Mobility for Long-distance: How People Choose Transportation in the Covid-19 Pandemic Era?

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Abstract: Transportation during the pandemic era is experiencing tremendous pressure, as although it causes the spread of the virus, restrictions on mobility worsen its operation. Therefore, this study aims to explain a model of mobility behavior on medium and long-distance trips in an archipelago based on the choice of transportation mode. The data was from cases in the western Timor island, focused on traveling from Kupang to various district cities. Data was collected using a questionnaire with a sample of 250 respondents, randomly selected in the Kupang area. The modes of transportation included were buses, cars, motorbikes, minibuses, and car sharing. Meanwhile, the analysis used the best-worst method (BWM) approach by comparing one mode, labeled as the best, with another, expressed as the worst, according to each respondent's perception, to describe the mode selection behavior before and during the pandemic. Based on the calculation algorithm in the BWM, the output of the analysis was the weight of each mode of transportation for each respondent. The final weight was based on the average weight estimated from the overall respondents and used to determine the ranking of each mode of transportation. Subsequently, the results showed that buses were the best mode of transportation, followed by cars, then car sharing, minibuses, and finally, motorbikes, which were rarely used. During the pandemic, the best or most frequently used mode of transportation was car sharing, followed by minibuses, cars, motorbikes, and buses as the last alternative in the ranking. This finding shows that long-distance travellers are more prone to the spread of Covid-19 virus. Therefore, clear regulations are needed regarding car sharing operations to ensure the provision of excellent services. Also, the improvement of intercity bus services is important, especially in terms of capacity management, cleanliness, and the application of health protocols during trips.

1 INTRODUCTION

Transportation, which has become a vital part of human life, became one of the causes of the massive viral spread during the pandemic. A study conducted by Iacus et al. (2020) showed transportation accounted for approximately 92% of the virus spread at the beginning of the pandemic and decreased after mobility was controlled. At the same time, many transportation operators have suffered losses due to the decline in travel within and between cities (Tirachini and Cats, 2020). The identification result by Labonté-Lemoyne et al. (2020) showed the widespread shifting of people from public to private vehicles on their daily commute. This was supported by other findings in the United States that there was a dynamic shift in travel behavior with people's perception of the Covid-19 impact (Truong and Truong, 2021). In addition, mobility within Shenzhen, China, has decreased by 20-60%, causing a delay in the growth of the virus spread (Zhou et al., 2020).

Population diversity, mobility patterns, and spatial factors affect the time needed to overcome a pandemic. A study by Merler and Ajelli (2010) showed that the diversity of mobility with varying levels of activity provides different levels of disease spread, causing closures and activity restrictions to be more effective control measures. However, these activity restrictions impact changing travel behavior.

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(Przybylowski et al., 2021) found that the majority of people surveyed reduced their use of public transportation and would reuse it, providing Covid 19 is more controlled. The study conducted by (Chang et al., 2021) showed that people with high travel activities were more susceptible to the virus transmission, where most of them were lower-middle-income people who cannot freely decide to reduce mobility. In addition, Chen et al.'s (2020) analysis results showed a positive correlation of travel restrictions with the spread of disease at the beginning of the pandemic, where higher restrictions led to reduced viral spread. The study analyzed two main strategies, namely without and with intervention on public transportation, where the first strategy allowed the maximum number of Covid-19 infected cases and the second reduced it.

According to Shen et al. (2020) long-term effective prevention and control measures need to be adopted by public transportation. Since the risk of infection in humans can be very high while traveling by public transportation, precautions such as strengthening management personnel, personal protection, environmental cleaning and disinfection, health, and education need to be taken seriously. The study by Ozbilen et al. (2021) also showed, on average, the people who used public transportation, ride-hailing, and car sharing were more at risk of contracting Covid-19 than those that walked or used cars. Therefore, building on the emerging positive perception of non-motorized modes as an opportunity to promote sustainable transportation and formulating viable solutions to address the high-risk perceptions related to public transportation use are recommended.

