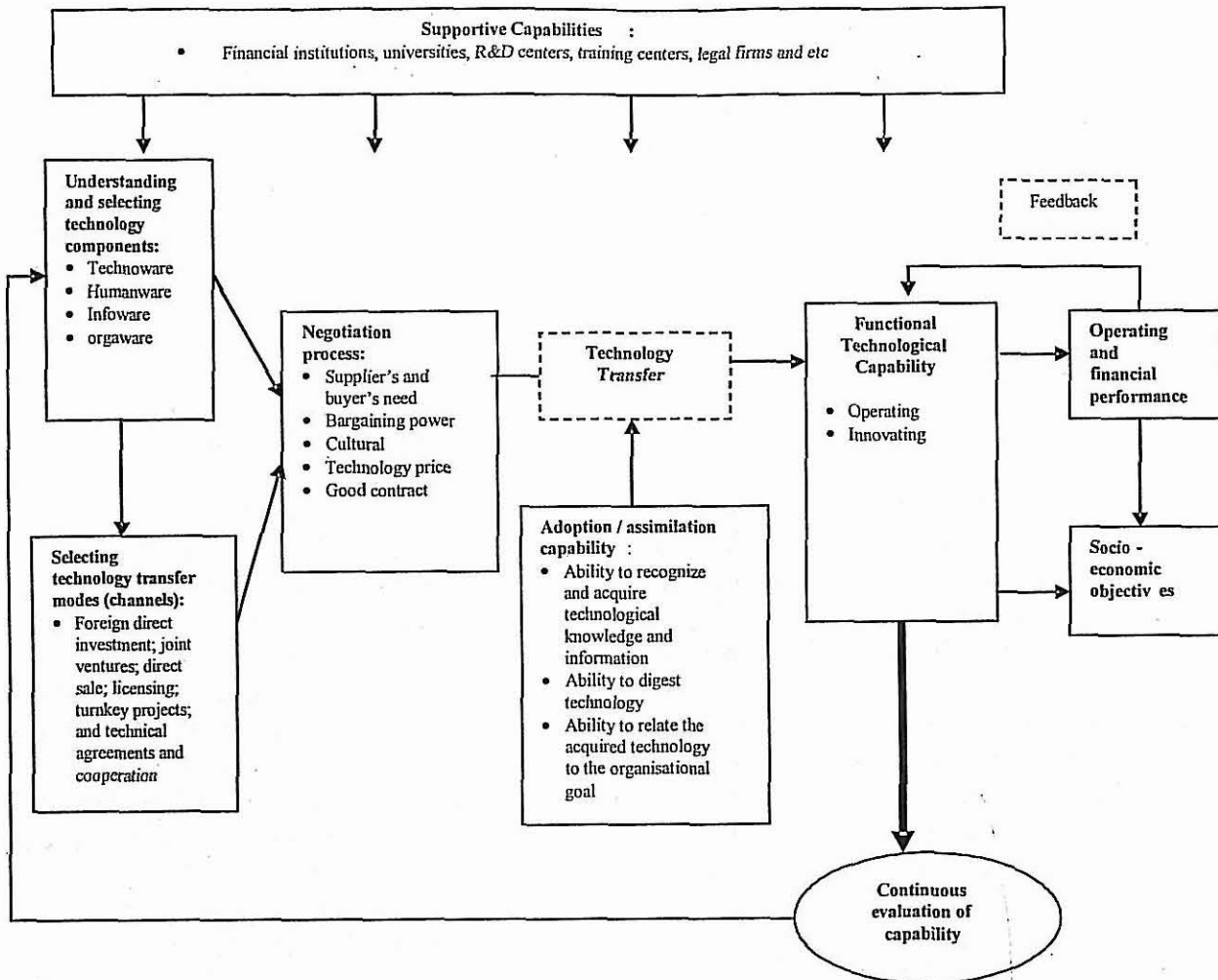


Figure 1: TT model in manufacturing industry. Source: Kumar et al. (2007)

Three types of capabilities are recognised i.e., adoption/assimilation, supportive and functional capabilities. Adoption or assimilation capabilities are: the ability to recognise and acquire technological knowledge and information; digest technology at the operational level through developing a skilled workforce; and to relate the acquired technology to the organisation's goal. Supportive capabilities are required to ensure and facilitate effective technology transfer process. This will help a technology receiving organisation to build up its bargaining power and develop its adoption and functional capabilities. Supportive capabilities include financial institutions, universities, R&D centres, training centres, legal firms and governmental bodies are paramount. Based on their model, Kumar et al. (2007) suggest that in order to capitalise the TT process in manufacturing, organisations should have operating and innovation capabilities. Operating capabilities refer to the ability to operate and maintain existing production facilities, whilst innovation capabilities refer to the ability to develop new products through in-house R&D capability and to assimilate these products to improve the performance of organisation.

