DEVELOPMENT OF A STRUCTURAL EQUATION MODEL OF THE VARIABLES AFFECTING THE ORGANIZATIONAL PERFORMANCE OF THE MASS RAPID TRANSIT SYSTEMS OF THAILAND

Sutep Punthupeng 1
Thepparat Phimolsathien 2

ABSTRACT

Introduction: The development of the Thai transport system in the future must be based on the advancement of three aspects: personnel, technology, and research and development must be promoted for the operation of efficient innovative tools and management as key mechanisms in the transport system’s development. The master plan of the Ministry of Transport under Strategy 5 for the development of the Thai transport system within 20 years (2017-2036) stated about the need for and initiation of technology and innovation, as well as the promotion of research and development for the application of rapid advancements within these aspects so to develop the transport infrastructure and management, which would engender higher efficiency of future transport as well. Technology is required and is suitable for the analysis and evaluation of performance in the view of safety technological innovation for subway station construction.

Objective: The main objective was to explore the development, congruence, and the indirect direct, and total effects of the variables affecting the organizational performance of the mass rapid transit systems of Thailand

Method: This is quantitative research, collecting data from 385 executives and chiefs of organizations relating to the mass railway transit systems and private manufacturers participating in the project with state enterprise agencies.

Result: Relationship between the two variables and among the multiple variables in conjunction with the estimation of the effects of the variables, which were obtained from the regression coefficients (coef.) of each individual relationship path following the hypothesis. The results indicated that all C.R. (t-test) values were statistically significant (> 1.96). Thus, every hypothesis was supported. Technology directly affects organizational performance (coef. = 0.143, p < 0.05). Technology directly affects innovation (coef. = 0.370, p < 0.001). Technology directly affects research and development (coef. = 0.786, p < 0.001). Research and development directly affects innovation (coef. = 0.624, p < 0.001). Research and development directly affects organizational performance (coef. = 0.449, p < 0.001). Innovation directly affects organizational performance (coef. = 0.372, p < 0.01).

Conclusion: Technology, innovation, and research and development truly affect organizational performance. The industrial sector should be more encouraged to participate in technology learning and to step into the manufacturing chain for the development of Thailand’s rail transport system. This would also save foreign currency, create employment opportunities in the country, and have continual economic effects for the national monetary circulation, which would eventually pave the way to the enhancement as well as development of the people’s abilities in the future.

Keywords: Innovation, Technology, Research and Development, Organizational Performance, Mass Rapid Transit System.

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2 King Mongkut’s Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. Email: thepparat.ph@kmitl.ac.th Orcid: https://orcid.org/0000-0003-3520-0216
DESENVOLVIMENTO DE UM MODELO DE EQUAÇÃO ESTRUTURAL DAS VARIÁVEIS QUE AFETAM O DESEMPENHO ORGANIZACIONAL DOS SISTEMAS DE TRANSPORTE RÁPIDO EM MASSA DA TAILÂNDIA

RESUMO

Introdução: O desenvolvimento do sistema de transporte tailandês no futuro deve se basear no avanço de três aspectos: pessoal, tecnologia e pesquisa e desenvolvimento devem ser promovidos para a operação de ferramentas inovadoras eficientes e gerenciamento como mecanismos-chave no desenvolvimento do sistema de transporte. O plano diretor do Ministério dos Transportes, de acordo com a Estratégia 5 para o desenvolvimento do sistema de transporte tailandês dentro de 20 anos (2017-2036), afirma a necessidade e o início da tecnologia e da inovação, bem como a promoção da pesquisa e do desenvolvimento para a aplicação de avanços rápidos nesses aspectos, de modo a desenvolver a infraestrutura e o gerenciamento do transporte, o que também geraria maior eficiência no transporte futuro. A tecnologia é necessária e adequada para a análise e a avaliação do desempenho, tendo em vista a inovação tecnológica de segurança para a construção de estações de metrô.

Objetivo: O objetivo principal foi explorar o desenvolvimento, a congruência e os efeitos indiretos, diretos e totais das variáveis que afetam o desempenho organizacional dos sistemas de transporte rápido em massa da Tailândia

Método: Esta é uma pesquisa quantitativa, com coleta de dados de 385 executivos e chefes de organizações relacionadas aos sistemas de trânsito ferroviário em massa e fabricantes privados que participam do projeto com agências de empresas estatais.

