An Evaluation of the Effectiveness of the Travel Restriction Policy During the COVID-19 Pandemic to Control the Numbers of Daily Rail Passengers in the Bangkok Metropolitan Region

Jehan CHUDUANG [a], Tithiwach TANSAWAT [b], Motoko KANEKO [c], Tetsuji MASUJIMA [d]

[a,b,c,d] *ALMEC Corporation, Tokyo, 160-0022, Japan;*
[a] *E-mail: jehan.chu07@gmail.com*
[b] *E-mail: tansawat@almec.co.jp*
[c] *E-mail: kaneko@almec.co.jp*
[d] *E-mail: masujima@almec.co.jp*

Abstract: In response to the COVID-19 pandemic, the Thai government implemented various travel restriction policies in the Bangkok Metropolitan Region (BMR) to prevent the spread of the virus within crowded trains. These policies included (i) time and spatial travel restrictions, (ii) closure of travel destinations, and (iii) the promotion of remote working to reduce the number of daily rail passengers. However, the effectiveness of these policies in controlling passenger numbers has not been thoroughly evaluated. This study utilizes a regression analysis model to assess the impact of each policy. The results indicate that the "closure of travel destinations" policy was the most effective, leading to a significant decrease of approximately 50% in daily rail passengers compared to the pre-pandemic average. These findings offer valuable insights for policy evaluation and decision-making, enabling the Thai government to enhance travel restriction measures during public health crises.

Keywords: Coronavirus 2019 pandemic, metro service, policy evaluation, rail passenger, travel behavior, travel restriction policy

1. INTRODUCTION

This paper is a case study of the “Project for Enhancing the Capacity of the Formulation of the Second Mass Rapid Transit Master Plan in the Bangkok Metropolitan Region” (M-MAP2). This project is a collaboration between the Department of Rail Transport (DRT) under the Royal Thai Government and the Japan International Cooperation Agency (JICA), which was started in June 2021. In M-MAP2, the consideration of the transport-related policies to control the spread of the Coronavirus 2019 (COVID-19) in rolling stocks was one of the project’s activities.

The COVID-19 pandemic began in December 2019 and rapidly spread around the world. The recent number of infected persons is over 30 million people (WHO, 2022). Moreover, the pandemic not only had a general impact on public health and numerous countries’ economies, but also a specific effect on the daily demand of public transportation. It was recognized that a crowded situation in a public transport vehicle could create the chance of people becoming infected from other passengers. Consequently, this anxiety naturally caused a decrease in the number of daily passengers using public transport services, such as a reduction of 77%, 75%, and 70% in the number of users in the UK, Canada, and the US, respectively (Salmi et al., 2021). Additionally, the governments of many countries considered that this reduced number of passengers would create a positive effect in the aspect of controlling the crowd level to make those users use public transport without this concern.

Even though people's anxiety of being affected caused changes in travel behavior to avoid the use of public transport services, the governments were still concerned about the congested level inside the public transport vehicle. Therefore, numerous governments announced various travel restriction policies aiming to further limit the number of public transport users. For example, in Japan, the number of daily rail passengers was still high even during the pandemic. Thus, the Japanese government tried to limit the use of the railway system through a series of actions, such as reducing the service schedule, promoting commuters to avoid traveling during rush hour, and encouraging remote working. Likewise, Singapore implemented travel restriction policies, such as promoting residents to refrain from going to department stores, encouraging remote working and online education, limiting trips across high-risk districts, and vigorously tracking close contacts of infected groups (Lee & Ong, 2020). In South Korea, the government also applied policies to reduce trips in Seoul, such as closing major travel destinations, e.g., restaurants and community spaces. Those implemented policies proved to be effective to additionally control the number of public transport users (Le, 2022).