The TT manufacturing model has been applied for the Libyan Iron and Steel Company (LISCO) project in Libya. It was reported that, the absorptive capacity to the organisation takes a longer time to take effect due to the incompetency of the local personnel. Nevertheless, the strength of this model is the elements of negotiation and financial factors. By means of effective negotiation between transferor and transferee, a successful TT could be achieved apart from a strong financial support. Successful negotiation should result in the watertight contractual stipulations on the part of both parties to ensure adoption and assimilation contingencies to be kept to a minimum. Finally, the

model incorporates continuous evaluation processes which provide continuous feedback to ensure all problems are resolved instantaneously instead of waiting for the full cycle to complete.

Further, rethinking the futile pursuit of elusive one-way TT led to the conceptualisation of TE. The concept was based on the holistic model of technology proposed by UNESCAP (ESCAP, 1994). The model is inline with Kumar et al. (2007) that identified four basic dimensions of technology as: technoware (hardware and physical facilities), humanware (people and their abilities), infoware (documented facts) and orgaware (organisational networks and managerial frameworks). The model was projected in a basic "THIO Diagram" representing the above four dimensions, illustrating that technology may be transferred at any given time or on a given project which need not only be in one direction. The transferred and exchanged processes could be occurred simultaneously (Kumaraswamy, 1995).

### 3.2 Technology Transfer (TT) Model in Information Technology (IT) Industry

Figure 2 shows a technology transfer (TT) model in IT developed by Baark and Heeks (1999) cited by Kaasboll and Nhampossa (2002). It involves the establishment of an information system developed for the health sector in South Africa and was transferred to the Mozambique Health Ministry. The model consists of five critical components for successful transaction. These are: choice of technology, followed by purchase and installation, assimilation and use, adaptation and diffusion/innovation. The cycle starts out with the choice of technology. From the technological perspective, transfer of technology could include both infrastructure and applications. The information technology infrastructure constitutes of networks, computer hardware and basic software. The second phase refers to the purchase and installation components, which include the procurement and the training needed to install the software and hardware. Carrying out the installation and operation of the infrastructure requires skilled technicians and electricity.

Next is the assimilation process. The purpose of assimilation and use is to make the users develop and maintain the competency necessary to use the system for various purposes. The assimilation process constitutes the enhancement of the organisation's ability to utilise the systems, including computer literacy technical training for users and support personnel. The fourth component is known as adaptation. Adaptation regards changing the system to suit to the local needs. The final phase regards the diffusion process in which, the knowledge could be disseminated to other organisations within the organisations and country.

Kaasboll and Nhampossa (2002) reported that problems with assimilation and adaptation were the major issues in Mozambique Health Ministry due to the poor implementation process. Although training was carried out prior to project implementation, the level of absorptive capacity among IT personnel in the country was insufficient for the smooth project implementation. Nevertheless, technology exchange process was not mentioned clearly in the model although it could be deduced that the exchange processes of TT occurred in the application, adaptation and diffusion programs.