Resultados: Relacionamento entre as duas variáveis e entre as múltiplas variáveis em conjunto com a estimativa dos efeitos das variáveis, que foram obtidos a partir dos coeficientes de regressão (coef.) de cada caminho de relacionamento individual seguindo a hipótese. Os resultados indicaram que todos os valores de C.R. (teste t) foram estatisticamente significativos (> 1,96). Assim, todas as hipóteses foram apoiadas. A tecnologia afeta diretamente o desempenho organizacional (coef. = 0,143, p < 0,05). A tecnologia afeta diretamente a inovação (coef. = 0,370, p < 0,001). A tecnologia afeta diretamente a pesquisa e o desenvolvimento (coef. = 0,786, p < 0,001). A pesquisa e o desenvolvimento afetam diretamente a inovação (coef. = 0,624, p < 0,001). A pesquisa e o desenvolvimento afetam diretamente o desempenho organizacional (coef. = 0,449, p < 0,001). A inovação afeta diretamente o desempenho organizacional (coef. = 0,372, p < 0,01).

Conclusão: A tecnologia, a inovação e a pesquisa e o desenvolvimento realmente afetam o desempenho organizacional. O setor industrial deve ser mais incentivado a participar do aprendizado de tecnologia e a entrar na cadeia de fabricação para o desenvolvimento do sistema de transporte ferroviário da Tailândia. Isso também economizaria moeda estrangeira, criaria oportunidades de emprego no país e teria efeitos econômicos contínuos para a circulação monetária nacional, o que acabaria abrindo caminho para o aprimoramento e o desenvolvimento das habilidades das pessoas no futuro.

Palavras-chave: Inovação, Tecnologia, Pesquisa e Desenvolvimento, Desempenho Organizacional, Sistema de Transporte Rápido de Massa.

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1 INTRODUCTION

With the increased problem of traffic congestion and the density of the vehicle movement rate on the roads in Bangkok, mass rapid transit systems are currently playing an important role in Thailand’s economic development. According to a survey of the Traffic Index Congestion Level in 2017 by TomTom NV, a world-leading manufacturer of a Global Positioning System (GPS), Bangkok was ranked as being the second most congested city in the world (see Table 1). The traffic congestion issue of Bangkok was described as severe despite having multiple mass transit systems[1].
Consequently, several effects have occurred; e.g., expenditure of commuting resulting in less production time that would help develop the country’s economy and society. People’s physical and mental conditions have also been affected by the travel inconvenience impinging on their work efficiency as well as effectiveness. Hence, innovative creations were initiated to fulfill the people’s needs; i.e., transit systems were introduced and developed into mass rapid transit systems, both the Bangkok Mass Transit System (BTS) and Metropolitan Rapid Transit (MRT)[2].

In addition, the data from the Office of Transport and Traffic Policy and Planning (OTP) expected that the increase of the rapid transit systems would raise the travel demand and would gradually expand the share market of the systems to replace that of buses. In 2032, the share market of the rapid transit systems would rise from 6.4% (in 2013) to 23.8% in 2037.

Thus, it can be inferred that the use of mass rapid transit routes is destined to unceasingly develop. In addition, further expansion of new lines connecting to the business areas out of Bangkok will bring more opportunities for business growth[4]. Consequently, rail is a potential form of land transport and a crucial factor for the country’s future development; moreover, it will create an adjustment of the logistics infrastructure of the country and other regional countries. This will result in a reduction of transport costs bringing the country to have a higher competitive ability. Therefore, Thailand should promote the industrial sector to participate in learning about technology and to step into the manufacturing chain for the development of the country’s rail transport system. Participation from the industrial sector and support from government agencies should also be focused in the dimensions of accelerating the development of human resources as well as and research and technology. This would create an extension of the knowledge base, a key indicator of competitive ability [2].

The development of the Thai transport system in the future must be based on the advancement of three aspects (see Figure 2). Personnel, technology, and research and development must be promoted for the operation of efficient innovative tools and management as key mechanisms in the transport system’s development. The master plan of the Ministry of Transport under Strategy 5 for the development of the Thai transport system within 20 years (2017-2036) stated about the need for and initiation of technology and innovation, as well as the promotion of research and development for the application of rapid advancements within these aspects so to develop the transport infrastructure and management, which would engender higher efficiency of future transport as well [5].

Table 1: The Most Congested Cities.