Regarding the COVID-19 situation in Thailand, the first infected person was detected on January 12, 2020, and the number of cases had increased to 4.7 million as of November 26, 2022 (Workpointnews, 2022). Similar to other countries, the anxiety of the COVID-19 pandemic naturally reduced the number of public transport users, but it was found that from the in-vehicle congestion level, it was still relatively possible to increase the chance to spread the virus, especially in the rail system, the main commuter mode in the BMR. In 2019, before the pandemic, the BMR had an average of around 1,102,575 daily rail users. However, despite the first outbreak wave in March 2020, the average number of daily rail users still remained up to 791,678 (MOT Data Catalog, 2022). Therefore, on March 26, 2020, the Thai government declared the 'Emergency Decree' and 'The Regulation' issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations, B.E. 2548 (2005) (No. 46). One of the goals of this declaration was to control the crowded situation inside the rolling stock in order to reduce the anxiety of the use of the rail system. During that time, a series of travel restriction policies, such as limiting the travel time, closing restaurants, and promoting remote working, were implemented.

From the statistics, after the implementation of those policies, the number of rail users continuously decreased (MOT Data Catalog, 2022). In addition, several factors led to the decrease in this number, such as the number of infected cases and economic recession. However, in Thailand, there was a lack of the focus on the verification of the effectiveness of each travel restriction policy on controlling the number of daily users. Therefore, the objective of this study was to systematically examine the effectiveness of the three major groups of the travel restriction policies, which were (i) time and spatial travel restriction, (ii) closure of travel destinations, and (iii) the promotion of remote working, so to control the number of daily rail passengers in the BMR during the COVID-19 pandemic.

2. LITERATURE REVIEW

2.1 Rail System in the Bangkok Metropolitan Region (BMR)

In the BMR, public inter-city trains have been operated by the State Railway of Thailand (SRT). In 1999, the first BTS metro system started with the aim of connecting the North-South and East-West corridors of the BMR. These elevated BTS lines are owned by the Bangkok Metropolitan Administration (BMA). After that, the Mass Rapid Transit Authority of Thailand

(MRTA) opened the first MRT Blue Line in 2004 as a circular loop line in the Bangkok area. Subsequently, the elevated Airport Rail Link (ARL) which was owned by the SRT was started in 2010, for the purpose of transferring passengers from Suvarnabhumi Airport to the city center. In the BMR, the metro system became a major public transport mode that took around 55.73% of the total mode share of public transport journeys in 2020 (Siewwuttanagul et al., 2020). Furthermore, the SRT has started to operate the newly constructed Red Line since 2021 to additionally collect passengers from the suburbs and Don Mueang International Airport. A summary of the rail system and metro services in the BMR are shown in Table 1 and Figure 1, respectively.

Table 1. Summary of the rail system in the BMR

Line	Owner	Station	Length	Purpose
BTS				
Sukhumvit Line	BMA	47	59.3	Support the North-East Corridor
Silom Line	BMA	14	14	Support the South-West Corridor
MRT				
Blue Line	MRTA	38	48	Support the Circular Corridor
Purple Line	MRTA	16	23.6	Support the North-West Corridor
SRT				
Inter-city	SRT	29	89.95	Collect Passengers from other provinces
ARL (City line)	SRT	8	28.6	Support airport transfers
Red Line	SRT	14	36.6	Support the North-West Corridor

