Exploring the impact of COVID-19 on transportation using Structural Equation Modeling

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Abstract

COVID-19 has had an impact on various aspects of life, including transportation. In this paper, exploration is carried out in Yogyakarta City, Indonesia, by looking at the various effects of COVID-19 on several variables related to transportation, including accidents, community mobility, and air pollutants of indicators. Then the analysis was carried out using the Structural Equation Modeling (SEM) method in the R Studio program. The study results show that community mobility is influenced by the number of the accident and community mobility does not influence the volume of air pollutants. This research can become input for the government planning to improve the transportation system.

Keywords: transportation, COVID-19, Structural Equation Modeling, SEM

1. INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). On December 31, 2019, the WHO China Country Office reported pneumonia of unknown etiology in Wuhan City, Hubei Province, China. Then, on January 7, 2020, China identified the case as a new type of coronavirus. Finally, on January 30, 2020, WHO declared the incident a Public Health Emergency of International Concern (PHEIC), and on March 11, 2020, WHO announced COVID-19 a pandemic (Sugihantono et al., 2020).

Indonesia reported the first case of COVID-19 occurred on March 2, 2020, where the number of cases and daily patients continued to increase until the end of 2020, as shown in Figure 1. Since the beginning, the Indonesian government has tried to suppress the spread of the pandemic through policies in lockdown for international flights and large-scale social restrictions for domestic. However, the first wave of the pandemic in Indonesia did not end until the end of 2020. On the contrary, the economic sector showed a decline.

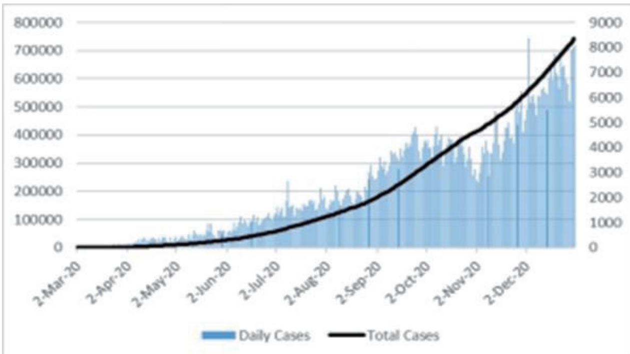

Figure 1 COVID-19 cases in Indonesia, 2020

Based on Cumulative Growth Rate (figure 2) data published by the Central Statistics Agency of Indonesia, economic growth in Indonesia has slowed by -2.07%. The transportation and warehousing sector shows a significant value when compared to other industries of -15.04%. So, the COVID-19 pandemic has had a massive impact on the transportation sector. So, the government must determine strategic policies related to transportation to improve the economy through good transportation planning. Furthermore, this study was made to explore and analyze the impact of COVID-19 on the transportation sector by looking at the effect of changes in community mobility during the pandemic on transportation using indicators related to the level of traffic accidents. In addition, the correlation between community mobility and air pollution is also seen.

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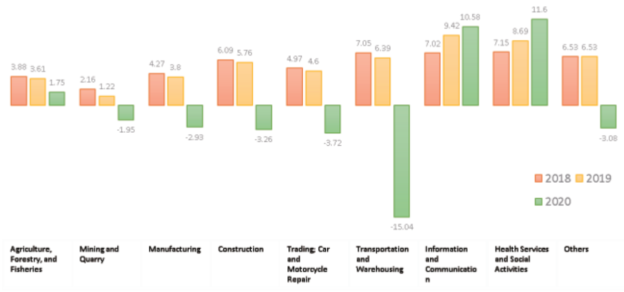

Figure 2: Cumulative Economic Growth Rate in Indonesia

The variables used in this study are latent, so they must be modelled on the Structural Equation Model (SEM). Many applications support SEM, such as AMOS, EQS, MX, etc. However, this research uses RStudio because it is open source, and there is a community that supports the development of this application with many packages that continue to be developed(Gana & Broc, 2019).

2. LITERATURE REVIEW

2.1 Structural Equation Modelling (SEM)

SEM is a quantitative method used to see the relationship between the variables studied. SEM tests the theoretical model using statistical methods from hypotheses to understand complex relationships between variables.

