Forecasting travel patterns during COVID-19 period using Community Mobility Report Case study: Bangka Belitung Province

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Abstract. The pandemic of COVID-19 has caused many changes and one of the changes is in people's travel patterns. Travel patterns have potentially related to environmental factors. The patterns in an urban environment can affect the liveability increase and the planning in urban areas. The change of travel pattern data is necessary for transportation planners and policymakers in providing safe transportation during the pandemic. Therefore, forecasting travel patterns is particularly essential to plan a better environment to reduce the spread of COVID-19. This study tries to forecast travel patterns during the COVID-19 period in Province of Bangka Belitung using the Community Mobility Report provided by Google. In this study, a time series model is necessary to predict future mobility. The model used in this research is exponential smoothing. The results find that the prediction of travel patterns for each trip destination experiences a fluctuating trend. The prediction for going to retail and recreation, grocery stores and pharmacies, parks, and transit stations tends to increase. Otherwise, the prediction of travel patterns for going to workplaces and residential decreases. Furthermore, the results of this study are feasible to plan a better environment to reduce the spread of COVID-19.

1. Introduction
The COVID-19 was discovered first in Wuhan, which spread straightaway throughout the world at the end of 2019. The rapid spread of COVID-19 surrounding the world prompted the World Health Organization (WHO) to set this situation as a Global Pandemic since March 11th, 2020 [1]. The spread of COVID-19 in Indonesia reached up Bangka Belitung. On March 30th, 2020, the first case was found in Bangka Belitung [2].

The pandemic of COVID-19 has caused many changes, one of which is the change in people's travel patterns. This condition can change people's behaviour patterns in mobility [3]. The changes in the behaviour of community mobility can occur because of the influence of public perceptions about the risk of COVID-19 transmission [4]. The changes in mobility also arise due to efforts to maintain distance by reducing various activities that are not so important. In addition, it is also influenced by government policies in reducing the spread of COVID-19 [5]. The reduction in travel by public transportation also affects changes in travel patterns (Meena, 2020). The COVID-19 pandemic has a considerable impact on daily activities that it plays a significant role in changing people's travel patterns [6],[7].
The travel patterns can be defined as travel flows for vehicles and passengers. It also can be described as the Origin-Destination Matrix [8] [9]. Travel patterns are substantial to overcome transportation problems [9]. On the other hand, travel patterns have potentially related to environmental factors [10]. Travel patterns in an urban environment can affect the liveability increase and the planning in urban areas[11]. In the conditions of CoVID-19, data on travel patterns have a significant role in determining travel restrictions in the area to reduce the spread of COVID-19 [12] [13]. The change of travel pattern data is necessary for transportation planners and policymakers in providing safe transportation during a pandemic [14]. Therefore, forecasting travel patterns is particularly essential to plan a better environment to reduce the spread of COVID-19.

This study tries to forecast travel patterns during the COVID-19 period in Province of Bangka Belitung using the Community Mobility Report provided by Google. In this study, a time series model is necessary to predict future mobility. The time series model used in this research is exponential smoothing. Furthermore, the results of this study could be used to plan a better environment to reduce the spread of COVID-19.

2. Methodology
This research tries to forecast travel patterns during the COVID-19 period in the Province of Bangka Belitung. In this study, forecasting travel patterns use the Community Mobility Report provided by Google. The Global Mobility Report is data of mobility that displays people's mobility during the pandemic around the world from time to time. The report provides people mobility data around the world from countries to provincial level. In addition, the report also describes people's mobility in 6 categories of trip destinations, such as: 1) retail and recreation, 2) grocery stores and pharmacies, 3) parks, 4) transit station, 5) workplaces, and 6) residential [15]. The Figure 1 below shows mobility report from month to month in Province of Bangka Belitung.

In this research, a time series method is necessary to predict future mobility. The time series forecasting shows the data by the pattern and the trend. It is common to show an increasing trend or a decreasing trend in this method [16]. The time series forecasting method used in this research is exponential smoothing. Exponential smoothing methods give more weight to recent observations. Then, the weight exponentially decreases as the observations are more distant. In addition, this method becomes the most effective when the parameters describe the time series changing slowly over time [17,18].
Holt-Winters Exponential Smoothing is applicable for time series forecasting data that exhibits both a trend and a seasonal variation. Two Holt-Winters Exponential Smoothing is applicable for time series forecasting data that exhibit a linear trend. Additive Holt-Winters Exponential Smoothing used for time series forecasting data with constant seasonal. The last, Multiplicative Holt-Winters Method used for time series forecasting data with increasing seasonal variation [16–18].

To forecast the next data period in this research, the following equations are used [18]:

\[ F_{n+k} = L_n + kT_n + S_{n-k+m} \]  

(1)

Where \( F_{n+k} \) is data period based on data period \( n \), \( L_n \) is based level for period \( n \), \( T_n \) is trend for period \( n \), \( S_{n-k+m} \) is seasonal factors for period \( (n-k+m) \).