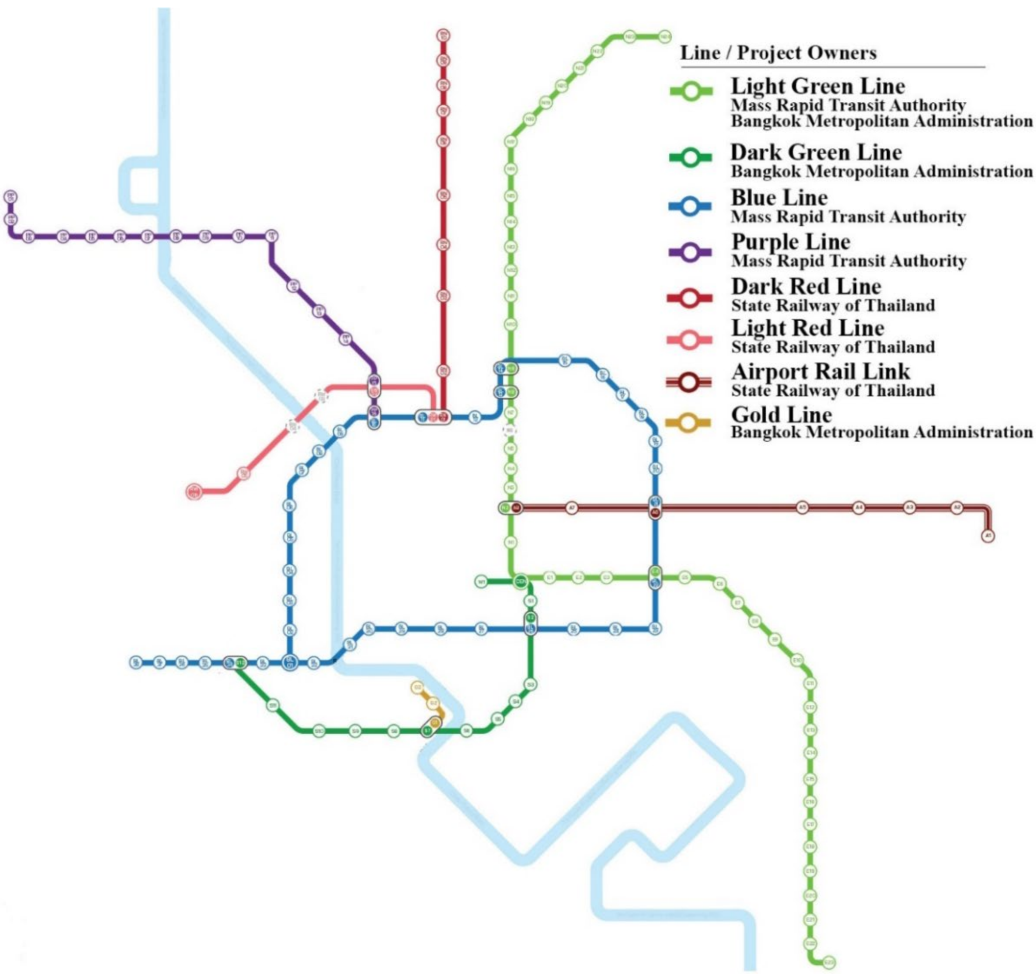

Figure 1. Bangkok mass rapid transit system in the BMR (Clare, 2022)

2.2 Travel Restriction Policies Focused in the Study

After the first pandemic wave began in early 2020, the Thai government took action to prevent the outbreak spreading, such as tracking infected people and asking people for cooperation to wear a mask and sanitize their hands. Subsequently, the Emergency Situation Declaration was announced on March 26, 2020. After that, the Center for COVID-19 Situation Administration (CCSA) was established (Panyaarvudh, 2020).

Despite the declaration, the number of infected people continued to increase. Therefore, to control the chance of COVID-19 spreading, especially via social activities and transportation, the government applied several travel restriction policies, such as a curfew policy was started on April 3, 2020, between 22.00 Hrs.- 04.00 Hrs. when everyone was to remain inside their place of residence, except only for urgent cases, such as going to the hospital. Later, the Ministry of Public Health officially defined the risk areas, the zones that had a high number of infected cases or super spreaders, where the government subsequently limited trips across those areas, such as Samut Sakhon province from December 27, 2020 to August 31, 2021. These kinds of policies were grouped as "time and spatial travel restrictions".

After the first grouped policy was announced, the number of infected people still increased. Major gathering places, such as schools, restaurants, and department stores were still crowded. When the second wave of the pandemic began, the government enforced the rule to close those places of gathering from May 15, 2020, which led to a positive effect to control the number of rail users as well. These policies were grouped as the "closure of travel destinations". During the implementation of the closure of travel destinations policies, the time and spatial travel restrictions policy continued to remain in effect.

Consequently, from April 13, 2021, the beginning of the third wave of the pandemic, the government encouraged offices of both the public and private sectors to adopt the concept of remote working, which allowed staff to work from their own residence, and self-isolation working, which allowed people to work remotely without travelling to their office. This was called the "promotion of remote working" policy. Despite the encouragement to adopt remote working practices, the previously announced measures, such as the time and spatial travel restrictions and closure of travel destinations policies, continued to remain in effect.

