Leveraging a Public Infrastructure Project as a Driver for Technology Development – A Case Study on a Technology Transfer Model for the Klang Valley Mass Rapid Transit Development Project

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Abstract: **In realizing the strategic leverage large public procurement has on technol- ogy development, several countries have introduced technology transfer programs within strategic public procurement to develop the capability of their local industries. This pa- per uses a mix-method analysis of qualitative and quantitative data from a case study of a technology transfer model in a public rail infrastructure project in Malaysia. For the quantitative analysis, a total of 202 respondents from the contractors and consultants have participated in the survey. The results of the analysis show that the critical success factors for determining the technology outcome of the KVMRT Technology Transfer program are "Technology Transfer Planning", "Transfer Environment" and "Learning Environment". The study concludes that the factor most influencing the outcome is "Learning Environ- ment". Based on the findings, recommendations were made to improve the technology transfer process for similar future rail projects. The study recommendations include (1) Improvement of the current government policy on Technology Transfer, (2) Focusing on innovation as one of the main criteria for a successful TT outcome, (3) Digitalization of the TT Process and (4) Establishment of a Technology Transfer Office (TTO) within a government strategic procurement project.**

Keywords: **Technology Transfer; Technology Transfer Model; Structural Equation Mod- eling; Knowledge Transfer; Klang Valley Mass Rapid Transit Project.**

Running Head: **Leveraging a Public Infrastructure Project as a Driver for Technology Development – A Case Study on a Technology Transfer Model for the Klang Valley Mass Rapid Transit Development Project.**

I. INTRODUCTION

Based on the OECD study, most developing countries leverage their public procurement as a strategic method of securing technology development and innovation for their country (Appelt et al., 2016). Public infrastructure devel- opment projects have always provided a dynamic and com- plex environment in which technology transfer and innova- tion can occur in various ways. Recent development has also shown that policymakers are leveraging the public pro- curement as a way to attract technology development and innovation due to their influence when selecting companies to participate in public projects (Edler et al., 2013). There have been numerous studies on public procurement and its impact on technology development and innovation. How- ever, there are few studies of the factors causing the impact of public procurement on company success in a micro-level environment (Blind et al., 2019). By better understanding the key factors for company-level success in a public pro- curement project, improvement can be done to further in- crease the effectiveness of the technology transfer process. The involvement of multiple stakeholders across the infras- tructure project provides the necessary environment for the learning and re-learning of new technology and knowledge. However, the effectiveness of technology transfer can de- pend on several key factors, which can be identified using qualitative and quantitative approaches when studying the nature of technology development within public procure- ment.

The Klang Valley Mass Rapid Transit (KVMRT) rail infrastructure development project is a high-profile public procurement project in Malaysia due to its massive scale in terms of the funding, manpower and technology needed for its implementation. The KVMRT rail infrastructure de- velopment was chosen as the case study for this research because the project's massive scale requires an effective Technology Transfer (TT) program. The TT program was implemented in the project from the start of tendering and throughout the implementation of the main project. The various key construction companies and railway stakehold- ers that are involved in the project provide a good sam- ple population for the research. The KVMRT develop- ment project also offers a good range of sample for research which contains a balanced representation of the construc- tion personnel involved in the planning, construction, test- ing and commissioning of the project. As in the previous study by Yin (2003), a case study approach can help re- searchers to identify critical factors in a dynamic and com-plex environment that can produce a valid hypothesis for further research. The technology transfer program in the KVMRT project used a government-mandated offset pro- gram, also known as an Industrial Collaboration Program (ICP), where the winning tenderer must ensure that the technology transfer is implemented (Hamdan, 2015). Once the winning bidder was awarded the project, further negoti- ations took place with the government to fine-tune the tech- nology transfer program offered by the contractors. The objective of this study is to analyze and evaluate the effec- tiveness of the technology transfer program in meeting its intended purpose and goals using the KVMRT development project as a case study.

Technology transfer can be defined as the acquiring of knowledge and techniques concerning design, process, material selection and also equipment maintenance and knowhow (Simkoko, 1989) (Waroonkun, 2007). Tech- nology transfer is considered a lengthy, complex and dy- namic process (Purushotham et al., 2015) and therefore the effectiveness of the technology transfer program is mea- sure through critical factors and sub-factors (Waroonkun, 2007). Technology transfer process also depends on many variables and interrelationship (Gibson et al., 1991). In Malaysia, technology transfer has mainly been used by the government as a way to jumpstart the technological de- velopment of local industries (MIGHT, 2014). However, specific sectors, such as Malaysia's rail industry, still de- pend heavily on foreign Original Equipment Manufacturers (OEMs) due to the absence of technology transfer program during previous rail infrastructure development projects in the country (MIGHT, 2014).

Objectives

This study provides an analysis of a case study involving the technology transfer model used in a public rail infras- tructure project in Malaysia. It aims to identify the current process flows and gaps in the technology transfer process of the project. The study to determine also the factors and sub-factors that contribute to the effective and successful tech- nology transfer in the project using mix-method of qualita- tive and quantitative analysis.

II. LITERATURE REVIEW

Public procurement is increasingly being used as a tool for developing local technology, especially in OECD coun- tries. However, few studies address the factors affecting the outcome of public procurement being used to develop local company capabilities (Georghiou et al., 2014). There is also a risk to the elivery of the main procurement if technol- ogy development and innovation are being given too much emphasis compared to the main objectives of the original procurement (Uyarra et al., 2010). Previous studies have shown that in a complex public procurement project with multiple stakeholders, there are many factors involved that can affect the technology transfer process. There have been many studies that attempt to study technology transfer fac- tors, mostly using a qualitative approach. One such study by Sazali et al. (2009) attempts to examine qualitatively the evolution of technology transfer models over time and the limitations of each model. The survey by A. Khan (2011) was to examine the effectiveness of technology transfer in the Pakistan automotive industry using a hybrid method in which qualitative analysis is conducted and supplemented by a questionnaire. However, in recent years several stud- ies have been conducted that started to use quantitative data analysis to model technology transfer. Research by Wa- roonkun (2007), for example, developed a model of tech- nology transfer for Thailand's construction industry using Structural Equation Modeling (Gliem et al., 2003). Crit- ical success factors for technology transfer within an In- dian context have also been conducted using the SEM ap- proach (Purushotham et al., 2015).

This literature review enabled the possible technology transfer factors and sub-factors for the KVMRT project to be collected, as shown in Table 1 below.