Furthermore, a study by Khaddar and Fatmi (2021) showed that the involvement of daily activities such as shopping, recreational activities, household affairs, and socio-demographic attributes had a significant effect on travel satisfaction during the pandemic. Meanwhile, the results of this analysis indicated that transportation modes like bicycles or walking were used more often because they were more satisfying in this era. A study conducted by Anwari et al. (2021) in Bangladesh showed that the majority of trips still use buses, especially to markets, for recreation, and short distance trips, though the use of this mode for village trips is decreasing.

However, this pandemic may last long because transmission is still occurring and could impact mobility (Moslem et al., 2020). Although not in all areas, population mobility is dynamic because one tends to have many choices, either travel or stay at home. In Indonesia, with various regional characteristics and uneven transportation systems in all regions, mobility is a need because of economic and social demands. Mogaji (2020) stated that limiting the mobility of people in developing countries will be very difficult due to economic demands during the pandemic. Therefore, studying the behavior of people's mobility during this time is necessary.

A study was also conducted by the Research and Development Agency of the Transportation Ministry in collaboration with the Bandung Institute of Technology concerning this issue. According to this study, there was a significant decrease in the mobility of people between and within cities in Indonesia during the social restrictions (Frazila et al., 2020) which impacted the changes in travel behavior. In Jakarta, the congestion index has dropped significantly since social restrictions, causing the city to be excluded from the 2020 list of the top 10 most congested cities in the world (Tomtom, 2021). However, mobility will increases again as the new normal begins (Frazila et al., 2020), though the implementation of health protocols is still mandatory. Within this framework, regulators need to take strategic and anticipatory steps to realize safe and comfortable transportation (Przybylowski et al., 2021).

Furthermore, Ramos et al. (2020) analyzed mobility to reveal that the style is determined by socio-demographic aspects of the environment, political orientation, vehicle ownership, and transportation mode use. The choice of mobility style will influence future policies of urban development that ensure environmental sustainability. Similarly, the household aspect plays an important role in mobility in China, especially because of policies that encourage people to bring the workplace closer to home (Yao and Wang, 2018). According to Litman (2003), mobility-based measurement can be approached through the distance traveled by each person, while accessibility is measured through the ability of people to travel, including the costs, available facilities, and infrastructure involved. Ali et al. (2021), also stated that besides the mobility aspect, considering the accessibility to achieving a comfortable and safe journey is important in the analysis of transportation planning.

The studies above have clearly explained the effect of mobility on the Covid-19 spread and vice versa. Public transportation is under tremendous pressure due to various restrictions, and most studies on mobility during the pandemic have focused on urban areas. However, studies to understand the behavior towards medium and long-distance travel,

which also seems to be one of the causes of Covid-19 spread, are still rare.

Therefore, this study focuses on discussing the behavior towards choosing a mode of transportation for medium and long-distance trips in terms of perceptions of the best and worst choices from some alternatives. This means one mode is considered the best, and some are regarded as the worst. The analysis of options with this approach can provide additional understanding of the mobility model in terms of the choice of transportation mode during the pandemic.

2 METHOD

This study's purpose was to describe a model of mobility behavior based on the choice of transportation mode for medium and long-distance travel via a road trip using a motorized vehicle. Inter-regional mobility data within the Timor Island and the Kupang origin area with the destination areas comprising South Central Timor (SCT), North Central Timor (NCT), Belu, and Malaka districts were used. Travel to SCT was categorized as medium distance, while to NCT, Belu, and Malaka were long distance.

The data was obtained from a disaggregated survey using a questionnaire distributed to respondents, and the simple random sampling technique was used to ensure the 250 people evaluated were selected randomly.

Meanwhile, the questionnaire was related to the use of these transportation modes on out-of-town trips before and during the pandemic. They also concerned the preferences for mode selection for out-of-town travel for those who never went outside the city during the pandemic. The questionnaire comprised the following questions:

A. Before the Pandemic

1. Have you ever traveled outside Kupang City before the pandemic?
2. Where was the longest trip outside Kupang before the pandemic in the Timor region?
3. Please rate the following modes of transportation between 1 – 9 to travel outside Kupang before the pandemic, where 1 indicates 'rarely used' and 9 is the 'most often used.'