In summary, this paper focused on three groups of travel restriction policies to prevent in-vehicle COVID-19 spreading from using public transport services as below.

1) Time and spatial travel restrictions
    - Restriction on travelers from risk areas
    - Lockdown and curfew
2) Closure of travel destinations
    - Restaurant and shopping mall closures
    - School and university closures
3) Promotion of remote working
    - Promote working from home or a private place
    - Self-isolation working policy

2.3 Previous Case Studies

Some researchers examined the changes in the travel behavior of people after the implementation of the travel restriction policies. For instance, Palm et al. (2021) studied the psychological aspect during the policy implementation in Canada. By using Heckman selection models to predict six dimensions of transport disadvantages and transport-related social exclusions, it was found that women and people with a poorer health condition were more likely to avoiding public transit during the implementation. Hara and Yamaguchi (2021) analyzed the changes in Japanese travel behavior resulting from COVID-19 using mobile terminal network operational data. The results showed that a significant reduction in the number of trips was able to be achieved without a strong enforcement policy by the government and concluded that the people's behavior significantly changed by only the declaration of a state of emergency. In Seoul, South Korea, subway ridership decreased substantially in late February 2021, due to the implementation of a travel restriction policy, but it slowly recovered when the pandemic rate became lower. Lam et al. (2020) concluded that the border control policy in Hong Kong, such as entrance limits and mandatory quarantine successfully reduced the transportation demand and subsequently reduced the number of infected cases.

In the aspect of the transportation mode shift, the lower public transportation demand reflected a shift to other modes of transport due to the risk of being infected. According to an international comparative study, the most notable modal shift from public transportation to private car was found in both European and Asian countries, such as South Korea and China. In some areas, the share of motorcycles significantly increased, such as in India and other Southeast Asian countries (Vichiensan et al., 2021). Bian et al. (2021) investigated the effects of pandemic-related policies on transportation systems in New York and Seattle, in the USA. After the implementation of social distancing restrictions, vehicular traffic and transit ridership in both cities significantly decreased. However, after the end of the policy implementation, the study also discovered that recovery in vehicular traffic was significantly faster than those of public transport users. Likewise, Riggs and Appleyard (2021) used survey data collected in the initial months of the COVID-19 pandemic to examine the changes in travel behavior caused by telework during the pandemic in March and April 2020. Surprisingly, a significant increase in recreational non-motorized trips was caused by telework.

In terms of the estimation of the effectiveness of the travel restriction policy, Crokidakis (2020) concluded that the isolation policy had a significant impact on the reduction of the use of public transport and pandemic rate according to the analysis of the Rio de Janeiro pandemic situation. By using the Susceptible Infectious Quarantined Removed (SIQR) model, it was found that the predicted number of infected people after the implementation of the isolation policy was 600 times lower than the situation without this policy. In Japan, trains were also considered the main commuting mode which the government wanted to control the number of users during the pandemic in order to make the remaining people who still needed to use train services use them without any worry about COVID-19. The Japanese government implemented travel restriction policies regarding the rail system, such as the service schedule reduction of the Osaka Metro and Japan Railway (JR) Kyushu. In addition, policies by railway operators were promoted, such as the announcement for commuters to avoid traveling during the rush hour and to encourage remote working. During the policy implementation, the daily number of rail passengers further decreased, which showed the effectiveness of those policies. For example, in 2020, it was recorded that the number of Osaka Station visitors reduced by 55%, and daily passengers of major stations of JR East decreased by 35% to 60% when compared with the case without any policy implementation (Dû, 2020).

3. METHODOLOGY

3.1 Data Collection

The data related to the analysis were collected from several sources. This study selected the analysis period from January 12, 2020, when Thailand found the first infected case, to November 12, 2022, which basically covered all the important stages of the implementation of the travel restriction policies.

The information of the number of people using public transport was obtained from the MOT Data Catalog, the main organization supported by the Office of the Permanent Secretary, Ministry of Transport. Simultaneously, the Department of Provincial Administration published the Regulation Issued Under Section 9 of the Emergency Decree on Public Administration in Emergency Situation, B.E. 2548 (2005), which included the travel restriction policy. A summary of the information sources is shown in Table 2.