Initial planning in the study refers to any preliminary ex- ercise conducted before the implementation of the technol- ogy transfer program. Several studies show that preliminary activity was necessary to ensure a successful technology transfer (Rose, 1995) (Smith, 1995). The study by Balakr- ishnan (2007) pointed out that the lack of initial planning has caused a lack of readiness from both of the technol- ogy providers and recipients in a technology transfer pro- cess (Balakrishnan, 2007).

Preliminary assessment and selection factors refer to the activity of selecting the participants and technology providers for the technology transfer program. Heslop (2001) stated that the identification of suitable recipients could lead to a successful technology transfer (Heslop, 2001). Balakrishnan (2007) also noted that the identifica- tion and technology assessment is vital before the imple- mentation of a technology transfer program (Balakrishnan, 2007).

Technology transfer requirements included in a tender can be categorized as initial strategic planning for the tech- nology transfer program. Interviews with the key person- nel of the KVMRT procurement agency highlighted several times that the measurement of the technology transfer pro- gram in the Klang Valley MRT project was based on the technology requirements document prepared for the inclu- sion in the procurement tender. Balakrishnan (2007) stated that Offset and technology transfer requirements would be notified later in the procurement stage, which has resulted in difficulties for both the technology providers and receivers in the technology transfer process (Balakrishnan, 2007). Some studies also stated the need for a clear and consistent vision as a factor for an effective transfer of technology (Se- cundo et al., 2016).

The "Knowledge Base" factor in this study includes both explicit and tacit knowledge. The effectiveness of the tech- nology providers contributes to the efficiency of the tech- nology transfer process (Gunsel, 2015). A. Khan (2011) also stated that technology providers who are willing to assist the recipients' learning by providing on-going assis- tance show improvements in the overall general knowledge of the technology (A. Khan, 2011).

FACTOR	VARIABLE NAME	REFERENCES
Technology Transfer Planning	Initial Planning Preliminary Assessment and Selection TT requirement included in the tender Technology Transfer Channel	(Smith, 1995) (Rose, 1995) (Balakrishnan, 2007) (Heslop, 2001) (Balakrishnan, 2007) (Balakrishnan, 2007) (Secundo et al., 2016)
Transfer Environment	Government Policy Government Enforcement Effective Coordination & Monitoring Different Culture or Nationality Mutual Trust Clear Understanding of Technology Transfer Scope Effective Communication	(A. Khan, 2011) (Balakrishnan, 2007) (Bozeman, 2000) (Rose, 1995) (Balakrishnan, 2007) (Oliveira et al., 2010) (Hamdan, 2015) (Waroonkun, 2007) (Lin and Berg, 2001) (A. Khan, 2011) (Sazali et al., 2009) (A. Khan, 2011) (Waroonkun, 2007) (Choi, 2009) (Gibson et al., 1991) (Smith, 1995)
Learning Environment	Strong commitment by the Senior Management Good Teamwork Adequate Facility High degree of interest by both provider and recipient Sufficient and Close Supervision Willingness to implement	(Rose, 1995) (Phan and Siegel, 2006) (Choi, 2009) (Parke and Sonesson, 2018) (Ruiz, 2010) (Wiseall et al., 2001) (Choi, 2009) (Gibson et al., 1991) (Asghari and Rakhshanikia, 2013) (A. Khan, 2011) (Waroonkun, 2007)
Technology Provider Characteristics	The degree of experience in TT Management practices and procedures Extensive Knowledge Base Honest and Transparent Willingness to learn and change their existing work practices	(Waroonkun, 2007) (Balakrishnan, 2007) (Waroonkun, 2007) (Heslop, 2001) (Waroonkun, 2007) (Gunsel, 2015) (Wiseall et al., 2001) (Meulman, 2017) (A. Bakar, 2006) (Malm et al., 2016) (A. Bakar, 2006) (Waroonkun, 2007)
Recipient's Characteristics	The degree of experience working with foreigner/technology provider Appropriate Management practices and approaches Adequate Knowledge Base Competitiveness	(A. Bakar, 2006) (Waroonkun, 2007) (Mohamed, 2015) (Rose, 1995) (Spann et al., 1995) (Heslop, 2001) (Waroonkun, 2007) (Bozeman, 2000)
Economic Advancement	Overall Performance Overall Profitability More innovative	(Bozeman, 2000) (Heslop, 2001) (Choi, 2009) (Ruiz, 2010) (A. Bakar, 2006) (Waroonkun, 2007)
Knowledge Advancement	Knowledge and skill Enhance working practices Enhances local workers competency	(Kiong, 2000) (Jusoff, 2009) (A. Khan, 2011) (Waroonkun, 2007) (Adzroe, 2015) (Chege, 2018)
Project Performance	Enhanced the project financial performance Enhanced the project schedule performance	(Omar et al., 2008) (Waroonkun, 2007)

Trust in partnership and alliances in technology trans- fer plays a significant role and shapes their relationship complexity, thereby affecting the technology transfer pro- cess (Meulman, 2017). The willingness to learn and change their existing work practices relates to an organization's ab- sorptive capacity. A factor highlighted by several studies is that the recipient's ability to absorb knowledge is one of the critical elements in a successful knowledge transfer (Malm et al., 2016). Another example of this factor playing a vital role in the technology transfer process is the Rolls-Royce case study. The Rolls-Royce University Technology Cen- tre was developed by Rolls-Royce with the objective of strengthening their technology acquisition. One of the crit- ical factors put in place is the open and trusting working relationship between the parties involved to ensure success- ful technology transfer (Wiseall et al., 2001).

The recipient's absorptive capacity was also being stated by A. Khan (2011) who noted it as a necessary factor for a successful technology transfer. A company will also have good absorptive capacity if it has previous experience in a technology transfer program. As stated by A. Bakar (2006), construction companies that have previous experience of technology transfer would perform better in a subsequent technology transfer program.

Mohamed (2015) highlighted that the recipients' exist- ing knowledge does affect the overall process of technol- ogy transfer and must be supported by learning intensity. Construction companies that are already at a higher devel- opment stage of the technology will generally do better in the technology transfer program. The recipient must also be in the same industry as the technology provider so that the technology transfer can be successful. A. Bakar (2006) stated that companies which implemented long-term plan- ning for technology transfer would achieve better results from the technology transfer process.

Innovation in this study refers to any improvement to the transferred technology as a result of the technology transfer process. As Choi (2009) pointed out, technology transfer must be accompanied by innovation to suit the new envi- ronment and condition of the recipient. Ruiz (2010) high- lighted that a technology and knowledge transfer process could become leaner and more agile by adopting the open innovation paradigm.