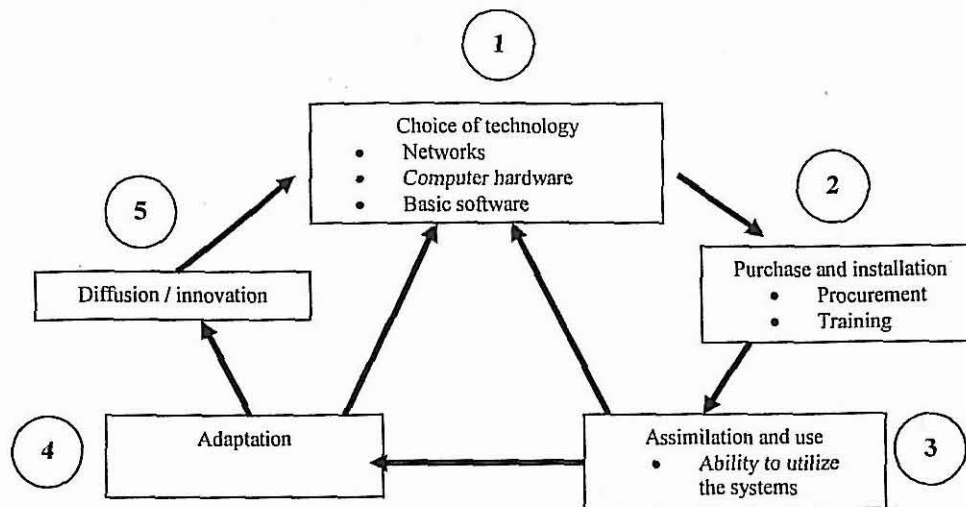


Figure 2: TT model in Information Technology industry. Source: Baark & Heeks, (1999)

### 3.3 Technology Transfer (TT) Model in Tourism Industry

Figure 3 presents the TT model in tourism industry developed by Kumar et al. (2004). The model highlights three important components of the TT process. The first deals with managerial capabilities which include leadership and employee support, knowledge and technical expertise, group management skills, and project management skills. They suggest that these four groups of managerial capabilities are essential that could have affected the relationship between technology transfer and technological capability. This is in line with the opinions of Wallender III (1979), Leonard-Barton (1995), Kuemmerle (1997) and Jayawardena & Haywood (2003) which postulate that successful technology transfer and improvement in technological capability depend on the critical managerial capabilities.

The second component deals with the organisational elements and this includes the learning culture, organisational structure, and the systems and procedures. The third addresses the organisation's absorptive capacity. Absorptive capacities consider the technological capabilities as essential components of the model. Technological capability is closely linked to the absorptive capacity of a particular project which includes dynamic learning, operational and investment capabilities. Hence, in order to develop technological capabilities, the efficiency and effectiveness of absorptive capacities of organisations or stakeholders are seen to be very crucial. Without the right level of absorptive capacity, there would be too great a gap to bridge when new technology is introduced. Absorptive capacity is similar to the assimilation and adaptation process in the TT model of IT industry as mentioned previously indicating the similarity of the two models (IT and Tourism). In addition, full government support is important for the smooth implementation process of technology transfer for the tourism industry.

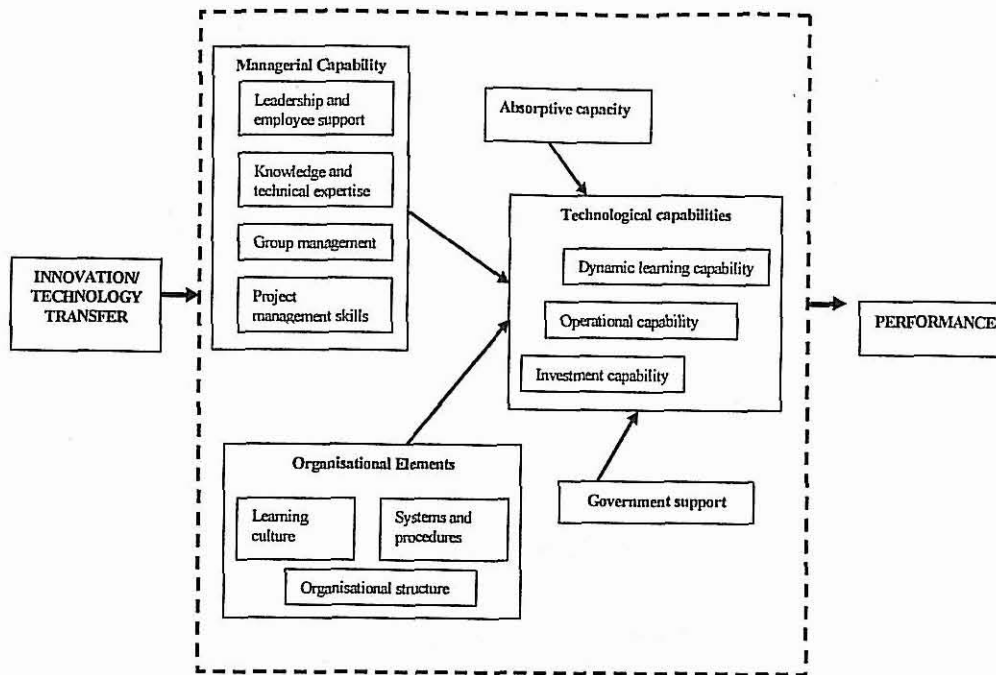


Figure 3: TT model in the Tourism Industry. Source: Kumar et al. (2004)