Table 2. Summary of the information sources

Type of Variables	Information Source
Pax per day	
Number of daily passengers using the BTS Skytrain	MOT Data Catalog
Number of daily passengers using the MRT Subway	“
Number of daily passengers using the Airport Rail Link	“
Number of daily passengers using the SRT (Inter-city) train	“
Number of daily passengers using the SRT (Red Line) train	“
Policy	
Information for the ‘time and spatial travel restriction’ policy	The Emergency Decree on
Information for the ‘closure of travel destinations’ policy	Public Administration in Emergency
Information for the ‘promotion to remote working’ policy	Situation, B.E. 2548 (2005)

3.2 Analysis of the Effectiveness of the Travel Restriction Policy to Control the Number of Daily Rail Passengers

Based on the collected data, the effectiveness of each grouped travel restriction policy was examined by the interpretation of the coefficient value of each grouped policy in the developed linear regression analysis model (Equation (1)). To observe the size of the effect of each grouped policy on each different railway line, which served diverse purposes, several models for each railway operator were developed. In the model, it should be noted that several policies were implemented at the same period, such as the policy to prohibit any trip in-out risk areas and a curfew; therefore, to avoid the effect of the high coordination value among several independent variables, those policies were combined into a grouped policy as mentioned above in Section 2.2.

$$Y_i = \beta_0 + \beta_i \cdot X_i \cdots \beta_n X_n \quad (1)$$

where

Y_i : Number of daily rail passengers (Daily passengers/day),
$X_{i \cdots n}$: The day of the policy implementation (1 = Implement; 0 = Others);
β_0 : Constant value, and
$\beta_{i \cdots n}$: Coefficient value for each policy.

4. RESULTS

4.1 Descriptive Statistics

The descriptive statistics, which describes the overall picture of the data used for the analysis are shown in Table 3.

Table 3. Descriptive statistics

Description	Unit	Obs.	Mean	Std. Dev.	Min	Max
Number of passengers of all systems.	Passengers/day	1036	731,397	347,289	95,394	1,601,451
Number of passengers using the SRT (Inter-city) train	Passengers/day	1036	37,397	21,128	1,733	101,061
Number of passengers using SRT (Red Line) train	Passengers/day	468	10,505	4,617	2,205	25,125
Number of passengers using Airport Rail Link train	Passengers/day	1036	33,952	17,268	5,183	88,133
Number of passengers using MRT Subway	Passengers/day	1036	228,534	113,300	28,223	492,282
Number of passengers using BTS Skytrain	Passengers/day	1036	426,769	199,704	56,100	950,500
Time and spatial travel restrictions	1 = Implemented on that day; 0 = others	1036	0.595	0.491	0	1
Closure of travel destinations	1 = Implemented on that day; 0 = others	1036	0.756	0.430	0	1
Promotion of remote working	1 = Implemented on that day; 0 = others	1036	0.655	0.475	0	1

Note: Obs. is the number of observations or days; Std. Dev. is the standard deviation.

The analysis period started from January 12, 2020 to November 22, 2022, a total of 1,046 days, covering all stages of the implementation of all grouped travel restriction policies during the COVID-19 situation in Thailand. Firstly, the “time and spatial travel restrictions” was implemented with a total duration of 616 days. Secondly, the “closure of travel destinations” was applied with a total duration of 783 days. Subsequently, “promoting remote working” was implemented since January 3, 2022, and several organizations have still continued applying remote working until the present time.

Table 3 shows that the BTS had the highest average number of daily passengers (426,769 users/day with a 46.79% standard deviation) because the BTS line passed through several important destinations in the city center, such as the offices in the commercial area. The MRT was mainly operated as a circular line, connecting to other lines, and passing through important places in the city, so it was generally crowded and ranked second with an average of 228,534 passengers/day or a 49.57% standard deviation.