<table>
<thead>
<tr>
<th>Word Ranking</th>
<th>City</th>
<th>Congestion Level</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>1</td>
<td>Mexico City</td>
<td>59%</td>
</tr>
<tr>
<td>2</td>
<td>Bangkok</td>
<td>57%</td>
</tr>
<tr>
<td>3</td>
<td>Jakarta</td>
<td>n.a.</td>
</tr>
<tr>
<td>4</td>
<td>Chongqing</td>
<td>38%</td>
</tr>
<tr>
<td>5</td>
<td>Bucharest</td>
<td>43%</td>
</tr>
</tbody>
</table>
Moreover, a number of relevant studies has revealed some interesting concepts. For example, Azhar [6] stated that the management of more advanced technology is required for safety control and is a core system to subway station construction. Alternatively, it could be said that safety management technology hugely affects efficiency. Safety innovation for construction does not merely rely on technological support, but also connects and is related to technology. Thus, technology is required and is suitable for the analysis and evaluation of performance in the view of safety technological innovation for subway station construction[7]. This conformed with the research of [8].In terms of problem solving through subway station innovation, it was found that this approach could be achieved through technology and safety. Somapa and Fongsuwan [9] discovered that technology had direct positive effects on organizational management efficiency, and that the organizational structure and accepted technology affected the organizational performance directly and in a positive manner.

With respect to the gaps in research, mass rapid transit systems are significant for Thailand’s future economic development. Furthermore, the master plan of the Ministry of Transport under Strategy 5 as mentioned above would assist in developing the necessary mass rapid transit systems into fruition. The researcher, therefore, became interested in studying the development of a structural equation model of the variables affecting the organizational performance in the mass rapid transit systems of Thailand so to obtain vital data for good management that would generate benefits and international standards for executives of all involved agencies as a guideline on strategic planning, transit rail plan design, and the enhancement of Thailand’s competitive performance for future sustainable development.

This study aims to develop a structural equation model of the variables affecting the organizational performance of the mass rapid transit systems of Thailand, examine the congruence of the development of the structural equation model of the variables affecting the organizational performance of the mass rapid transit systems of Thailand based on empirical data and study the indirect, direct, and total effects of the variables affecting the organizational performance of the mass rapid transit systems of Thailand.

In order to achieve the research objectives, the conceptual framework of this study was conducted based from the following concepts and theories.
1.1 Technology

Transport systems have much significance to economic growth of all countries across the world. They reduce traffic congestion and provide fast product delivery to different destinations[10]. Additionally, high-speed efficient trains save energy, are safe and provide transport convenience [11], which is a result of their control and transport technology[12]. Furthermore, Nakamura [13] mentioned that train control technology is an operational function creating reliability and confidence in safety. This is the development of new train control systems grounded on IT and present communications that controls and supports route safety, as well as controls the train’s operation in order to prevent tragic incidents[14]. Control technology also creates work safety [15]. Moreover, transport technology connects to traffic safety control for even more safety and environmental effects on the account of transport. Thus, the promotion of a green economy results in transport safety as well as sustainability [16]. According to the study of Fan Chen and Yajing Liu[8], the integration of multiple technologies is indispensable for the technological innovation process. For Building Information Modeling (BIM) technology, the simplest feature is to set 3D images. This technology can also be exploited to examine a crash for raising the efficiency of the engineering design and for diminishing any errors and repetition possibilities during the construction with finer efficiency. Technological abilities and management influence the technological innovation performance. This is in accordance with Azhar [6], who explained that traditional safety management technology is difficult to fulfill the demand to construct subway stations. The management of more efficient advanced technology is considerable for safety control and is a paramount system for subway station construction. Manufacturing efficiency improved by using information and communication technology (ICT) in conjunction with the BIM, is specially concentrated on. Safety management technology may be more efficient, as safety innovation for subway construction does not only depend on technological support, but also is connected and related to technology. Hence, the analysis and evaluation of the performance in view of safety technological innovation for subway station construction must be taken into consideration [7]. This conforms with Sexton and Barrett [17], who indicated that the ability to use technology is one factor to success. Overall, technology is an aspect directly affecting the emergence of new innovation. Introducing technology to organizations also directly affects knowledge management and supports internal knowledge transfer. This is further enhanced by the study of Somapa and Fongsuwan [9] that demonstrated the positive role of technology on organizational management efficiency.