Transfer outcomes in the study refer to the macro and microeconomic levels of a company. One key transfer outcome is the increasing competitiveness of the recipient. The competitiveness factor in this case relates to the firm-level competitiveness because of the technology transfer. Competitiveness is an outcome where the firm gains a competitive advantage through technology transfer (Spann et al., 1995).

From the literature review, a conceptual model was developed with the enabler factors and outcome factors identified beforehand. The conceptual model provides the five main enabling factors and the three outcome factors that contribute to a successful technology transfer program as shown in Figure 1 above. Thirty-five (35) variables were identified during the literature review stage that relate to the enabling and outcome factors. The conceptual model serves as an important step for the analysis to be done during pilot and primary study stages.

III. RESEARCH METHODS AND DATA GATHERING

This study can be categorized as field research as it re- lies on the collection of original qualitative and quantita- tive data from real case studies and companies (Edmond- son et al., 2007). Further study has also supported the need for the mixed method validation of quantitative results in a new or partially explored domain (Yauch et al., 2003). For the study, the research methods and data gathering used both qualitative and quantitative methods. Qualitative tech- niques were used during the pilot study that involved inter- views and participatory observations followed by the use of NVIVO 12 as the analysis tool. Interviews and participatory observations can be considered reliable methods of data gathering in specific case studies (Balakrishnan, 2007). The quantitative method involving questionnaires with a Likert scale was used during the primary research and the quanti- tative analysis tool used was IBM SPSS Statistics v24 and IBM SPSS AMOS v20. The quantitative analysis methods involved using Factor Analysis and also Structural Equation Modeling (Gliem et al., 2003).

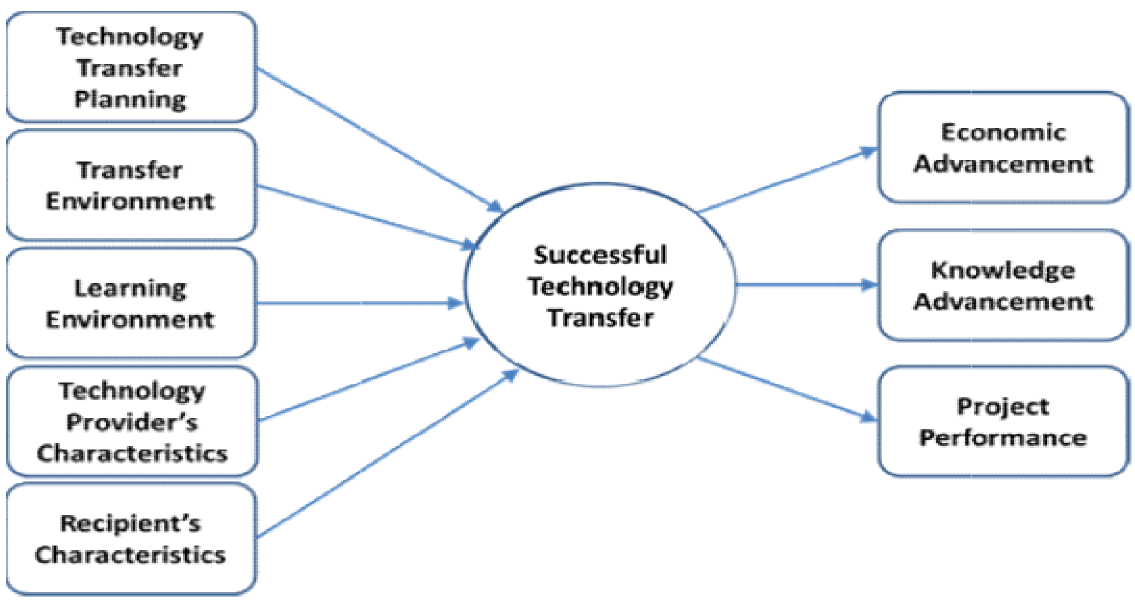

Fig. 1. Conceptual KVMRT TT Model

There are four main stages to the research: (1) Concep- tual Model Development, (2) Pilot Study, (3) Primary Study and (4) Model Validation. The conceptual model develop- ment stage was mainly based on the literature review. The pilot study and primary study stages are where the concep- tual model is being tested and analyzed. The fourth stage; the model validation stage, is primarily to validate the find- ings from stages two and three. The literature review took place throughout the study to support the findings and anal- ysis in each of the stages. The research methodology used a mixed-method combination of the qualitative and quanti- tative methods. The stages of research are shown in Figure 2 below.

Pilot Study

For the pilot study, data was gathered through face-to- face interviews with six (6) key people from the procure- ment agency who were involved in managing and monitor- ing the technology transfer program in the KVMRT project.

As can be seen in Table 2, all the key staff have more than four years' experience in the technology transfer program, with two of them having ten years of experience. The inter- views were conducted based on a structured questionnaire with open-ended questions which had been emailed to the selected respondent prior to the meeting. This was done to allow the respondents to fully understand the questions before providing their answer during the interview. The in- terview session was recorded using a digital voice recorder and transcribed afterwards. This transcription was then an- alyzed using NVIVO 12.

The evidence of the analysis is based on the excerpts from the interview as can be seen in Table 3 below. The excerpts are labeled with an identifier that refers to a spe- cific respondent. The meaning of the theme is based on the literature review of studies related to TT that carefully elaborated on the suggested theme.

Through the analysis, the critical success factors or the latent variables could be identified and verified. The defined variables act as an input to the formulation of the question- naire for the quantitative data gathering. Among the critical success factors identified from the analysis are: recipient's characteristics, provider's characteristics, and the planning of the technology transfer. The technology outcome that was highlighted from the interviews was the effect of the program on the improved salary and career progression of the staff involved.