B. During the Pandemic

1. Have you ever traveled outside Kupang during the pandemic?
2. Where was the farthest trip outside Kupang during the pandemic within the Timor region?
3. Please rate the following modes of transportation to travel outside Kupang during the pandemic between 1 – 9, where 1 indicates 'rarely used' and 9 is the 'most frequently used.'
4. For those who have never traveled outside Kupang.

Rate the following modes of transportation between 1 – 9 for traveling outside Kupang to SCT, NCT, Belu, or Malacca, where 1 indicates 'rarely to be used,' and 9 is the 'most likely to be used,' during the pandemic to travel outside Kupang.

The choice of transportation assumed to be the best and worst choice was the rarely used mode, using a measurement scale 1 – 9, where 1 states the worst choice and 9 represents the best. Based on the research objectives, the method employed was the best-worst method (BWM) developed by Rezaei (2020) and is used for multi-criteria analysis, though its use for transportation studies is still minimal. Meski demikian, BWM telah digunakan untuk studi dibidang logistik. However, BWM has been used in studies related to logistics transportation. The method can also be used to compare and consider various conflicting criteria in order to determine criteria with the most and the least significant influence (Moeslem et al., 2020; Salimi & Rezaei, 2016). Rezaei, 2015 found that BWM had better performance than the analytical hierarchy process (AHP) for multi-criteria analysis. AHP analysis was based on the comparison between criteria, while BWM went directly to the best option and the worst one. Meanwhile, a study conducted by Moslem et al. (2020) on inner-city travel showed that it can adequately explain the choice of mobility in the city, hence some parts of the Moslem research method were used. However, the focus was on medium and long-distance travel, and a stated preference (SP) analysis was added to the discussion. This study described the preferences of people who have never traveled outside the city during the pandemic.

The stages in data analysis are as follows (Rezaei, 2020):

1. Identify criteria (C) for selecting the type of mobility.
2. Define the best and worst alternative options using a scale of 1 – 9, where 1 indicates the 'least important,' and 9 represents the 'most important.'
3. Evaluate pairwise comparisons for the most important alternative (best)
$$C_b = (C_{b1}, C_{b2,} \ldots\ldots, C_{bn})$$
4. Evaluate pairwise comparisons for the least important alternative (worst)
5. Optimal weight analysis of the most important criteria choice for mobility based on the mode used.
$$C_w = (C_{w1,} C_{w2}, \ldots\ldots C_{wn})$$

Absolute maximum difference:

$$minmax_j \left\{ \left| \frac{W_b}{W_j} - C_{bj} \right|, \left\{ \left| \frac{W_j}{W_w} - C_{wj} \right|, \right\} \Sigma_j^{s.t.} W_j = 1, W_j \geq 0 \right\}$$

The principle of linear programming was used to solve the problem above:

$$min\xi^* s.t \left\{ \left| \frac{W_j}{W_w} - C_{wj} \right| \leq \xi^*, \ \Sigma_j W_j = 1, W_j \geq 0 \right\} \quad (2)$$

3 RESULT AND DISCUSSION

Geographically, the pattern of land travel from Kupang to several district cities in the Timor territory is through one main access called Trans Timor. Figure 1 shows that the main intersection for access to several district cities, namely Soe, Kefamenanu, and Atambua, will be seen after passing through the Kupang district and entering the SCT (Soe) area. Besides being the provincial capital and the center of trade and education, Kupang is also a transit city for people who travel between islands or countries. Therefore, it is a tourist attraction and a travel generator.

Figure 1: Map of Timor Islands (Wikipedia, n.d.).

Transportation between regions within Timor Island mostly uses road transportation for passengers and logistics. Air transportation services are only available on the Kupang – Atambua route. Several public transportation modes that operate are intercity buses, minibuses, and car sharing, with capacities of 22, 9, and 7 passengers, respectively. Most buses and minibuses serve the Kupang to Soe, Kefamenanu, Atambua, and Betun routes. Meanwhile, car sharing mostly serves the Kupang to Soe and Malaka routes and has grown rapidly after road access to several district cities has increased significantly.