1.2 Research and Development

Research and development is a huge part of the innovation process. It is an investment in technology and future capabilities, which finally becomes a new product in work and service [18]. Research conducted for application and development is an applied form of research. Basic research mainly emphasizes on the creation of new principles and theories [19]. Koblen[20]suggested that research and development includes a real needs assessment and synthesis; product/service design and development; product/service testing, and product/service launch. Likewise, Yin, et. al.[21] described that research and development contains a pattern development survey, experiments, and testing. Moreover, the study of technological needs produces the development of technology [22]. Mourtzis et al. [23] stated that customer opinions are collected and used for product design according to customers’ needs. Suggestions from customers for product and service design are further used for the innovation of product and service changes[24]. New service development also requires the collection and analysis of the conceptual development need and service design, performance testing, and marketing; thus,
resulting in new service development processes [25]. Koblen et al. [20] specified that research and development gives rise to innovation creation, and concentrates on research projects with the use of the integrated technology objectives of the projects and significantly developed technology. As a consequence, it can be stated that the effects of teamwork performance and efficiency mostly result from research and development [26,27,28]. This literature review on research and development resulted in the following hypotheses:

1.3 Innovation

Innovation is the creativity of implementation with activities concerned with new product development, introduction of new services, and new processes [29]. Innovation is also a capital activity influencing organizational existence paving the way to social and economic changes [30]. In addition, innovation embraces the bases; i.e., product innovation and process innovation whereby product innovation is related to the new product or service development, and any concepts essential for organizational growth as well as financial performance. Process innovation helps to accelerate the organizational competitive abilities [31]. Foret et al. [32] stated that innovation incorporates product innovation, process innovation, publishing innovation, organizational innovation, and administrative innovation. In the same way, Hui-Ling Huang [31] defined innovation as consisting of product innovation, process innovation, organizational innovation, and administrative innovation. Salim et al. [33] also conducted research on organizational learning and its relationship to innovation and performance. The results revealed that the two hypotheses were supported. Thus, it can be generalized that organizational learning guides innovation creativity, and that innovation is positively related to organizational performance. This is similar to the research of Alipour and Karimi [34], which proved that innovation and knowledge transfer were related to organizational performance. In addition, Raymond et al. [35] stated that performance evaluation displays an inevitable relationship to new innovation. Therefore, it can be concluded that innovation is a primary component for sustainability [36].

1.4 Organizational Performance

Organizational performance is an evaluation of the performance associated with organizational target indicators in compliance with their strategies [37]. It is the performance evaluation of the previous year’s targets compared with all the competitors and business units [38]. According to the study of Fang Yi Lo and Pao Hung Fu [39], organizational performance involves sustainable development, growth, and internationalization. Similarly, Dinga et al. [40] noted that organizational performance holds security, credit risk, generates profits, and sales volume growth. Moreover, Woodside et al. [41] stated that organizational performance is linked to organizational growth, sustainable development, and business internationalization. Sustainability from service is based on organizational core values in the aspects of economy, environment, and society to evaluate organizational success [42]. Accordingly, Vlad and Tatarnikov [43] presented that the concept of sustainable development is the investigation of relations for communication-based train control (CBTC). This is a highlighted factor affecting sustainable development of urban transport. It is also one of the most efficient approaches because pleasant efficiency reduces accidents, effects on the environment, and organizational costs. Apart from this, sustainable development is a guideline on service and service innovation development including the resources that raise the values of interested parties [44]. Fast and convenient services raise the sales volume [45]. Therefore, it can be stated that the most organizational business competitive abilities are organizational performance that is a result from
organizational growth, sustainable development, and business internationalization[39]. From the literature review of organizational performance, the developed model for the research could be developed (see Figure 3).

Figure 2: The conceptual framework.