### 3.4 Technology Transfer (TT) model in Construction Industry

#### *Construction Industry China (Guan et al. 2006)*

Figure 4 presents the TT model of China developed based on the understanding of work done by Guan et al. (2006). The major concerns of the model are: types of technology transfer (knowledge, skills and tools), technological capabilities (the efficiency and competitiveness in the use of imported technologies), the channels (modes of TT), barriers of TT and finally, the organisations/stakeholders. In their model, technological capabilities are divided into four (4) components: operative, acquisitive, adaptive, and innovative capabilities. Operative capability deals with knowledge and skills in order to run the tools (i.e. machinery and equipments). Acquisitive capability refers to the search of new skills and knowledge, adaptive capability is to adapt TT in the operation of the product, while, innovative capability means the use of knowledge, skills and tools to innovative new products. Therefore, to acquire these technological capabilities, various forms of channels (i.e., training programs, managerial and institutional programs, procurement and contractual contracts) are required. Through these channels foreign technology could be transferred to Chinese organisations such as the buyers. Nevertheless, in China the lack of organisational skills, management and marketing are the form of TT barriers that should be taken into consideration as suggested by Guan (2002) and Guan & Ma (2003). Apart from the importance of technological capabilities that support the absorptive capacity in the TT process, the organisational and managerial culture, the role and the structure, the needs and expectations of Chinese stakeholders are crucial that could act as barriers of TT which is in line with the idea of Farrands (1997).

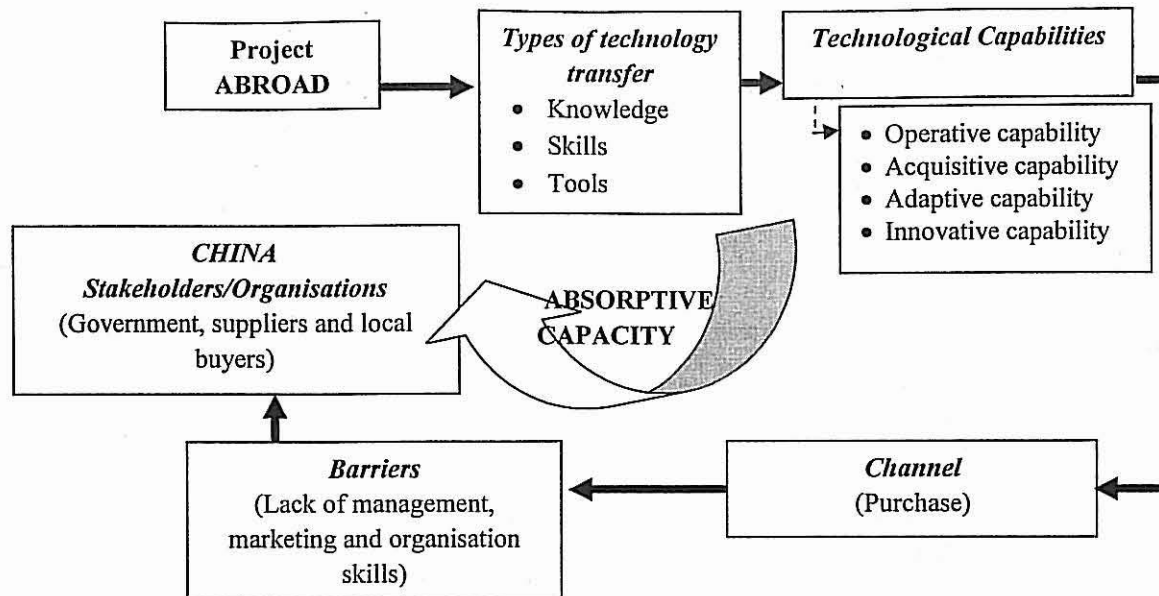


Figure 4: TT Model in China. Source: Guan et al. (2006)