The development of the first SEM program, the linear structural relations model (LISREL), was carried out in the mid-1980s. However, SEM for all disciplines usages has been carried out since 1994 (Schumacker & Lomax, 2012). SEM has advantages when compared to other statistical approaches, including:

- Describe complex phenomena through statistical modelling and measurement.
- Distinguish between measurement error and statistical analysis so that the validity and reliability produced are clearer.

Several studies related to transportation use the SEM method, such as the Eboli study, which explores the interaction between land use and transportation using SEM. The results of his research indicate that travel behaviour which is strongly influenced by the economic characteristics of the community can identify the relationship between variables related to land use and transportation systems(Eboli et al., 2012). Furthermore, Lee's research which shows the size of traffic accidents on Korean toll roads, uses SEM, which concludes that its size is influenced by road factors, driver factors and environmental factors(Lee et al., 2008).

2.2 The impact of covid-19 on community mobility

Mendolia's research stated that community mobility by data from Google would be influenced by policies determined by the government of a country where the steps taken are affected by the number of cases and deaths caused by COVID-19. If the impact caused by Covid-19 becomes higher, the social interaction and movement of the community will be increasingly restricted by the government according to the characteristics of their respective countries(Mendolia et al., 2021).

2.3 The impact of covid-19 on accidents

Covid-19 impacts people's habits in driving their vehicles and vigilance in driving (Katrakazas et al., 2020). A study conducted by katrakazas showed a significant decrease in Greek by 41% in the first month of the pandemic. The amount of vehicular traffic is also decreasing, but this causes the average speed of vehicles to increase by 6-11%.

2.4 The impact of covid-19 on air pollution

Based on several studies, COVID-19 has a relationship with air pollution. At the beginning of the COVID-19 pandemic, it showed a decrease in the concentration of NO_2, $PM_{2.5}$ and an increase in ozone O_3 in 34 countries due to the decline in the number of vehicles globally(Venter et al., 2020). Furthermore, based on travaglio's research, an increase in the amount of air pollution on a small scale will increase the number of deaths in the UK due to COVID-19 on a large scale(Travaglio et al., 2021).

Finally, based on several research results, the relationship between Covid-19 and several variables can be seen. The hypothesis in this study is that there is a relationship between community mobility variables with the accident and air pollution, which will try to be modelled using the SEM method. As a first step, exploration will be carried out by analyzing the impact of COVID-19 on an area.

3. CASE STUDY

The research was conducted in Yogyakarta City, which is one of the densely populated cities in Indonesia. The city's highest income comes from the tourism sector due to its many historical and cultural sites, interesting natural attractions, cultural events, and delicious foods. However, the number of visitors has decreased because of the COVID-19 outbreak, as shown in figure 3.

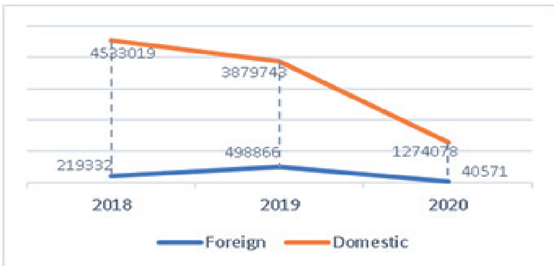

Figure 3: The number of tourism visitors in Yogyakarta City

The monthly chart in 2020, as shown in Figure 4, shows an increase in the number of domestic tourists until the end of the year, although cumulatively it is still far from the previous year. However, this shows an increase in community mobility—meanwhile, foreign tourists are still deficient because of the ban on international flights.