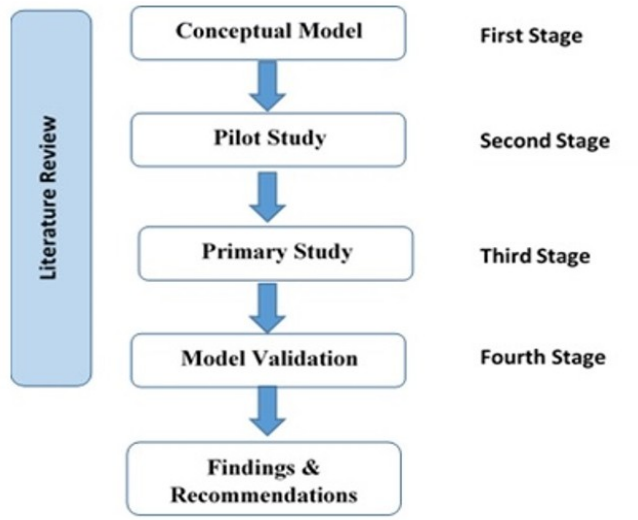

Fig. 2. Stages of the Study

Table 2. Participant's Characteristics for Pilot Study

Participant's ID	Position	Department	Experience in TT
A1	General Manager	Procurement	4 Years
A2	Assistant Manager	Procurement	4 Years
A3	Head of Department	Systems Package	10 Years
A4	Head of Department	Systems Package	10 Years
A5	Head of Department	Systems Package	4 Years
A6	Head of Department	Systems Package	4 Years

Table 3. Theme Frequencies Identified from Interview Analysis Theme

Theme	Frequency	Evidence
Technology Transfer Plan- ning	10	"For agency's requirement, technology transfer is related to the technical team, so we requested respective Systems team what their requirements" (A2) "The objective of the tech- nology transfer is defined together with government at that time. The government already have the gap analysis and rail blueprint" (A3)
Technology Transfer Channel	13	"Joint Venture is much more effective as they will do it to- gether and that is more effective" (A3) "There is technology transfer in the process of assembly, installation, testing and commissioning" (A6)
Learning Environment	16	"On-Job-Training (OJT) is the best, but you cannot accom- modate all. There is a limitation to participants" (A1) "Dur- ing OJT they get to get to be involved in the process even though at that time they do not know the right" (A3)
Government's Policy	4	"Agency follows the Offset Requirement Document (ORD) set by the government for the technology transfer" (A1) "The Offset Requirement document given by the govern- ment is only for the tender stage" (A2)
Technology Transfer Environ- ment	8	"Because of offset, we have meeting and progress update. There is a structured approach." (A2) "Monitoring is done through project management such as project meeting" (A6)
Communication Channel	6	"The communication mechanism is effective.Will im-prove better with no intervention from external parties" (A1) "The communication channel is good because we have the agency's ICP Committee and the working committee." (A3)
Technology Provider's Char- acteristics	6	"Due to the technology is the WPC's core business, there is limited technology transfer" (A5) "We need to consider WPC's limitation such as space, trainer availability and fa- cilities" (A3)
Technology Recipient's Char- acteristics	13	"The recipient must be ready. They should not use this op- portunity to get projects but to learn." (A4) "The recipient should be from people who have experience for an effective technology transfer" (A5)

From the qualitative analysis, nine (9) key themes were identified. The most influential factor is the "Learning Environment" with sixteen (16) frequencies. The second and third most influential factors are the "Technology Trans- fer Channel" and "Technology Recipient's Characteristics" with thirteen (13) frequencies each. The fourth influen- tial factor is the "Technology Transfer Planning" with ten (10) frequencies. The fifth and sixth influential factors are "Technology Transfer Environment" and "Coordination & Monitoring" with eight (8) frequencies each. The seventh and eighth influential factors are "Communication Chan- nel" and "Technology Provider's Characteristics" with six (6) frequencies each. The ninth factor, the "Government Policy" has the lowest value, with only four (4) frequen- cies.

Based on the interviews, a gap analysis on the KVMRT Technology Transfer process was conducted. As can be seen in Figure 3, this gap analysis was based on a com- parison between the current service provider's perspec- tive in implementing the TT program and the procurement agency's perspective and needs from the TT program.

Recommendations were then made to improve the KVMRT technology transfer process further and to propose recommendations to close any weaknesses or gaps of the current TT program. This method of gap analysis is useful in terms of improving the framework for particular service management issues (Han et al., 2017).

Primary Study

For the primary study, a survey approach was taken for data-gathering. A total of 435 participants received the questionnaire. The survey duration was seven months which started in November 2017 and ended in May 2018. From the feedback, 306 survey forms were returned, which represents a return rate of 70.3%.Of the 306 returned survey forms, 104 were rejected be- cause they were either incomplete or contained spoilt an-swers. Filters were also put into the questionnaire to en-sure quality feedback. One of the filters is the participant's amount of experience in the technology transfer program with those who answered that they had no previous expe- rience being rejected. From the filtering process, only 202 responses were used for the quantitative analysis.

Respondents' Demographics

The participants for the primary study consist of con- tractors and personnel involved in the KVMRT project. A probability sampling technique with specific cluster sam- pling was used for data gathering from the target popula- tion within the KVMRT project's workforce of up to 2,000 which had been identified as suitable respondents for the study (Lin Say, 2012). 435 workers, about 22% of the total targeted population, were further identified due to their di- rect participation in the technology transfer program. Based on a population size of 2,000, with a confidence level of 95% and margin error of 5%, this number is acceptable for an accurate analysis (Taherdoost, 2016). From the 435 survey forms distributed, 306 were returned representing a 70% response rate. This is considered a good response rate as a minimum of 60% is normally required for researchers conducting surveys in fields other than pharmacy (J.E., 2008).

From the 306 returned survey forms, only 202 were con- sidered to be valid because of several factors such as return- ing an incomplete form and/or lack of experience in the TT program. The respondents fall into seven categories: the Main Contractor, Sub-Contractor, Consultant, University, Government agency and others. From the survey results, the main respondents came from the main contractor (65% of the total sample). Sub-contractors represent 16% with consultants representing 7%, and others representing 11%. The majority of the participants were aged between 20 and 30 years and represent 40% of the sample. 35% are aged from 30 to 40 years, and 16% are aged from 40 to 50. The remaining 9% are aged 50 years and above.