The SRT Inter-city train could be grouped as regional focused trains that collected people from other provinces which had a lower population density than the city center. Therefore, the SRT (Inter-city) train had a smaller average number of daily passengers (37,397 people/day with a standard deviation of 56.50%). For the Airport Rail Link that connected Suvarnabhumi Airport to the city center, there were 33,952 users/day on average with a standard deviation of 50.86%. For the newly opened SRT (Red Line), this line had a considerably smaller number of passengers than other lines (10,505 users/day with a 43.95% standard deviation). In summary, during the analysis period, the average daily passenger number of all lines was 731,397 passengers/day with a 47.48% standard deviation.

In Figure 2, it is obvious that the number of passengers of each line further decreased when the travel restriction policies were implemented. To confirm the effectiveness and size of the effect of each grouped policy, the examination by developing the regression analysis model is shown in the next section.

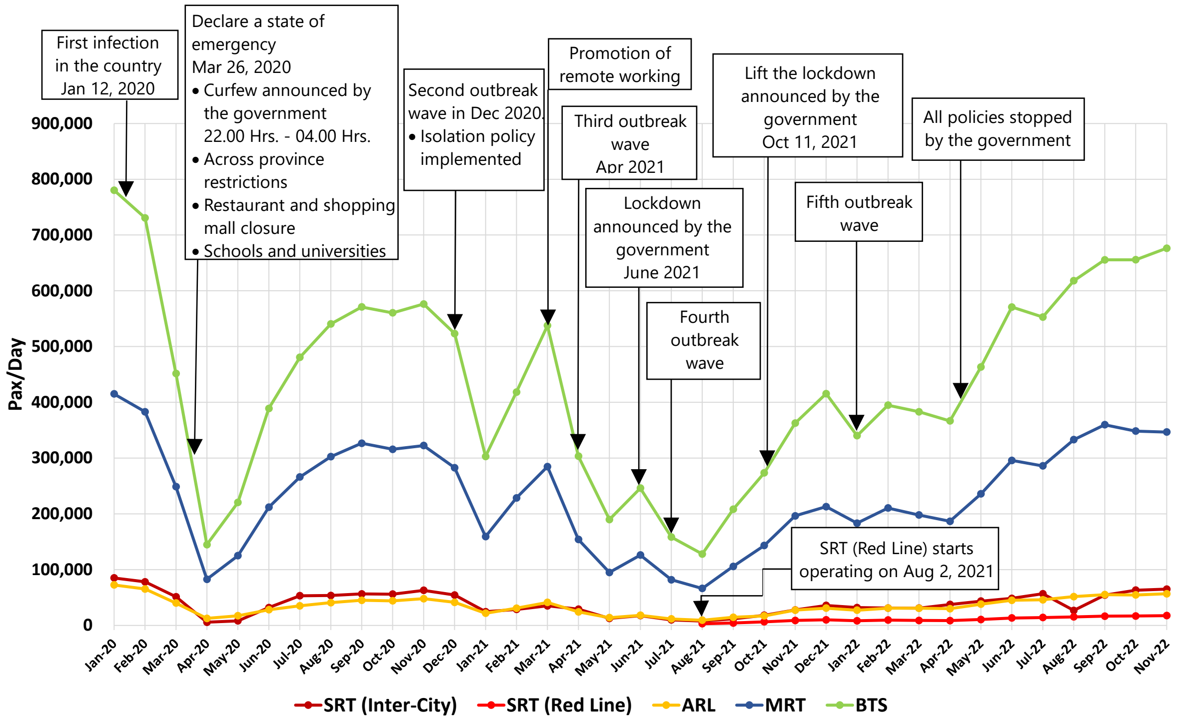

Figure 2. Average number of monthly passengers and implemented travel restriction policies during the COVID-19 pandemic

4.2 Effect of Each Grouped Travel Restriction Policy

A regression analysis model was developed to examine the size of the effect of each grouped travel restriction policy on the demand for daily rail transport (Table 4).