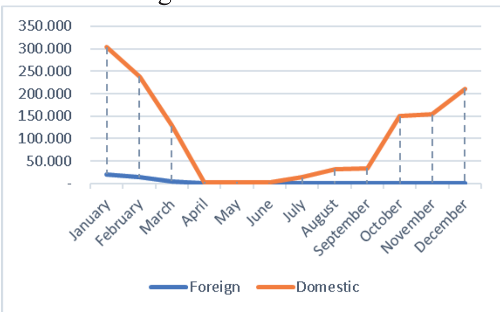

Figure 4: The number of tourism visitors in Yogyakarta City by the month at 2020

4. RESEARCH DATA

There are several data in the Yogyakarta City that were explored related to the COVID-19 pandemic in 2020

4.1 Accident

Traffic accident data obtained from the Yogyakarta City police in Figure 5 in 2020 shows a decrease compared to the data in 2019. Although the number of accidents increased at the beginning of 2020, it was reduced during the pandemic in March. Furthermore, April showed a significant difference compared to the previous year. However, the following month showed an increase in the number of accidents even in November, more severe than the last year because of the increasing vehicle volume and the decreasing government restrictions on road usage. Furthermore, Figure 6 shows the accident rate in each sub-district which shows a downward trend in 2020 except Gedongtengen and Gondomanan.

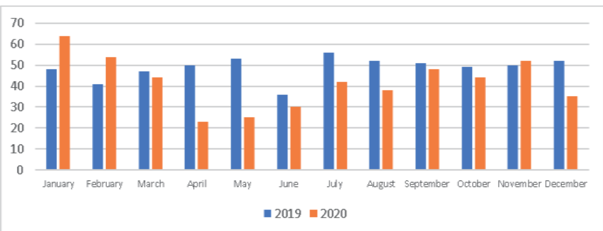

Figure 5: Accident by month

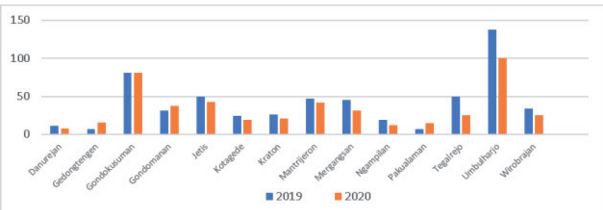

Figure 6: Accident by subdistrict

The sub-districts in Yogyakarta have different areas and population numbers, so it is difficult to determine the level of accidents only by number. Furthermore, to see areas that are prone to accidents, it can be seen in Figure 7. In 2019 there were several accident-prone points in the sub-districts of Wirobrajan, Gondokusuman, Jetis, and Tegalrejo, while in 2020, the accident-prone points were only in Gondokusuman.

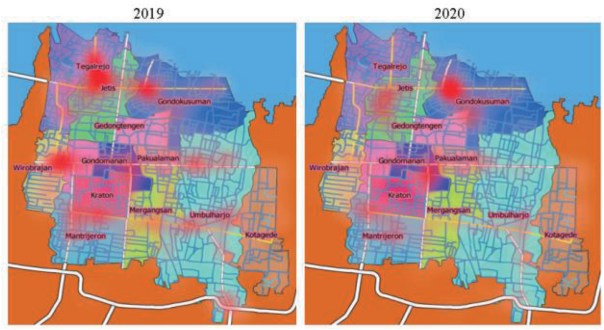

Figure 7: The heatmap of accident in Yogyakarta city

4.2 Community mobility

Google shares community mobility reports data that show the movement trend of people in Yogyakarta. Reports are generated based on an aggregate of Google anonymous users who have enabled the location history facility.

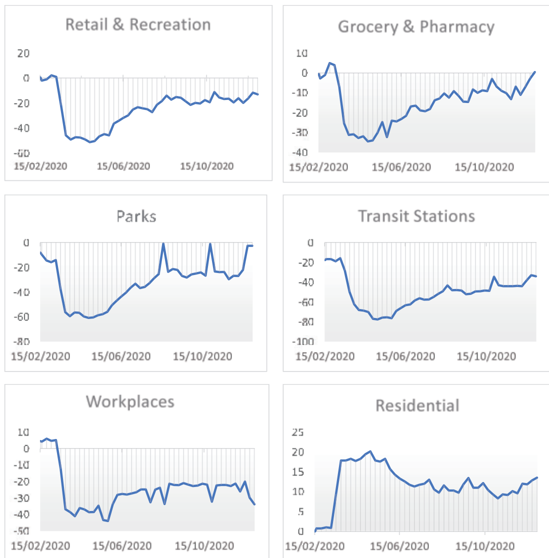

Figure 8: Google community mobility data in Yogyakarta

In the early months of 2020, the graph shows the people in Yogyakarta mainly reduced their outdoor activities and preferred to stay at home except in parks, which showed a relatively high value since the middle of the year. Accumulatively for grocery, pharmacy, retail, and games, the value is almost close to conditions before the pandemic. Meanwhile, transit stations still show low numbers because people still have a low level of trust in the protocols run by transportation agents. Furthermore, workplaces show a low number because most of the private offices still follow work from home.