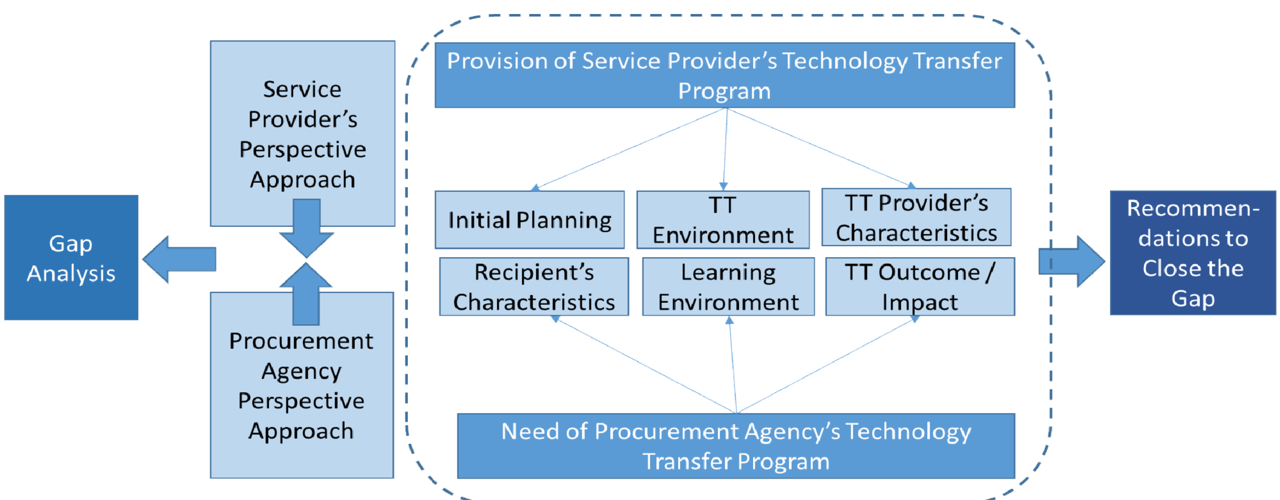

Fig. 3. Gap Analysis Framework and Process Flow for the KVMRT TT Program

For the respondents' education background, 73% have a Bachelor's degree, 11% have a Master's degree, and 9% have a Diploma. The majority of the respondents (38%) have less than five years' working experience, 25% have between 6 to 10 years, and about 12% have working ex- perience between 11 to 15 years. When asked about their specific experience in the rail industry, a majority of the respondents (82%) had less than five years. The respon- dents years of experience in technology transfer were also recorded with the majority (77%) having between 1 to 5 years' experience and involvement with technology trans- fer.

Data Analysis

The data collected were analyzed using IBM SPSS v24 to conduct an exploratory factor analysis by obtaining the KMO value and Cronbach's Alpha. The Structural Equa- tion Modeling was carried out using IBM SPSS AMOS v20 for testing the interrelationship of the technology transfer model (Gliem et al., 2003). Below are the results for the exploratory factor analysis and structural equation model- ing conducted on the conceptual TT model (Baden-Fuller and Haefliger, 2013) (Gliem et al., 2003).

Analysis of Variance (ANOVA)

Before performing the factor analysis, Analysis of Vari- ance or ANOVA was conducted. The justification for con- ducting the ANOVA analysis is because the respondents of the primary study consist of personnel from different types of organizations. In this particular analysis, the one-way ANOVA used as a way to compare the means of the se- lected groups and determine if the variance from each other of the members of a particular group is statistically signifi- cant (Field, 2015). The Tukey *post hoc* test shows that there is no statistically significant difference between the types of organizations for all variables except for the "Mutual Trust" variable (p = 0.036). The two statistically significant types of organization are between "Consultant" and "Others". By analyzing the mean values of these two groups for that par- ticular variable, the "Consultant" group rated the "Mutual Trust" variable as high (mean = 4.2) and the "Others" group, which consisted mainly of clients and the project owner, rated "Mutual Trust" as a moderate factor (mean = 3.6). Since the variance only occurred with one variable and with one combination of groups, the data collected from differ- ent types of organization can be treated as one usable sam- ple.

The respondents also have different years of experience within technology transfer programs. ANOVA is needed to determine whether there is a significant difference between these groups. From the ANOVA conducted using the Tukey *post hoc* test, the data shows that there is no statistically significant difference between the group with less experi- ence and those with tremendous experience in Technology Transfer for all variables except for "Technology Provider's Willingness to Implement" (p = 0.029). The statistically significant difference is between one to five and six to nine years of experience in the Technology Transfer projects.

The mean data shows that people with one to five years in a TT project believe that the technology providers' will- ingness to implement TT is highly important in a successful TT program (mean = 4.0) and respondents with six to nine years believe that this particular variable is only moderately important in a successful TT program (mean = 3.3). How- ever, since the variance only comes from one variable and one combination within the group, the data can be treated as one usable sample even though the respondents have a dif- ferent level of TT experience. The survey also shows that the majority of the respondents have between one to five years' experience in TT.

Exploratory Factor Analysis

The Exploratory Factor Analysis method is to summa- rize the factors further and reduce the primary factors into a smaller set of factors that can represent a structure with a new set of variables (Baden-Fuller and Haefliger, 2013) (Waroonkun, 2007). The extraction method uses "Maximum Likelihood", and the rotation method is "Pro- max" with "Kaiser Normalization". The "Maximum Like- lihood" extraction method is the one most commonly used by researchers in finding unknown factors and parameters in a parametric setting (Hossain and Kozubowski, 2014). Maximum Likelihood will also generally give the best re- sults if the data are normally distributed (Costello and Os- borne, 2005). From the EFA, five out of the eight factors retained were loaded correctly with 60% cumulative vari-ance explained. Based on the pattern matrix, 24 out of 35 variables were retained. From the exploratory factor SPSS analysis, the Kaiser-Meyer-Olkin value of 0.91 was above the minimum value of 0.5 (Shadfar andMalekmohammadi, 2013) (Yong and Pearce, 2013).

The five factors retained were (1) Technology Transfer Planning, (2) Transfer Environment, (3) Learning Envi- ronment, (4) Technology Provider's Characteristics and (5) Technology Transfer Outcome. One factor dropped was the Recipient's Characteristics as most of the variables have a factor loading below the threshold loading of 0.4. The threshold factor loading of 0.4 was used as the sample re- spondents number above 200 (Hair, 1998). The pattern ma- trix shows that the loading of three factors: "Economic Advancement", "Knowledge Advancement" and "Project Performance" can be collected into a single group. There- fore, the three factors were grouped into one factor without any significant changes in terms of relationship with other factors in the TT model. The grouped factors re-labelled "Technology Transfer Outcome". Factor loading are an ex- cellent indicator of the relative contribution of a particular variable to a factor (Field, 2015).

In determining the sampling adequacy, the Kaiser- Meyer-Olkin measure of sampling adequacy was used (Shadfar and Malekmohammadi, 2013). From the data analysis, the KMO shows a value of 0.92, which is above the minimum value of 0.5 (Yong and Pearce, 2013). This value shows that the sample size (n=202) is acceptable for the factor analysis.