Base level equations, trend equations, and the seasonal factor equation that used are as follow:

\[ L_n = \alpha(X_n - S_{n-k}) + (1-\alpha)(L_{n-1} + T_{n-1}) \]  

(2)

\[ T_n = \beta(L_n - L_{n-1}) + (1-\beta)T_{n-1} \]  

(3)

\[ S_n = \gamma(X_n - L_n) + (1-\gamma)S_{n-m} \]  

(4)

3. Result and Discussion

This study analyzes the Community Mobility Report to forecasting travel patterns in Province of Bangka Belitung use Exponential Smoothing Method. The forecasting predicts the travel pattern during COVID-19 period from July 2021 until December 2022. The result shows that the forecasting model overall get 6.768 for the Root Mean Square Error (RMSE) and 0.654 for the average coefficient of determination (R2). Regarding Table 1, the all of the forecasting model average fit is in 65.4% with the range between 44.5% and 83.5%. Then, the model fit for each trip destination can be seen in Table 2.

| Table 1. The fit statistic of forecasting model |
|-----------------------------------------------|
| Fit Statistic | Mean | Minimum | Maximum |
|----------------|------|---------|---------|
| R-squared      | 0.654| 0.445   | 0.835   |
| RMSE           | 6.768| 2.259   | 13.637  |

| Table 2. The model fit each trip destination |
|-----------------------------------------------|
| Model                          | Model Fit statistics | Description    |
|---------------------------------|----------------------|----------------|
| R-squared | RMSE   |             |               |
| Retail_and_Recreation-Model_1   | 0.445 | 7.177 | Model Fit 44.5% |
| Grocery_and_Pharmacy-Model_2    | 0.718 | 5.222 | Model Fit 71.8% |
| Parks-Model_3                   | 0.703 | 6.837 | Model Fit 70.3% |
| Transit Stations-Model_4        | 0.487 | 13.637| Model Fit 48.7% |
| Workplaces-Model_5              | 0.738 | 5.478 | Model Fit 73.8% |
| Residential-Model_6             | 0.835 | 2.259 | Model Fit 83.5% |

The prediction of travel pattern for going to retail and recreation until December 2022 face a fluctuating trend. There was a significant decrease in January and April 2022. The model fit is in 44.5% and the RMSE is in 7.177. The forecasting result shows that there is no error value and the value still within the UCL and LCL. The detail prediction of travel pattern for retail and recreation until December 2022 can be seen in Figure 2.
Figure 2. The forecasting of travel pattern for going to retail and recreation

Based on the Figure 3 below, the forecasting of travel for going to grocery and pharmacy until December 2022 has a fluctuating trend, but it tends to increase. The model fit is in 71.85% and the RMSE is in 5.222. The forecasting result shows that there is no error value and the value still within the UCL and LCL.

Figure 3. The forecasting of travel pattern for going to grocery and pharmacy

Figure 4 shows the detail of travel patterns prediction for going to parks until December 2022. The travel patterns trend for going to parks is fluctuated. The prediction also shows that there is significantly increase mobility that go to parks because the prediction over the baseline. Then, the model fit is in 70.3% and the RMSE is in 6.837. The forecasting result shows that there is no error value and the value still within the UCL and LCL.

Figure 4. The forecasting of travel pattern for going to parks
Regarding Figure 5, the forecasting travel pattern for going to transit stations until December 2022 get a fluctuating trend. The forecasting also tends to arise. In addition, the model fit is in 70.3% and the RMSE is in 6.837. The forecasting result shows that there is no error value and the value still within the UCL and LCL.

![Figure 5. The forecasting of travel pattern for going to transit stations](image)

The graph (Figure 6) below gives information about the result of the forecasting travel pattern for going to workplace until December 2022. The result shows that the travel pattern experiences a fluctuating trend. It tends also to decline. The model fit is in 73.8% and the RMSE is in 5.478. The forecasting result shows that there is no error value and the value still within the UCL and LCL.

![Figure 6. The forecasting of travel pattern for going to workplace](image)

Last, the prediction of travel patterns for going to residential until December 2022 trend is fluctuated. The prediction also tends to decrease. The model fit is in 83.5% and the RMSE is in 2.25. The forecasting result shows that there is no error value and the value still within the UCL and LCL.

![Figure 7. The forecasting of travel pattern for going to residential](image)
4. Conclusion

Regarding the result, it knows that the forecasting model overall gets 6.768 for the Root Mean Square Error (RMSE) and 0.654 for the average coefficient of determination (R2). All of the forecasting models average fit is in 65.4% with the range between 44.5% and 83.5%. In addition, the prediction of travel patterns for each trip destination experiences a fluctuating trend. The prediction of travel patterns for going to retail and recreation, grocery stores and pharmacies, parks, and transit stations tend to increase. Otherwise, the prediction of travel patterns for going to workplaces and residential tends to decrease. However, all of the forecasting results show that there are no error values. The values are still within the UCL and LCL. That means all of the forecasting results are valid to be used. Furthermore, the results of this study are feasible to plan a better environment to reduce the spread of COVID-19.