Table 4. The regression analysis model of the effect of the travel restriction policy on the demand for rail transport

Railway Line	Constant	LIMIT_IMP		DES_CLOSE_IMP		REMOTE_W_IMP		Adj R-squared
		Coef.	%Red	Coef.	%Red	Coef.	%Red	
All Lines	**1,262,015**	**-162,150**	**-22%**	**-362,138**	**-50%**	**-244,473**	**-33%**	**0.44**
SRT Inter-city Train	72,968	-14,531	-39%	-16,291	-44%	-22,279	-60%	0.51
SRT Red Line	15,074	-3,410	-32%	-5,992	-57%	(dropped)	NA	0.69
SRT Airport Rail Link	62,255	-9,132	-27%	-19,382	-57%	-12,534	-37%	0.52
MRT Lines	393,435	-43,550	-19%	-113,100	-49%	-81,539	-36%	0.39
BTS Lines	726,451	-89,440	-21%	-210,173	-49%	-133,489	-31%	0.43

Note: All variables had a 99% significant level (***); %Red was a % decrease in the daily passenger volume on the day that the policy was implemented.

From Table 2, on the days that the Thai government implemented the "time and spatial travel restriction" (LIMIT_IMP), "closure of travel destinations" (DES_CLOSE_IMP), and "promotion of remote working" (REMOTE_W_IMP) policies, all the negative values of their coefficients showed that the number of daily passengers of the railway of all lines was less than the average number of daily passengers during the analysis period that had a 99% confidential level. It appeared that these groups of travel restrictions policies were effective.

LIMIT_IMP contributed the least to control the daily passenger travel by rail with only a 22% reduction. It seemed that people were still able to adjust their travel period during the curfew period. The %Red in the number of daily passengers (%Red) of the SRT inter-city train and Red Line, which mainly collected daily passengers who lived far away from Bangkok's city center, significantly reduced more than those of other lines. Thus, it was obvious that the policy to restrict people to travel across provinces, especially the red-zone area was implicitly effective to control the inter-city rail demand. In addition, during the curfew policy, the effect on the SRT rail commuters who lived in the suburbs was larger because they tended to spend a longer travel time than those with shorter trip demands who had more time to make their trips.

After the government implemented DES_CLOSE_IMP, this grouped policy tended to have the largest effect on the overall rail users in general. However, the analysis did not find any significant differences in the size of the effect of this grouped policy among all lines. Nevertheless, it could be implied that this policy was the most effective to control the number of rail users in general.

During the period that both the public and private sectors adopted the concept of working remotely, the coefficient of REMOTE_W_IMP showed that this grouped policy was the most effective in controlling the demand for the SRT Inter-city Line. As mentioned above, SRT commuters tended to live in the suburbs. Additionally, it seemed that a longer travel time and distance made their commuting more difficult and discouraged them from travelling to the workplace, which was mostly located in the city center. On the other hand, the passengers of the BTS and MRT lines, who generally lived closer to the urban area with more office density, tended to have less effect from this grouped policy. Unfortunately, the effect of this grouped policy on the SRT Red Line could not be obtained because this line was opened after the continuous promotion of remote working.

5. CONCLUSION

This study systematically analyzed the effectiveness of travel restriction policies to control the number of BMR daily rail passengers, which had never been systematically examined before. The grouped policies focused in this study were (i) time and spatial travel restriction, (ii) closure of travel destinations, and (iii) the promotion of remote working implemented by the Thai government during the Emergency Situation Declaration.

From the regression analyses, the study investigated the effect of the policies on all rail systems in the BMR consisting of the SRT Inter-city Lines, SRT Red Line, SRT Airport Rail Link, MRT Lines, and BTS Lines. From the relationship between the implemented policies and the number of daily rail passengers, the "closure of travel destinations" was the most effective to control the number of passengers of all rail lines with around a 50% decrease from the average number of daily passengers. On the other hand, the "time and spatial travel restriction" contributed the least to control the daily passengers travelling by rail with only a 22% reduction of users. However, these grouped policies still had a significant effect on the SRT inter-city trains with a 39% reduction in the number of passengers because several SRT inter-city train users could not travel across risk areas which reduced a lot of the demand. As a consequence, it seemed that "promoting remote working" had the greatest impact on the passengers of the SRT Inter-city Line, who were discouraged to commute to the offices in the city center because of the longer travel distance and time. This policy reduced 60% of the demand of this line on the implementation date.