### Construction Industry in Indonesia (Wie, 2003)

Figure 5 shows the TT model of Indonesia developed based on the understanding of work done by Wie (2003). The model highlighted four important factors which includes: the types of technology transfer (knowledge, machinery/tool, skills and technical know-how) that are needed to run an enterprise; technological capabilities (i.e., the ability of the Indonesian utilising the imported technology effectively to develop new products and processes) (Bell et al. 1984 and Kim & Linsu, 1997); different forms of channels or modes of technology transfer (Foreign Direct Investment (FDI), licensing agreement, import of capital goods, foreign education and training, and technical consultancies) and stakeholders (Government, foreign suppliers and local buyers).

To capitalize TT projects in Indonesia, the organisations should have the capability to use, adopt, replicate, modify and able to implement TT locally and, further extend the knowledge and skills to the nearby countries. Therefore, in order to develop the Indonesian technological capabilities, the efficiency and effectiveness of absorptive capacities by stakeholders are seen to be the utmost essential. Further, the model visualized a two-way flow, technology transfer (TT) and technology exchange (TE) which involves the transfer and exchange process of different components of technology in terms of knowledge, tools and skills to other countries and in line with the opinion of Kumaraswamy (1994) and (1995). The two-way flow of TT and TE could generate a more useful impact of technological capabilities in the organisations/firms.

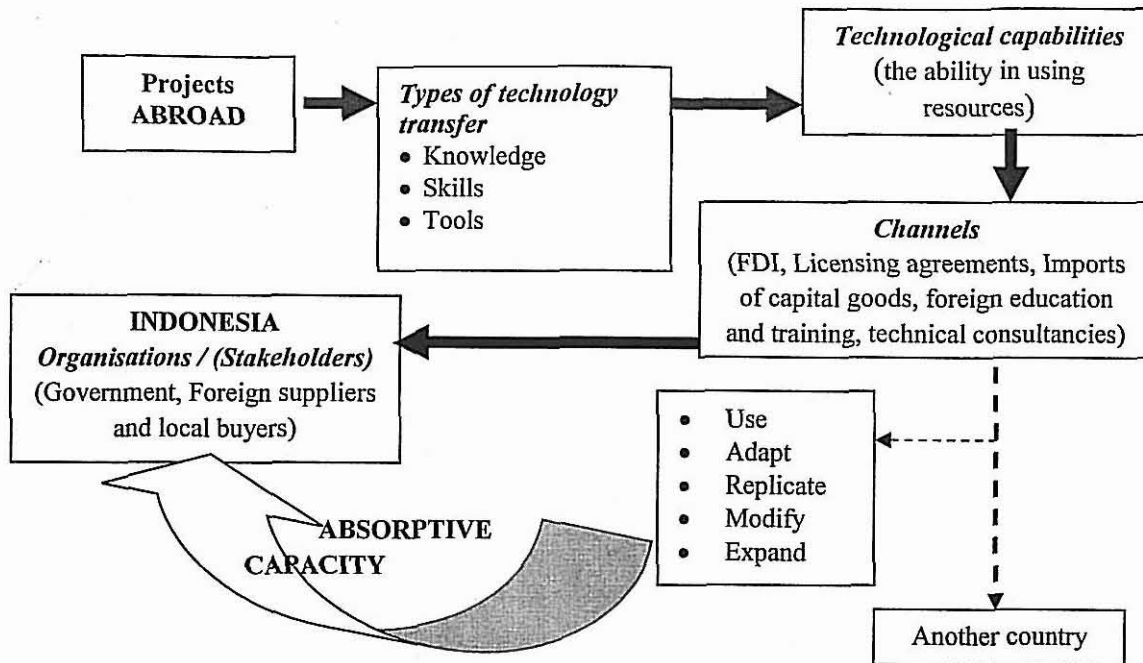


Figure 5: TT Model in Indonesia. Source: Wie (2003).