The survey data in Table 1 shows the majority of the farthest travel destination for respondents before the pandemic was Soe, and the nearest was Kefamenanu. Generally, the number of respondents who traveled the furthest to Malaka and Belu was not much different from before the pandemic. The distance to Soe, Kefamenanu, Atambua, Malaka is approximately 110 Km, Kefamenanu 200 Km, 280 Km, and 255 Km, respectively. Meanwhile, the reason respondents traveled out of town most often was for family matters, while the least was tourism and so on.

Table 1: Responden characteristics.

Respondent characteristics	Proportion
Age	
1. < 20 Year	22%
2. 20 – 30 Year	31%
3. 30 - 40 Year	33%
4. 40 - 50 Year	8%
5. > 50 Year	5%
Profession	
1. PNS/TNI/POLRI	22%
2. Entrepreneur	30%
3. Student	17%
4. Others	31%
Income	
1. < IDR 1 million	45%
2. > IDR 1 million – IDR 2.5 million	11%
3. > IDR 2.5 million – 5 million	23%
4. > IDR 5 million – 7.5 million	17%
5. > IDR 7.5 million	4%
The furthest trip out of town before the pandemic	
1. Soe	34%
2. Kefamenanu	8%
3. Atambua	30%
4. Malaka	28%
Reasons to travel before the pandemic	
1. Work	14%
2. Back to hometown	31%
3. Family Affairs	44%
4. Tour	6%
5. Others	5%
The furthest trip out of town during the pandemic	
1. Soe	29%
2. Kefamenanu	11%
3. Atambua	22%
4. Malaka	17%
5. Never yet	21%
Reasons to travel during a pandemic	
1. Work	11%
2. Back to hometown	36%
3. Family Affairs	30%
4. Tour	2%
5. Others	21%

However, there was a change in the percentage of destination areas during the pandemic, as respondents who traveled to Soe City were more dominant, though the percentage was smaller than before Covid-19. About 21% of the respondents did not travel outside the city during the pandemic, while the reason for travel was majorly for family matters and return to hometown.

The respondent's choice of transportation mode before and during the pandemic changed based on the assessment of the available modes, namely buses, cars, motorcycles, minibuses, and car sharing. Respondents gave an assessment of 1 to state the most frequently used and 9 to state the rarely used. Table 2 shows the analysis of their responses using a matrix comparison where the best and worst modes were compared to other transportation choices. From this comparison, the consistency of the respondents' answers < 0.1 was considered eligible.

The following is an example of analysis for one respondent.

In the analysis example, the best choice was a bus, and the worst was a motorcycle. The results in Table 2, which are the output of the analysis based on the algorithm developed by Rezazai, showed that the consistency value (Ksi) was 0.07 < 0.1, meaning the respondent's answer met the requirements.

Table 2: Pairwise Comparisons between the Modes of Transportation.

Criteria Number = 5	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Names of Criteria	Bus	Car	Motorcycle	Minibus	Car Sharing
Select the Best	Bus				
Select the Worst	Motorcycle				
Best to Others	Bus	Car	Motorcycle	Minibus	Car Sharing
Bus	1	5	8	5	2
Worst to Others	Motorcycle				
Bus	8				
Car	2				
Motorcycle	1				
Minibus	2				
Car Sharing	7				
Weights	Bus	Car	Motorcycle	Minibus	Car Sharing
	0.46568627	0.1078431 4	0.0490196	0.1078431	0.2696078
Ksi*	0.07352941				