2 METHOD

2.1 Questionnaire Design

Questionnaires were designed as the instrument following the conceptual framework and the operational definition. The instrument or the questionnaires were designed based on a 7-point Likert scale[46]. Five experts examined the questionnaire congruence and calculated the inversion of control (IOC). Items with IOC of 0.5 up were used. The revised questionnaires were brought for the collection of the primary data from 30 samples in order to examine the scale. Cronbach’s alpha coefficient was used for the internal congruence examination so to obtain the mean of the correlation coefficient. The questionnaires with the values of 0.70 up were considered as having high reliability[47]. The internal congruence examination by Cronbach’s alpha coefficient for the mean of the correlation coefficient produced the alpha coefficient between 0.835-0.926, which signified high reliability.
2.2 Data Analysis

In regards to the data analysis, the researcher chose AMOS for the variable relationship analysis together with the application of a structural equation model (SEM) or the analysis of a causal relationship model among the correlational research variables analyzed by advanced statistics with relationship patterns among the variables. The sample or population size in this research was considered as 20 samples per one variable (20:1). Schumacker and Lomax [48] suggested that SEM analysis requires a larger sample size than other analysis methods, for accurate estimation and can be utilized as a good representative of the entire population. Furthermore, Hair [47] claimed that a sample size must be large enough for data collection in terms of SEM and normal curve distribution. For this reason, the samples of this research comprised 385 executives and chiefs of organizations related to the mass railway transit systems, as well as private manufacturers joining the project with state enterprise agencies.

2.3 Results

2.3.1 Measurement Model

Measurement model analysis was conducted by using confirmatory factor analysis (CFA) with the application of AMOS and parameter estimation for maximum likelihood (ML). The variables were analyzed through a reflective scale together with the statistics to examine the congruence and goodness of fit measures between the measurement model and the empirical data. The accepted standard criteria was employed (refer to Table 2).

<table>
<thead>
<tr>
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</tr>
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<td>$\chi^2$</td>
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<td>$\chi^2/df$</td>
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</tr>
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<td>Goodness of Fit Index</td>
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Table 2 - Standard criteria for congruence.

[46,47]

Table 3: Relative influence of items (standardized regression weights).

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<tbody>
<tr>
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<td>.062</td>
<td>.637</td>
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<td>***</td>
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<tr>
<td>Organization_Performance ← Innovation</td>
<td>.372</td>
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<td>.030</td>
<td>.730</td>
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<td>.557</td>
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<tr>
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<td>-</td>
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<td>.052</td>
<td>.805</td>
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Note: ***The level of statistical significance was .01.

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<td>.030</td>
<td>.730</td>
<td>13.451</td>
<td>***</td>
</tr>
<tr>
<td>Growth ← Organization_Performance</td>
<td>.846</td>
<td>.071</td>
<td>.557</td>
<td>16.494</td>
<td>***</td>
</tr>
<tr>
<td>Sustainability ← Organization_Performance</td>
<td>.878</td>
<td>.058</td>
<td>-</td>
<td>20.464</td>
<td>***</td>
</tr>
<tr>
<td>Financial ← Organization_Performance</td>
<td>.856</td>
<td>.052</td>
<td>.805</td>
<td>20.564</td>
<td>***</td>
</tr>
</tbody>
</table>

Note: ***The level of statistical significance was .01.
3 RESULTS

3.1 Results of the Structural Equation Model Analysis

Structural equation model analysis is a technique of multiple variable analysis embracing factor analysis and multiple regression together. Such technique was useful to the researcher for exploring the relationship among the variables at one time [47]. According to AMOS, the examination statistics for SEM, the results of the examined congruence and goodness of fit measures between the measurement model of the conceptual model, and the empirical data exhibited that the values of the standard regression weight of technology were between 0.802-0.877 with R2 or a squared multiple correlation between 0.643–0.769. The values of the standard regression weight of innovation were between 0.345-0.896 with R2 or a squared multiple correlation between 0.119-0.803. The values of the standard regression weight of the research and development were between 0.832–0.932 with R2 or a squared multiple correlation between 0.693-0.853. The values of the standard regression weight of the organizational performance were between 0.847-0.946 with R2 or a squared multiple correlation between 0.557-0.803 (refer to Table 3).

The results of the examined congruence and goodness of fit measures between the measurement model of the conceptual model and the empirical data presented that the structural equation model fitted the empirical data (Figure 4); with the results of the Chi-square ($\chi^2$) test $= 94.422$, df $= 74$, p $= .055$, CMIN/DF ($\chi^2$/df $)= 1.276$, GFI=.955, CFI=.994, AGFI=.926, NFI=.973, and RMSEA= .033.