### Construction Industry in Tanzania (Benda, 2005)

Figure 6 presents TT model of Tanzanian construction industry developed by Benda (2005). In this model, Benda (2005) classifies four components/clusters that should be observed for the understanding of technology transfer. These are: the environment, organisation, technology and, capacity building. The environment consists of national and industry setting environment, while organisation comprises of foreign and domestic contractors firms. She further classifies the organisation into actors, projects, and collaboration. The actors are the foreign contractors (main contractor), the local sub-contracting companies and the local construction workers. The kind of project is carried out by the foreign domestic collaboration (FDC) and the type of collaboration is by means of joint venture (JV) and subcontracting. The third addresses different form of technology which could be in the form of technical means, manpower, information/documentation and organisation used for the project. Finally, technology is transferred via projects into organisation in which collaboration could facilitate to improve the organisational performance and local capacity building. The capacity building refers to the level of capital, knowledge and skills possessed by the domestic construction firms.

In conclusion, Benda (2005) reckons that foreign-domestic collaborations have proved to be an effective component for technology transfer for the purpose of capacity building. Nevertheless, local companies and workers could only obtain knowledge and skills in the collaboration process despite the technical capabilities (i.e., construction materials, products, methods, equipments and tools). This is because to a certain extent foreign companies prefer to bring-in necessary equipments and tools for the project instead of relying on the local equipments and products. Once the project is completed companies will sell that equipment to local joint venture companies. The strength of this model is that it is very simple to understand and implement. However, a major weakness is that the component of technological capabilities is not been mentioned which is considered to be the lacking part out of it compared to other models of technology transfer (i.e., manufacturing, IT and tourism).

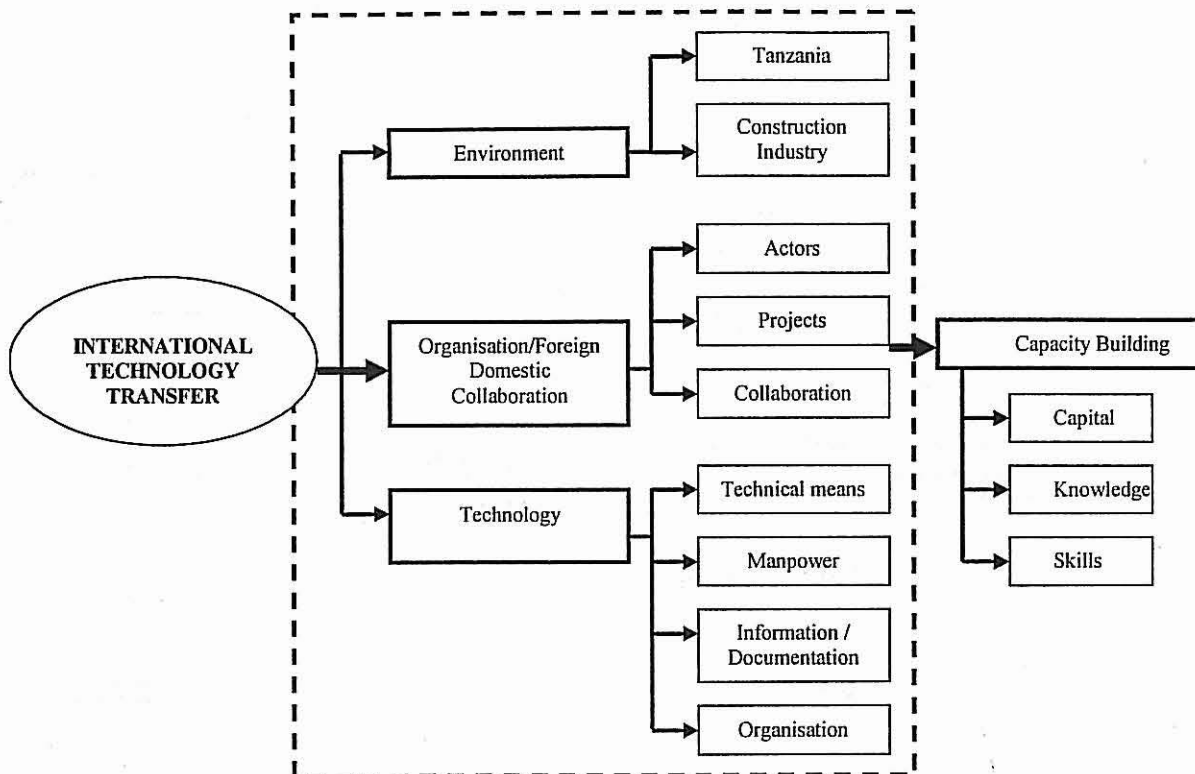


Figure 6: TT model in Tanzania. Source: Benda (2005)