4.3 Air Pollutant

The Ministry of Environment and Forestry collected the pollutant standard index data using an Air Quality Monitoring Station (AQMS) located in Yogyakarta. The data shown in Figure 9 is weekly data as the average result of daily data.

The graph shows the impact of COVID-19 on several types of polluting gases. CO and SO2 gas showed a similar trend with a decline until August and continued to increase until the end of the year. Meanwhile, O3 gas decreased until May and a significant increase until the end of the year. Finally, PM10 gas did not show any impact from COVID-19 during 2020.

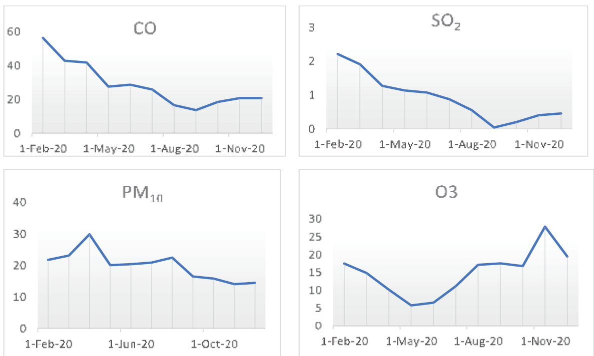

Figure 9: The pollutant standard index data in Yogyakarta

5. ANALYSIS

The three data show results that COVID-19 has an impact on each variable. However, to see the relationship between variables, it will be modelled on SEM. All data used in the modelling is weekly data which is the average of daily data. Thus, the three variables use the same interval.

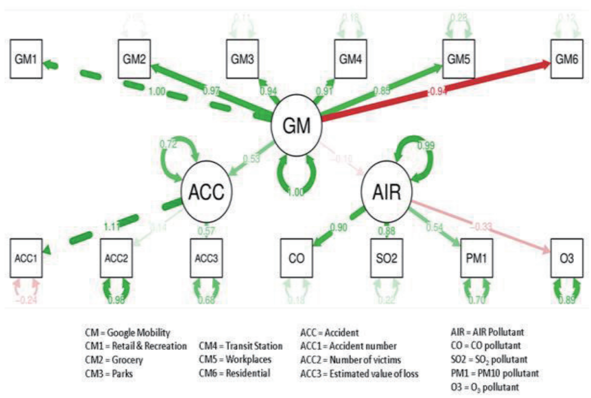

Figure 11:The Structural Equation Modelling result in R Studio

The results of the modelling in R Studio in Figure 11 show the relationship between each variable consisting of accidents (ACC), Community Mobility (CM) and Air Pollutants (AIR). Each variable is associated with several indicators. It can be seen that the connecting lines have varying values. The greater the deal, the greater the relationship between variables or indicators. However, there is also a minus value and a red line, such as the relationship between CM and CM6 (residential). In this relation, the more people who live at home, the smaller the community mobility will be.

The relationship between CM and ACC means that the high movement of people will increase the probability of traffic accidents. Meanwhile, the red relationship between CM and AIR implies that people's activity does not directly impact increasing air pollution. To see the parameters of the SEM can be seen from the output in Table 1.