References
[1] WHO 2021 Coronavirus disease (COVID-19) pandemic
[2] Frazila, Russ bona; Sjafruddin, Ade; Santoso, Idwan; Zukhruf, Febri; Suryo, Taufiq; Maulana, Andrean; Ziaulhaq, Agung; Farda M 2020 Kajian Pemodelan Pergerakan Orang di Bidang Transportasi Jalan Selama Covid-19
[3] Nissa N K 2020 Dampak Perubahan Pola Mobilitas Masyarakat Indonesia terhadap Sektor Transportasi saat Pandemi COVID-19
[4] Parady G, Taniguchi A and Takami K 2020 Travel behavior changes during the COVID-19 pandemic in Japan: Analysing the role of risk perception and social influence on going-out self-restriction Transportation Research Interdisciplinary Perspectives 7 100181
[5] Arimura M, Ha T V, Okumura K and Asada T 2020 Changes in urban mobility in Sapporo city, Japan due to the Covid-19 emergency declarations Transportation Research Interdisciplinary Perspectives 7 100212
[6] Shamshiripour A, Rahimi E, Shabanpour R and Mohammadian A (Kouros) 2020 How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago Transportation Research Interdisciplinary Perspectives 7 100216
[7] Abdullah M, Dias C, Muley D and Shahin M 2020 Exploring the impacts of COVID-19 on travel behavior and mode preferences Transportation Research Interdisciplinary Perspectives 8 100255
[8] Tamin O Z 2014 Metode Estimasi Matriks Asal Tujuan (MAT) untuk Peramalan Kebutuhan Transportasi Teori, Contoh Soal, dan Aplikasi (Bandung: Penerbit ITB)
[9] Safitri R 2015 Analisis Pola Pergerakan Berdasarkan Estimasi Matriks Asal Tujuan Menggunakan Data Telepon Seluler ( Studi Kasus Provinsi Bali ) Propil 3 9
[10] Hess F, Salze P, Weber C, Feuillet T, Charreire H, Menai M, Perchoux C, Nazare J A, Simon C, Oppert J M and Enaux C 2017 Active mobility and environment: A pilot qualitative study for the design of a new questionnaire PLoS ONE 12
[11] Mastroianni P, Monechi B, Servetto V D P, Liberto C, Valenti G and Loreto V 2016 Individual mobility patterns in urban environment COMPLEXIS 2016 - Proceedings of the 1st International Conference on Complex Information Systems (SciTePress) pp 81–8
[12] Gibbs H, Liu Y, Pearson C A B, Jarvis C I, Grundy C, Quilty B J, Diamond C, Simons D, Gimma A, Leclerc Q J, Auzenbergs M, Lowe R, O’Reilly K, Quaife M, Hellewell J, Knight G M, Jombart T, Klepac P, Procter S R, Deol A K, Rees E M, Flasche S, Kucharski A J, Abbott S, Sun F Y, Endo A, Medley G, Munday J D, Meakin S R, Bosse N I, Edmunds W J, Davies N G, Prem K, Hué S, Villabona-Arenas C J, Nightingale E S, Houben R M G J, Foss A M, Tully D C, Emery J C, van Zandvoort K, Atkins K E, Rosello A, Funk S, Jit M, Clifford S, Russell T W and Eggo R M 2020 Changing travel patterns in China during the early stages of the COVID-19 pandemic Nature Communications 11
[13] Przybylowski A, Stelmak S and Suchanek M 2021 Mobility behaviour in view of the impact of the COVID-19 pandemic-public transport users in gdansk case study Sustainability (Switzerland) 13 1–12
[14] Meena S 2020 Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India *Indian Journal of Science and Technology* **13** 2491–501

[15] Google 2021 Global Mobility Report

[16] Djakaria I and Saleh S E 2021 Covid-19 forecast using Holt-Winters exponential smoothing *Journal of Physics: Conference Series* vol 1882 (IOP Publishing Ltd)

[17] Habibur Rahman M, Salma U, Moyazzem Hossain M and Tareq Ferdous Khan M 2016 *Revenue Forecasting using Holt-Winters Exponential Smoothing Clustering and Multidimensional Scaling* View project Statistical Modelling View project Revenue Forecasting using Holt-Winters Exponential Smoothing

[18] Bustami, Irawansyah H and Gamal M D H 2015 Holt-Winters Forecasting Method That Takes into Account the Effect of Eid *Science Journal of Applied Mathematics and Statistics* **3** 257

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