The analysis results of Table 3 were transformed into the structural equation model as below:

Research and Development = 0.79 Technology, R2 = 0.62
Innovation = 0.37 Technology, R2 = 0.89
Organizational Performance = 0.14 Technology+0.37 Innovation +0.45 Research and Development, R2 = 0.86

3.2 Results of the Hypothesis Testing

Hypothesis testing was conducted by t-Value (C.R.), p-Value, and finding the relationship between the two variables and among the multiple variables in conjunction with the estimation of the effects of the variables, which were obtained from the regression coefficients (coef.) of each individual relationship path following the hypothesis. The results indicated that all C.R. ( t-test) values were statistically significant ( > 1.96). Thus, every hypothesis was supported (refer to Table 4).

H1: Technology directly affects organizational performance and in a positive manner. The hypothesis testing results found that coef. = 0.143, so H1 was accepted with a statistical significance of p < 0.05.

H2: Technology directly affects innovation and in a positive manner. The hypothesis testing results found that coef. = 0.370, so H2 was accepted with a statistical significance of p < 0.001.

H3: Technology directly affects research and development and in a positive manner. The hypothesis testing results found that coef. = 0.786, so H3 was accepted with a statistical significance of p < 0.001.
H4: Research and development directly affects innovation and in a positive manner. The hypothesis testing results found that coef. = 0.624, so H4 was accepted with a statistical significance of p < 0.001.

H5: Research and development directly affects organizational performance and in a positive manner. The hypothesis testing results found that coef. = 0.449, so H5 was accepted with a statistical significance of p < 0.001.

H6: Innovation directly affects organizational performance and in a positive manner. The hypothesis testing results found that coef. = 0.372, so H6 was accepted with a statistical significance of p < 0.01.

Table 4: Results from the hypotheses testing on organizational performance

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>coef.</th>
<th>t-test</th>
<th>TE</th>
<th>DE</th>
<th>IE</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Organizational Performance &lt;--- Technology</td>
<td>0.143</td>
<td>2.336</td>
<td>0.81</td>
<td>0.14</td>
<td>0.67</td>
<td>Supported</td>
</tr>
<tr>
<td>H2: Innovation &lt;--- Technology</td>
<td>0.370</td>
<td>4.488</td>
<td>0.86</td>
<td>0.37</td>
<td>0.49</td>
<td>Supported</td>
</tr>
<tr>
<td>H3: Research and Development &lt;--- Technology</td>
<td>0.786</td>
<td>13.777</td>
<td>0.78</td>
<td>0.78</td>
<td>-</td>
<td>Supported</td>
</tr>
<tr>
<td>H4: Innovation &lt;--- Research and Development</td>
<td>0.624</td>
<td>6.154</td>
<td>0.62</td>
<td>0.62</td>
<td>-</td>
<td>Supported</td>
</tr>
<tr>
<td>H5: Organizational Performance &lt;--- Research and Development</td>
<td>0.449</td>
<td>4.505</td>
<td>0.68</td>
<td>0.44</td>
<td>0.23</td>
<td>Supported</td>
</tr>
<tr>
<td>H6: Organizational Performance &lt;--- Innovation</td>
<td>0.372</td>
<td>2.832</td>
<td>0.37</td>
<td>0.37</td>
<td>-</td>
<td>Supported</td>
</tr>
</tbody>
</table>

Note: * significant p < .05, *** significant at p < .001, Coefficient refers to the Beta (β).

TE: Total effects; DE: Direct effects; IE: Indirect effects; Coefficient: coef.

Figure 3: Final Model.

Chi-square ($\chi^2$) = 94.422, df = 74, p = .055, CMIN/DF ($\chi^2$/df) = 1.276, GFI=.955, CFI=.994, AGFI=.926, NFI=.973 and RMSEA=.033.
4 DISCUSSION

According to the results of the research, technology was found to have a direct and positive effect on organizational performance. These results conformed with those of the study of Azhar[6], which had the conclusion that the management of more advanced technology is required for safety control and is a core system to subway station construction. In another way, it can be said that safety management technology hugely affects efficiency. Technology, therefore, is needed for performance analysis and evaluation[7]. The results also showed concordance with Somapa and Fongsuwan’s [9] study in which technology had the direct positive effects on organizational management efficiency. Radio-frequency identification (RFID) for transport network management also provided some advantages; i.e., cost saving, convenience, safety, and reduced operational time. Operational costs as well as travel rounds were less simultaneous, and the transportation time per round was shortened. Furthermore, the results matched the dimension that organizational structure and accepted technology directly affected organizational performance in a positive manner. Likewise, Hui-Ling Huang [31] pointed that the strategic application of technology integrated with IT for performance evaluation affects organizational performance with statistical significance.