*Construction Industry in Tanzania (Mansfield and Sasillo, 1990)*

Figure 7 presents the technology transfer (TT) model of Tanzania developed by Mansfield and Sasillo (1990). Based on the model, the stakeholders' organisations are the government, local contractors and international firms that participated actively throughout the construction project phases; ranging from feasibility study, design, construction and supervision. Most of the construction works are carried out by foreign or international firms whilst, local contractors are required to take merely a low proportion of new construction work. The reason for the above predicament is most likely due to the lack of management capabilities by Tanzania's contractors to manage construction projects efficiently and effectively as claimed by Mansfield and Sasillo (1990). The main criticism of TT projects in Tanzania is that some technology borrowed from outside tends to be more advanced and impractical to be implemented for the Tanzania's projects due to the lack of knowledge of the local practitioners. These are the main barriers faced by them. The absorptive capacity therefore, depends on the local practitioners. With regards to Tanzanian, due to the lack of knowledge of the local practitioners, the absorptive capacity is regarded as minimal. By and large, it is suggested that local engineers should be given a chance to practice their knowledge, with emphasis on promoting self-reliance in the industry. Furthermore, training should also be given a greater recognition for those who have participated in the construction industry. Mansfield and Sasillo (1990) suggest that in order to enhance transfer of technology, self determination and confidence should be developed within the local practitioners for the fact that the modes of transfer of technology (i.e., channels) via joint-venture and training and development are the recipes for TT projects.

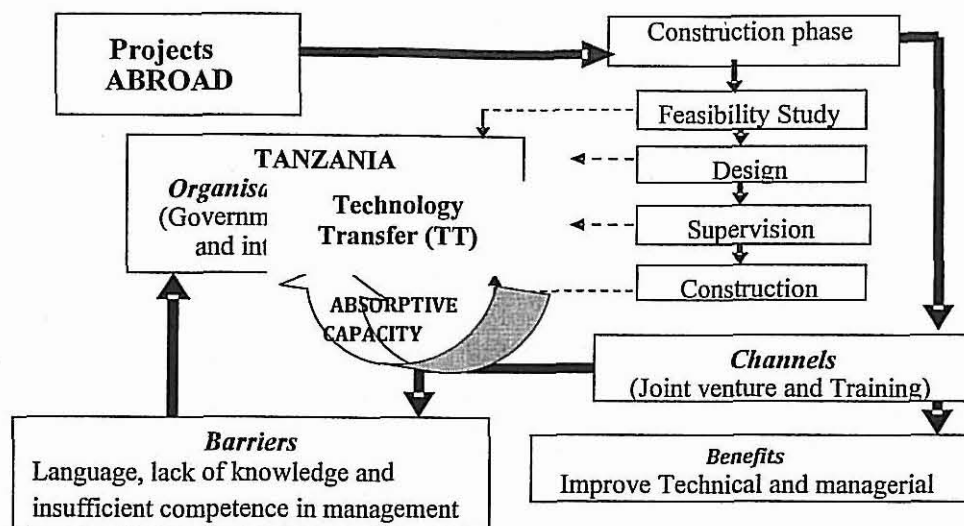


Figure 7: TT Model in Tanzania. Source: Mansfield and Sasillo (1990)

#### 4.0 SUMMARY AND DISCUSSION OF THE TECHNOLOGY TRANSFER (TT) MODELS

As listed in figure 1 to 7, most of the TT models approach above, if not all, focus on the types of technology transfer, technological capabilities, modes of technology transfer, absorptive capacity and their impacts on organisational performances. The first model of TT of manufacturing industry by Kumar et al. (2007) appears to be more applicable to be adopted and used in construction. It is a process-based form of model in which the components for successful transactions (i.e., types and modes of technology transfer, technological and managerial capability and absorptive capacity) are embedded within the model. Absorptive capacity is explained under the adoption and assimilation process. All the processes involved are spelled out clearly and comprehensively. At the same time financial factors and the achievement of the socio-economic objectives are highlighted. In addition, the availability of supportive capabilities within the environment is seen as an important component to mitigate problems and difficulties.