The reliability of the variables for each factor analyzed was within the acceptable Cronbach Alpha limit which should be between 0.6 and 0.9 (Gliem et al., 2003) (Field, 2015). The factor analysis retains four factors. The technology transfer outcome factors were merged into one factor. As a result, the remaining factors for further analysis are, (1) Technology Transfer Planning,

(2) Transfer Environment, (3) Learning Environment, (4)

Technology Provider's Characteristics, and (5) Technol- ogy Transfer Outcome. From the factor extraction, the EFA retains twenty-four from the initial thirty-five latent variables.

Structural Equation Modeling (SEM)

SEM is a valid tool to validate and test the dependencies of the latent variables within a complex model (Nachtigall, 2003). Among the advantages of SEM is the ability to es- timate and test multivariate model and fit indices and deter- mine whether a model accurately represents the interrela- tionships among the factors and variables involved (Weston and Gore, 2006). SEM was used to test the interrelationship between the five factors and twenty-four variables obtained from the EFA using Confirmatory Factor Analysis or CFA. The measurement indices that can be used for confirma- tory factor analysis are the CMIN/DF or relative chi-square, Root Mean Square of Approximation (RMSEA), Goodness of Fit Index (GFI), Normal Fit Index (NFI), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) (Kline, 2011). Table 4 below shows the Goodness of Fit (GOF) indices based on the SEM analysis.

The CMIN/DF or degree of freedom has a measured value of 1.660, which falls below the accepted value of 5.0 (Kline, 2011) (Shadfar and Malekmohammadi, 2013). The measured Root Mean Square of Approximation (RM- SEA) value is 0.06 which is an acceptable value of below 0.08 (Kline, 2011). Other indices such as the Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normal Fit Index (NFI), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) are measured at acceptable val- ues of close to 1 (Waroonkun, 2007) (Kline, 2011) (Pu- rushotham et al., 2015).

From the result of the model fit indices, it is concluded that the hypothetical model produced earlier from the pilot study and EFA is a good fit. Figure 4 below shows the SEM Measurement Model from the SEM analysis and Table 5 shows the summary of the Factor Analysis results.

Assessing the Validity and Reliability

After the measurement model was developed, it is crucial to test its validity and reliability of the measurement model before proceeding with the SEM structural model. In order to validate and test this model, its construct validity needs to be established. Construct validity is when a set of identified variables behaves in a similar fashion to the latent factors with which it is compared (Hair, 1998). The Cronbach Al- pha for all factors was measured at 0.8 and above, which shows that the model is acceptable and has a high level of internal consistency with the variables measured (Tavakol and Dennick, 2011). The Composite Reliability values are all less than 0.9.

The Composite Reliability (CR) and Average Vari- ance Extracted (AVE) can be used as an indicator (Birt, 2016) (Anderson and Gerbing, 1988). Convergent valid- ity is achieved as the CR value is greater than 0.7, and the AVE is greater than 0.5.

From the final iteration of the measurement model, the five factors are retained. However, of the twenty-four vari- ables analysed, only twenty-one are retained. This is be- cause the analysis in which removing the variable "Tech- nology Provider's Willingness to Implement" was removed resulted in no discriminant validity concerns, as shown in Table 6 above.

SEM Structural Model Validity

After the SEM measurement model was tested, the next step was to develop the SEM structural model. The results for this structural model are shown in Figure 5 below.

In the final iteration of the structural model, four out of the five factors were retained. These factors are: "Technology Transfer Planning", "Transfer Environment", "Learning Environment" and "TT Outcome". The factor dropped is "Technology Provider's Characteristics". From the twenty-one variables analyzed, only seventeen were re- tained. The iteration was made to achieve a good model fit based on the model fit indices that had been measured

Table 4. SEM Model Fit Indices

Measurement Indices	Recommended Value	Value Measured	Reference
The degree of Freedom or CMIN/DF	< 5.0	1.660	(Kline, 2011) (Shadfar and Malekmohammadi, 2013)
Root Mean Square of Ap- proximation (RMSEA)	< 0.05 (Ideal) < 0.08	0.06	(Kline, 2011) (Pu- rushotham et al., 2015)
Goodness of Fit Index (GFI)	(Acceptable)		
Normal Fit Index (NFI) to 1 (Perfect fit)	> 0.9 (Acceptable) Close	0.881	(Kline, 2011) (Pu- rushotham et al., 2015)
Comparative Fit Index (CFI)	9 (Acceptable) Close to 1 (Perfect fit)	0.950	(Kline, 2011) (Pu- rushotham et al., 2015)
Tucker-Lewis Index (TLI) to 1 (Perfect fit)	> 0.9 (Acceptable) Close	0.940	(Kline, 2011) (Pu- rushotham et al., 2015)