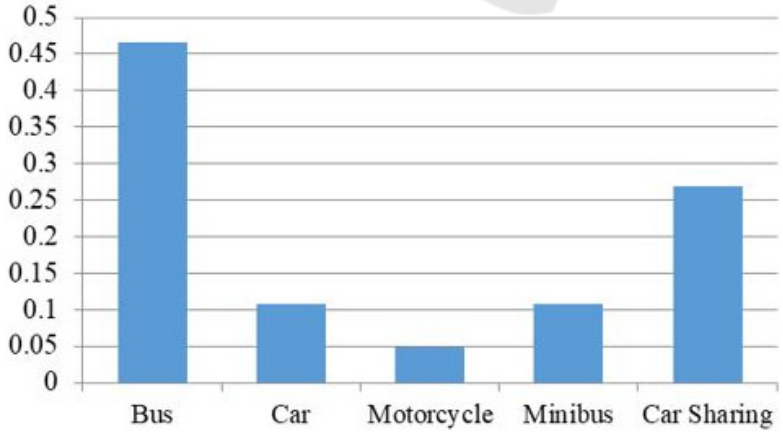

Figure 2: Average Weight of the Mode of Transportation used before the Pandemic from one respondent.

Consequently, the weighted output in Table 2 shows the ranking level of each transportation mode. Figure 2 shows that the 1st rank was the mode of transportation with the largest weights, while the 5th rank had the smallest, meaning buses are the main choice and motorbikes are the most frequently used option.

All the respondents' answers before and after the pandemic were analyzed, including the mode selection preferences for those who will travel out of town during the pandemic. After the analysis, the next step was to determine the total weight, which was the average of the overall value for each mode of transportation. Figure 3 shows the bus weights were more, making them the best choice or the top rank, while the motorbikes were the least, thereby becoming the worst choice or lowest ranking. Conversely, cars were placed 2nd place, while minibuses and car sharing were balanced in weight.

During the pandemic, the mode of transportaion for mobility outside Kupang city to several areas in Timor showed a change. Figure 4 illustrates the change during the pandemic, where buses were no longer a priority choice. Car sharing was the best choice for traveling outside this city, followed by minibus, while the car weights were slightly above the motorbike, and the lowest was the bus.

Finally, an analysis of the mobility choices of the respondents who had never been out of town during the pandemic was conducted. Figure 5 shows the best choice to travel outside the city is car sharing, followed by the car, minibus, and motorbike, while the last option is the bus.

This study found that there was a change in choosing transportation modes before and during the pandemic. Although the high use of buses before the pandemic could be due to the affordable fares and adequate availability, the users and operators tended

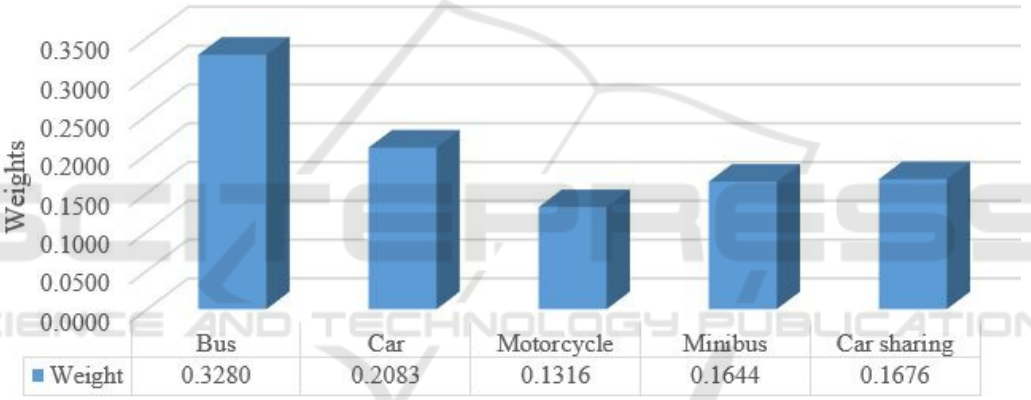

Figure 3: Average Final Weight of the Mode of Transportation used before the Pandemic.