Next, technology was found to have a direct and positive effect on innovation. This complied with the study of Fan Chen and Yajing Liu [8] that investigated the integration of multiple technologies being indispensable for the technological innovation process. Technological abilities and management also influence technological innovation performance. Liu et al. [7] suggested that safety innovation for subway construction does not only depend on technological support, but is also connected and related to technology. This was in accordance with Sexton and Barrett [17], who came to the realization that the ability to use technology is a factor to success because technology directly affects the emergence of new innovation.

For H3, technology was found to directly and positively affect research and development. This was supported by Kuma et.al [49], who addressed that technological transfer must be conducted together with research and development work. In South Korea, the key factors to success are knowledge from technological transfer, government support, personnel development, and research and development. Moreover, the major factors to the success of having technology are technological research and development, knowledge and the national train system infrastructure, collaborations among involved institutions, universities, and agencies. This is why South Korea has its own technology and can always develop rail systems that meet the people’s demands.

For H4 and H5, research and development was found to directly affect innovation and in a positive manner; thus, affecting organizational performance in the same way. This was similar to the results of the study of Koblen et al. [20], which demonstrated that research and development gives rise to innovation creation and concentrates on research projects. Additionally, it hugely affects teamwork performance and efficiency [26,27,28].

Finally, innovation was found to have a direct and positive effect on organizational performance. This conferred with the study of Hui-Ling Huang [31] that stated innovation embraces the bases; i.e., product innovation and process innovation in which product innovation is related to a new product or service development, and any concepts essential for organizational growth as well as financial performance. Process innovation also assists in accelerating organizational competitive abilities; thus, innovation is a capital activity influencing organizational existence paving the way to social and economic changes [30]. Moreover, innovation is a primary component for sustainability[36]. Sustainability from service was based on organizational core values in the aspects of the economy, environment, and society to evaluate organizational success [42]. This concurred with Salim et al. [33], who found that
innovation was positively related to organizational performance. Moreover, the results of the study of Fan Chen and Yajing Liu [8] illustrated that in terms of problem solving through subway station innovation, it was found that this approach could achieve technology and safety innovation, as this resulted in improved operations when compared with real situations. Therefore, it can be stated most organizational business competitive abilities come from organizational performance, which is a result from organizational growth, sustainable development, and business internationalization[39].

5 CONCLUSIONS

Mass rapid transit systems currently play an important role and are a crucial factor for Thailand’s future economic development. The potential of land transport helps save energy and is eco-friendly. Thus, having extensive rail systems that people can access appropriately would promote the valued potentiality of the areas resulting in systematic settlement, enhancement of the quality of life, and more safety from fewer road accidents. Additionally, this would see an adjustment of the logistics infrastructure of the country and other regional countries. Transport costs would be reduced that would bring higher competitive abilities for the country. The findings of this present research explained that technology, innovation, and research and development truly affect organizational performance. The industrial sector should be more encouraged to participate in technology learning and to step into the manufacturing chain for the development of Thailand’s rail transport system. This would also save foreign currency, create employment opportunities in the country, and have continual economic effects for the national monetary circulation, which would eventually pave the way to the enhancement as well as development of the people’s abilities in the future.

5.1 Research limitations and Further Research

According to the results of the research and the literature review, it was found that Thailand’s mass rapid transit systems initially relied on imported technology for development projects of rail transport systems but never set up any absorption process for further implementation. The country, therefore, has continued to rely on other countries’ technology. Moreover, there are still limited possibilities that the Thai industrial sector will join the projects and the development of the rail transport system industry still lacks experts, basic knowledge of train and rail technology, and the technological transfer process. Hence, future research should pay attention to considerable issues, particularly variables on organizations, experts, and technological transfer that Thailand must consider for application for further expansion of rapid transit networks in order to reach the country’s increasing competitive abilities.

REFERENCES


[34] Farhad Alipour and Roohangiz Karimi, Mediation Role of Innovation and Knowledge Transfer in the Relationship between Learning organization and Organizational Performance, International Journal of Business and Social Science, 2, 19, 144-147, 2011.


[43] Emil P, Vlad , Valeriy Tatarnikov, R&M&A&S of communication based train control systems applied to Urban Rail Transportation—A way to improve city sustainability, IEEE, 24-