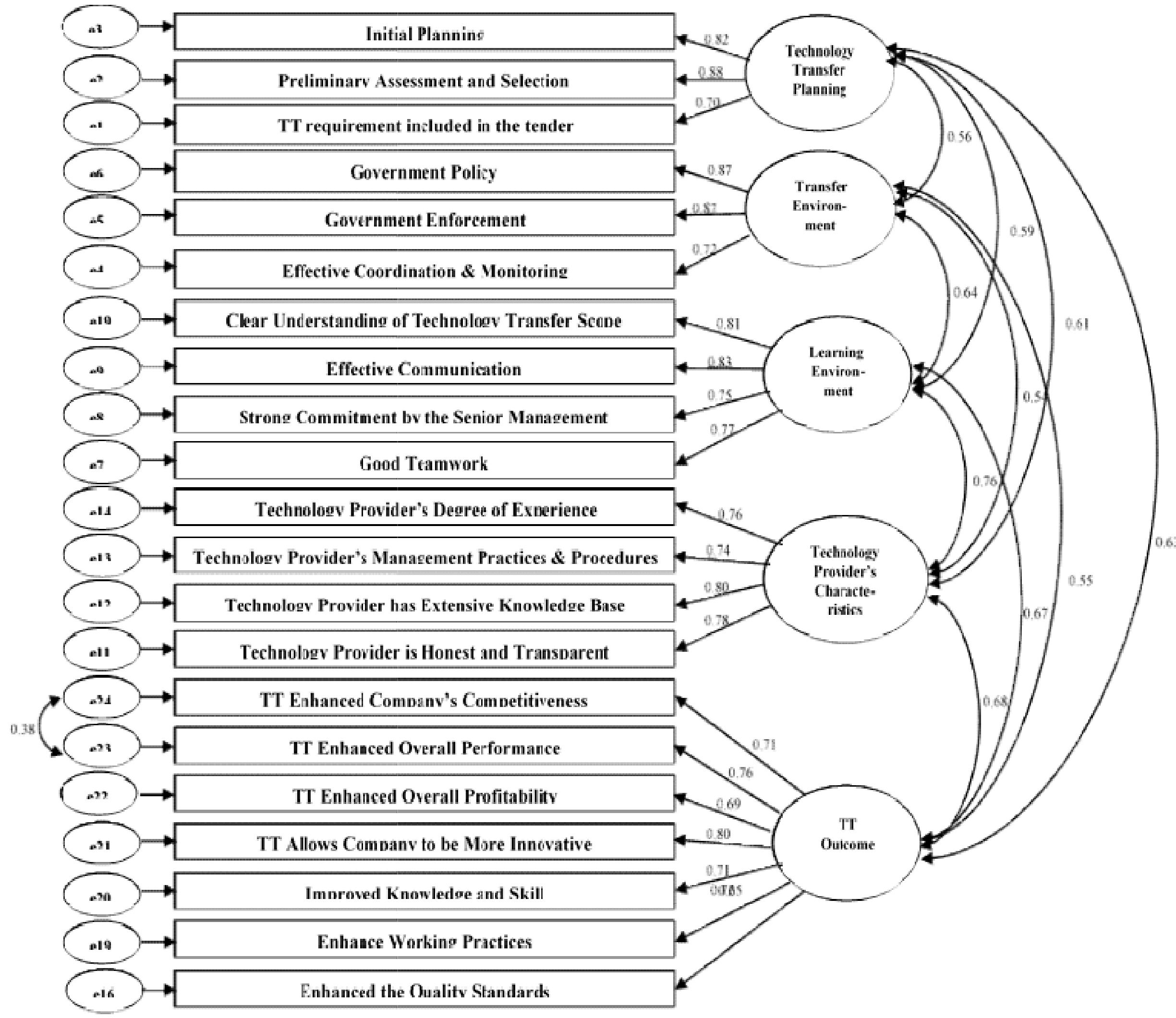

Fig. 4. SEM Measurement Model

Table 5. Summary of Factor Analysis Results

LatentVari-ables/Factors	Indicators/Sub-Factors	Overall		Factor Loading	AVE	CR	Cronbach Alph
		mean	SD				
Technology Transfer Planning	T1: Initial Planning	3.88	0.79	0.82			
	T2: Preliminary Assessment and Selection	3.93	0.75	0.88	0.64	0.84	0.83
	T3: TT Requirement included in the Tender	3.89	0.82	0.70			
	T5: Government Policy	3.91	0.84	0.87			
Transfer Environment	T7:Effective Coordination & Monitoring	4.00	0.80	0.72			
	T10: Clear Understanding of TT Scope	4.18	0.80	0.81			
Learning Environment	T11: Effective Communication	4.16	0.79	0.83	0.63	0.87	0.87
	T12: Strong Commitment by the Senior Management	4.20	0.80	0.75			
	T13: Good Teamwork	4.20	0.78	0.77			
	T18: Provider's Degree of Experi- ence	4.04	0.80	0.76			
Technology Provider's charecteristic	T19:Provider's Management Practices and Procedures	3.91	0.73	0.74			
	T20:Provider has Extensive Knowledge Base	4.02	0.77	0.80	0.60	0.86	0.86
	T21: Technology Provider is Hon-est and Transparent	4.11	0.79	0.78			

	T26: TT Enhanced Company's Competitiveness	3.99	0.71	0.71			
Technology Transfer Outcome	T27: TT Enhanced Overall Per- formance	4.05	0.69	0.76	0.52	0.88	0.89
	T28: TT Enhanced Overall Prof-itability	3.87	0.78	0.69			
	T29: TT Allows Company to be More Innovative	3.99	0.72	0.80			
	T30: Improved Knowledge and Skill	4.14	0.72	0.71			
	T31: Enhance Working Practices	4.18	0.67	0.72			

Table 6. Discriminant Validity

	CR	AVE	MSV	F1	F2	F3	F4	F5
F1: Tech- nology	0.856	0.598	0.581	0.773				
Provider's Charac- teristics F2:	0.843	0.643	0.402	0.613	0.802			
Tech- nology Transfer Planning F3:	0.864	0.680	0.404	0.542	0.557	0.825		
Transfer Environ- ment F4:	0.870	0.626	0.581	0.762	0.590	0.636	0.791	
Learning Environ- ment F5: TT Outcome	0.883	0.520	0.457	0.676	0.634	0.550	0.665	0.721

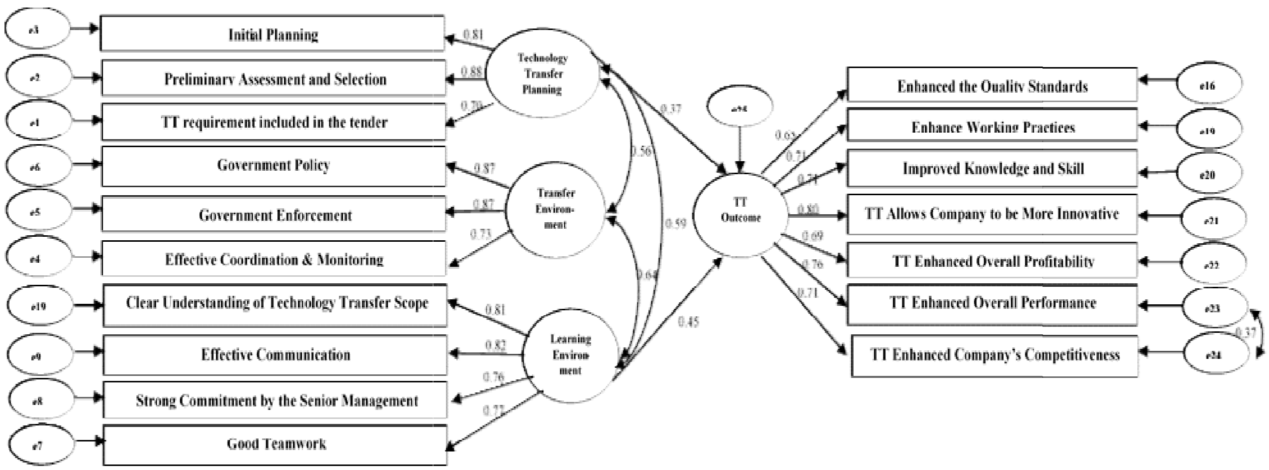

Fig. 5. Final SEM Structural Model

to ensure that the structural model was accurate. Table 7 shows the model fit indices for the structural model and the reference used as the recommended threshold for the value obtained from the analysis. The final iteration of the SEM model shows consistency since the characteristics of both the provider and recipient of the technology are omit-ted from the final TT model.