IT model of technology transfer by Baark and Heeks (1999) seems to be very simple and less challenging. Despite the hardware and the software components, the model is less focusing on the managerial and humanware aspects which are one of the focal components of TT process. Therefore, the model is regarded as less suitable to be adopted as best practice approach for the construction industry. Meanwhile, the model of TT of tourism industry by Kumar et al. (2004) seems to be broad and comprehensive which take into consideration dynamic leanings, learning culture and leadership components. Nevertheless, to a certain extent this model is lacking of many important components such as negotiation process and the supportive capabilities which is paramount to tourism industry (service-and people-oriented organisation). This could be due to the minimal concentration on the implementation cycle for tourism because of no tangible end-product apart from customer satisfaction.

The variety of TT models in construction such as TT from China, Indonesia, and Tanzania appears to be similar in approach in particular, the needs of local stakeholders/organisations' capabilities to adopt newer technology abroad and use them locally for the benefits of the nations. The Tanzania model by (Mansfield & Sasillo, 1990) on the other hand, emphasising the usefulness of knowledge transfer to local practitioners. Further, the model developed by Benda (2005) failed

to consider further on organisational technological capabilities which is one of the focal point of TT process in construction.

Most of the models above failed to discuss in detail the process of technology exchange (TE). The visualisation of TE in any industries i.e., manufacturing, construction, IT and tourism are paramount in terms of mutually beneficial two-way technology flows that could surmount many present obstacles to TT. This means to say that the technological strength of one party compensate for the weakness of other in each case. Therefore, technology transfer (TT) and technology exchange (TE) could occur concurrently via construction project development, in which some technology could transfer through the exchange process and in line with the idea Shresta and Kumaraswamy (2000). According to them mutual technology transfer/exchange processes occurred via project implementation and further disseminated to other parts of the world, irrespective of whether originating from a developed or developing countries.

Further, from the construction industry's perspective, it could be deduced that the overall models of TT of construction industries are less supportive in term of encouraging TT processes compared to the model of TT by manufacturing industry. Although the recipes are good on their own to suit the Tanzanian, China and Indonesian construction environments, many lessons are learned with regards to the critical components of TT (i.e. types of technology (knowledge, tools and skill), channels of TT, and project as a medium of transfer) that are needed for successful transactions. The impacts of TT on organisational performance however, could be measured via the level of absorptive capacity, technological capabilities, barriers and benefits to the organisations/firms.

## **5.0 CONCLUSION**

This paper has reviewed various models of TT from manufacturing, IT, tourism, and construction industries to capture the critical components for successful TT transaction, and the impacts of TT on organisational performances. Based on the consideration of these TT models many lessons are gathered and learned. These are:

- The components of TT are the types of technology (knowledge, tools and skills); numerous modes (channels) of TT; and construction project as a medium of transfer
- The impacts of TT on organisational performance could be measured via the level of absorptive capacity and technological capabilities
- Barriers of TT in organisation are in the form of culture differences, language, social values and dissimilar objectives
- TT involves various project stakeholders in the organisations/firms (i.e., Client, Government, consultants, suppliers, and employees ) that have stake in TT
- Benefits of TT could be perceived in the form of improving project efficiency and effectiveness, increased profits, and user's satisfaction.

Therefore, to acquire a successful absorptive capacity of TT in any organisations/firms, it is important to consider the level of organisational technological capabilities, the competency of the local stakeholders/practitioner, the organisational and managerial cultures, the role and structure, the needs and expectation of project stakeholders. In considering these variables, a further empirical research is needed. A combined approach of the two methodologies (e.g. quantitative survey data and qualitative case-study) would be useful for data elicitation prior further validation processes.

The research presented in this paper is part of an ongoing PhD research at the Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA (UiTM), Malaysia to develop a framework of technology transfer (TT) and the development of technological capabilities in the

Malaysian construction industry. The results of the study could provide an insight into the Malaysian construction project development and could provide valuable guidelines, especially to both public or private sectors in Malaysia that are looking forward to a global construction marketplace.

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