This study significantly contributed to the field of policy evaluation. The results of this study would benefit the Thai government as methodology to estimate the effect of each implemented travel restriction policy. In terms of limitations, this study focused on only the effect from the travel restriction policy, so the effects from other factors, such as the number of the infected cases were not examined. However, those unexamined effects were expressed and included in the constant values in the developed regression analysis models. Nevertheless, in order to understand the wider factors affecting the changes of the travel behavior of rail users in the BMR during the COVID-19 situation, a comprehensive analysis that combined not only the travel restriction policy, but also other variables, such as the number of cases, vaccinated people, and alternative transportation mode, should be conducted. In addition, this study analyzed only the macro data based on the secondary data, so an in-depth interview with rail users should be further done in order to understand the actual causes of the decision-making to reduce the use of the railway system. Therefore, the policy implementation would be more effective if the policymakers were able to understand the factors affecting the individual's travel behavior.

REFERENCES

Zilin, B., Fan, Z., Jingqin, G., Yanyan, C., Sai, S.C.P.V., Suzana, D.B., Kaan, O., Xuegang, B., Jingxing, W. (2021) Time lag effects of COVID-19 policies on transportation systems: A comparative study of New York City and Seattle. *Transportation Research Part A: Policy and Practice*, 145: 269-83.

Clare (2022) Bangkok Metro map.

Crokidakis, N. (2020) COVID-19 spreading in Rio de Janeiro, Brazil: Do the policies of social isolation really work?, *Chaos, Solitons & Fractals*, 136: 109930.

Department of Provincial Adminitration (2005) The Regulation Issued Under Section 9 of The Emergency Decree on Public Administration in Emergency Situations, B.E. 2005.

Dû, S.L. (2020) COVID-19 and public transport in Japan: status under state of emergency'.

Hara, Y., Yamaguchi, H. (2021) Japanese travel behavior trends and change under COVID-19 state-of-emergency declaration: Nationwide observation by mobile phone location data'. *Transp Res Interdiscip Perspect*, 9: 100288.

Lam, H.Y., Lam, T.S., Wong, C.H., Lam, W.H., Leung, C.M.E., Au, K.W.A., Lam, C.K.Y., Lau, T.W.W., Chan, Y.W.D., Wong, K.H., Chuang, S.K. (2020) The epidemiology of COVID-19 cases and the successful containment strategy in Hong Kong-January to May 2020. *Int J Infect Dis*, 98: 51-58.

Le (2022) Sanitary rules in South Korea', Chambre de Commerce et d'Industrie Franco-Coreenne.

Lee, W.C. Ong, C.Y. (2020) Overview of rapid mitigating strategies in Singapore during the COVID-19 pandemic. *Public Health*, 185: 15-17.

MOT DATA CATALOG (2022) People's travel during the COVID-19 epidemic & Number of ridership using public transport duing the COVID-19 pandemic, edited by Ministry of Transport Office of the Permanent Secretary.

Palm, M., Jeff, A., Bochu, L., Yixue, Z., Michael, W., Steven, F. (2021) Riders Who Avoided Public Transit During COVID-19, *Journal of the American Planning*

Association, 87: 455-69.
Panyaarvudh, J. (2020) Dr Taweesin: Shining the light of clarity on Covid-19 situation. *Thaipbsworld*.
Riggs, W., Bruce, S.A. (2021) Exploring the Implications Travel Behavior During COVID-19 for Transit: Potential for Ridesharing and Carsharing'. *SSRN Electronic Journal*.
Salmi, J., Johan, B., Ivo, M. (2021) Rail and the Effects of the COVID-19 Pandemic.
Siewwuttanagul, S., Supawadee, K., Wantana, P. (2020) Investigation on Physical Distancing Measures for COVID-19 Mitigation of Rail Operation in Bangkok, Thailand. *International Journal of Building, Urban, Interior and Landscape Technology (BUILT)*, 15: 93-102.
Vichiensan, V., Yoshitsugu, H., Sudarat, K. (2021) COVID-19 Countermeasures and Passengers: Confidence of Urban Rail Travel in Bangkok. *Sustainability*, 13: 9377.
WHO (2022) Coronavirus disease (COVID-19) pandemic.
Workpointnews (2022) Updated number of COVID-19 infected in Thailand.