Table 1: The Output of the modeling

	lhs	op	rhs	est	se	z	pvalue	ci.lower	ci.upper	std.lv	std.all
1	ACC	=~	ACC1	1	0	NA	NA	1	1	3.895	1.115
2	ACC	=~	ACC2	0.223	0.218	1.02	0.308	-0.205	0.651	0.868	0.14
3	ACC	=~	ACC3	49.779	18.507	2.69	0.007	13.507	86.051	193.901	0.566
4	AIR	=~	CO	1	0	NA	NA	1	1	11.533	0.904
5	AIR	=~	SO2	0.054	0.01	5.638	0	0.035	0.073	0.621	0.88
6	AIR	=~	PM10	0.269	0.072	3.756	0	0.129	0.41	3.106	0.544
7	AIR	=~	O3	-0.269	0.125	-2.151	0.031	-0.514	-0.024	-3.099	-0.327
8	CM	=~	CM1	1	0	NA	NA	1	1	14.83	1
9	CM	=~	CM2	0.689	0.025	27.729	0	0.64	0.738	10.22	0.972
10	CM	=~	CM3	1.087	0.057	19.071	0	0.976	1.199	16.128	0.943
11	CM	=~	CM4	1.02	0.07	14.526	0	0.883	1.158	15.131	0.907
12	CM	=~	CM5	0.711	0.065	10.87	0	0.582	0.839	10.538	0.849
13	CM	=~	CM6	-0.315	0.018	-17.912	0	-0.35	-0.281	-4.672	-0.936
14	ACC	~	CM	0.139	0.028	4.963	0	0.084	0.194	0.53	0.53
15	AIR	~	CM	-0.078	0.121	-0.643	0.52	-0.315	0.159	-0.1	-0.1
16	ACC1	~~	ACC1	-2.963	4.548	-0.651	0.515	-11.877	5.952	-2.963	-0.243
17	ACC2	~~	ACC2	37.758	7.843	4.814	0	22.386	53.129	37.758	0.98
18	ACC3	~~	ACC3	7.97E+04	2.00E+07	3.992	0	4.05E+04	1.19E+08	7.97E+04	0.679
19	CO	~~	CO	29.683	20.545	1.445	0.149	-10.585	69.95	29.683	0.182
20	SO2	~~	SO2	0.112	0.061	1.821	0.069	-0.009	0.232	0.112	0.225
21	PM10	~~	PM10	22.987	5.052	4.55	0	13.086	32.889	22.987	0.704
22	O3	~~	O3	80.355	16.997	4.728	0	47.041	113.669	80.355	0.893
23	CM1	~~	CM1	0.069	1.351	0.051	0.959	-2.58	2.718	0.069	0
24	CM2	~~	CM2	6.036	1.415	4.266	0	3.263	8.808	6.036	0.055
25	CM3	~~	CM3	32.362	6.944	4.661	0	18.752	45.972	32.362	0.111
26	CM4	~~	CM4	49.434	10.414	4.747	0	29.024	69.845	49.434	0.178
27	CM5	~~	CM5	42.997	8.997	4.779	0	25.362	60.631	42.997	0.279
28	CM6	~~	CM6	3.085	0.658	4.689	0	1.796	4.375	3.085	0.124
29	ACC	~~	ACC	10.915	5.034	2.168	0.03	1.048	20.781	0.719	0.719
30	AIR	~~	AIR	131.692	38.338	3.435	0.001	56.552	206.833	0.99	0.99
31	CM	~~	CM	219.942	45.895	4.792	0	129.989	309.895	1	1
32	ACC	~~	AIR	-0.025	4.947	-0.005	0.996	-9.722	9.672	-0.001	-0.001

Lhs column consists of latent variables while rhs consists of manifest indicators. Next, column est stands for estimation where rows 1-15 represent unstandardized variable loadings, rows 16-28 describe the unstandardized (error) variance of manifest indicators, rows 29-31 represent the latent variable variances and row 32 represents the covariance between variable. Furthermore, column se means the standard error of estimation. Finally, the p-value is the probability value which uses in the hypothetical test. Suppose we use the α at 5%. In that case, we can see in the line 14 show 0 to determine the relationship between accident and community mobility and line 32 show high number (0.996) to determine no relationship between Accident and Air pollutant.

6. CONCLUSION

Modelling result describes the relationship quantitatively between variables and indicators. Based on the analysis, community mobility does not have a significant effect on air pollutant. Meanwhile, traffic accidents are influenced by community mobility. Thus, to reduce the occurrence of traffic accidents, community mobility must be limited. However, to minimize air pollutant, it is necessary to explore other causes and limit them, such as pollution from factories or power plants that still use coal.

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