Table 7 above shows that the final SEM structural model can be accepted since the relative chi-square value of 1.965 is below the threshold value (Kline, 2011); the RMSEA value which measured 0.07 is also within the accepted threshold value (Kline, 2011); and the index values for GFI, NFI, CFI and TLI are all acceptable (Kline, 2011) (Pu- rushotham et al., 2015).

Table 7. SEM Structural Model Fit Indices

Measurement Indices	Value Measured	Recommended Threshold	Reference
Relative chi-square CMIN/DF	1.965	<5.0	(Kline, 2011) (Shadfar and Malekmohammadi, 2013)
The Goodness of Fit Index (GFI)	0.9	> 0.9 (Acceptable) Close to 1 (Perfect Fit)	(Kline, 2011) (Purushotham et al., 2015)
Root Mean Square of Approxi- mation (RMSEA)	0.07	<0.05 (Ideal) <0.08(Acceptable)	Kline (2011)
Normal Fit Index (NFI)	0.9	> 0.9 (Acceptable) Close to 1 (Perfect Fit)	Kline, 2011) Purushotham et al. (2015)
Comparative Fit Index (CFI)	0.94	> 0.9 (Acceptable) Close to 1 (Perfect Fit)	(Kline, 2011) (Purushotham et al., 2015)
Tucker-Lewis Index (TLI)	0.93	> 0.9 (Acceptable) Close to 1 (Perfect Fit)	(Kline, 2011) (Purushotham et al., 2015)

IV. FINDINGS AND CONCLUSION

The findings from the primary study show a clear relationship between the TT enabling factors and the TT outcome. Significant relationships between several of the TT variables and the enabling factors that correlated with TT outcome are identified. The critical success factors for determining the Technology outcome of the KVMRT Technology Transfer program are; “Technology Transfer Planning”, “Transfer Environment” and “Learning Environment”. From the EFA and CFA, “Recipient’s Characteristics” and “Technology Provider’s Characteristics” are not critical success factors. The findings show that in a government-mandated technology transfer program such as in the KVMRT project, the selection of technology provider and the recipient is not a critical factor in ensuring the pro-gram’s success. This result differs from the findings of studies where contractors are not mandated by the government to undertake technology transfer where the "Technology Provider’s Characteristics" and "Recipient’s Character- istics" would be critical success factors (Waroonkun, 2007). The factor with the greatest influence on the Technology Transfer Outcome is the Learning Environment. The latent variables for the Learning Environment are; “Clear Under- standing of Technology Transfer Scope”, “Effective Communication”, “Strong Commitment by the Senior Management” and “Good Teamwork”. However, the highest factor loading among all the variables in the Learning Environment is for "Effective Communication". This finding is sup- ported by several studies in TT e.g. (Arenas and Gonzalez, 2018) which highlighted that from examining technology transfer models, the element of communication remains essential for most of them. The findings suggest that “Improvement to the Communication” would result in a bet- ter learning environment such as by enhancing the software and hardware support for communication methods within the TT process. Based on the findings from the pilot and primary studies, recommendations were then made to fur- ther improve the technology transfer process of similar fu- ture rail infrastructure projects. The study recommenda- tions include (1) Improvement of current government’s pol- icy on Technology Transfer, (2) Focusing on innovation as one of the main criteria for a successful TT outcome, (3) Digitalization of the TT Process and (4) Establishment of a Technology Transfer Office (TTO) in government strategic procurement projects.

V. LIMITATIONS OF RESEARCH

The study was conducted based on the case study of the technology transfer program in the Klang Valley Mass Rapid Transit development project. As the infrastructure project would take about seven years to complete (Kaur, 2016), this study can only take into account the technology transfer process and its impact during the implementation of the infrastructure project. Therefore, the long-term ben- efits of the technology transfer program are not taken into consideration.

The KMVRT technology transfer program is driven by government policy, and therefore the study did not take into account the market "push" and "pull" factors because the technology transfer requirement had been already deter- mined by the government and included in the procurement tender (Hamdan, 2015). Whether or not the requirement includes the current market needs was not identified and studied in detail and therefore not included in the KVMRT technology transfer model.

Further Areas for Research

The study was conducted based on the case study of the KVMRT project. The advantage of choosing this project as a case study is that a proper technology transfer pro- gram had been put in place by the government. Therefore, the technology transfer model of the KVMRT project may be influenced by government policy. Similar SEM analysis can be done on the same type of projects, but without the mandatory government requirement to implement a technology transfer program. A comparison can be made to see whether government policy impacts on the effectiveness of the technology transfer process and model.

Although the KVMRT technology transfer program also considers the transfer that occurs during the construction stage of the project, the technology transfer model developed in this study might not be suitable for these later stages of the program where the market push and pull factors may come into play. Further research could determine the link- ages of the market factor in the technology transfer model, especially during the operation of the railway system.

VI. CONCLUSION

This study has made a contribution to the areas of (i) identifying the factors and sub-factors that contribute to the successful technology transfer process in the KVMRT infrastructure development project, (ii) the development of a conceptual technology transfer model for the KVMRT infrastructure development project, and (iii) validating the model statistically using SPSS and SEM tools. From the SEM analysis of the four latent variables and indicators, the interrelationship between the factors and sub-factors of the conceptual model are identified and measured successfully. The study also shows that the latent variables of “Government Policy”, “Government Enforcement” and “Effective Coordination and Monitoring” that shape the “Transfer Environment” factor have a weak correlation to the “Technology Transfer Outcome”. However, “Transfer Environment” does have a strong correlation to the “Technology Transfer Planning” and “Learning Environment”. It can be concluded from this observation that the company’s or recipient’s ability to transform themselves after the technology transfer program is not dependent on government policy and enforcement, but more on the learning environment created. However, the “Learning Environment” does Have a high correlation with the government’s intervention through policy and enforcement throughout the KVMRT

Technology Transfer program. Therefore, government policy should be enhanced to include the ability to shape the learning environment in which the parties operate. The policy should also avoid the need to focus on the selection of the technology providers and recipients as currently being practiced by the government agencies involved. The results of the study can form the basis for planning future technology transfer programs for projects similar to the Klang Valley Mass Rapid Transit Infrastructure Development Project.

Data Availability Statement

Some or all data, models, or code that support the find- ings of this study are available from the corresponding author upon reasonable request (Raw or processed data files).

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