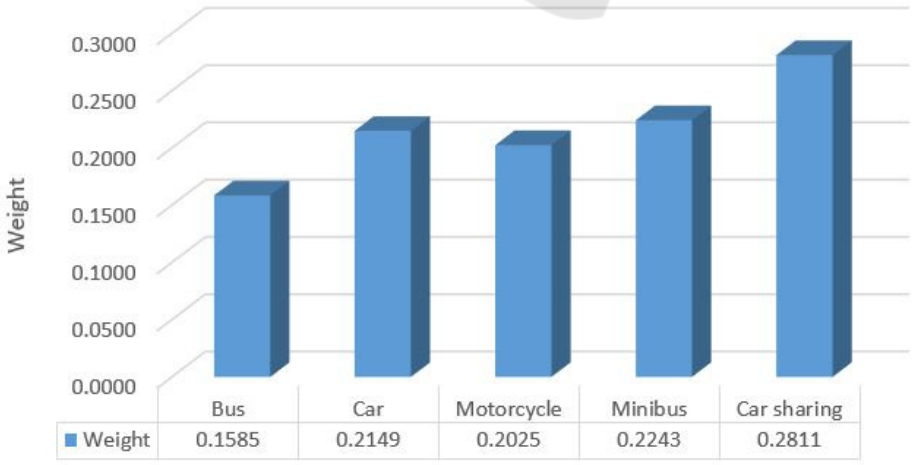

Figure 4: Average Final Weight of Transportation Modes used during the Pandemic.

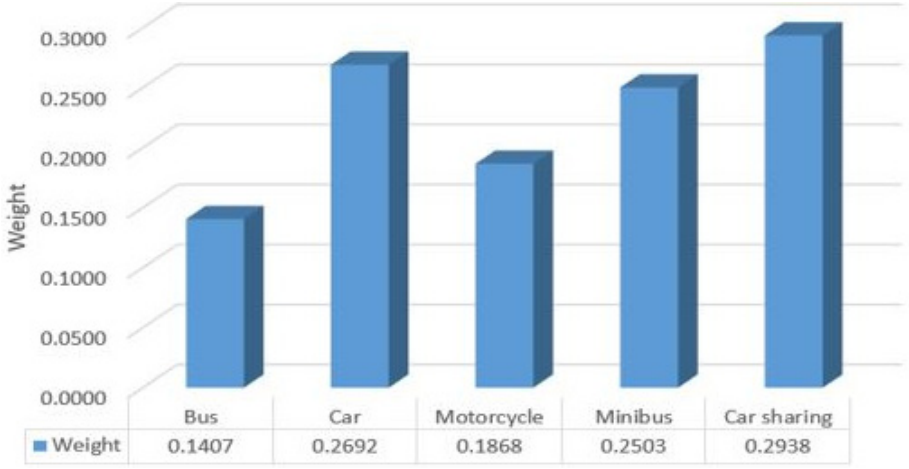

Figure 5: Average Final Weight of the Transportation Modes used when Traveling Out of Town during the Pandemic.

to ignore or neglect the demands for health care standards. According to the study by Moslem et al. (2020) involving short distances, many people switched to walking and using cars during the pandemic even though car use before Covid-19 was quite high. In another study, (Burgdorf, Mönch, & Beige, 2020) found that most long-distance trips were on the road using buses, then trains, and rarely planes.

According to the results, the use of car sharing during the pandemic was higher than buses. Likewise, the mode most often used was car sharing for those who had never been out of town. Car sharing is a relatively new transportation service for long-distance travel in Timor, whose use is growing due to poor bus services, such as lateness and longer trips due to frequent stops. It is also a solution to overcome the use of private vehicles, according to Hui et al. (2019). Ferrero et al. (2018) stated that the main principle of car sharing was using private vehicles together with other persons going to the same destination, associated with door-to-door service. This method provides convenience for users. However, Chapman et al. (2020) found that this service on inner-city trips is attractive to those who have cars, though they cannot be sure that the transportation mode can reduce car use.

Meanwhile, the problem faced was that the inability to properly control the growth of car sharing creates unfair competition between its existence and bus operations at the local level. The first obstacle is that the absence of clear local regulations regarding car sharing operations. Second, there is no travel insurance guarantee that can cope with accidents because the vehicle-operating license is for personal use, not public transportation. Therefore, the first step is to make clear car sharing regulations concerning ownership, operations, and routes to ensure healthy competition with other public transportation modes. The application of these regulations can be similar to the minibus, which has a capacity of 9 passengers.

Furthermore, an equally important factor is the need for efforts to improve intercity bus services, especially regulating passenger capacity, cleanliness, and adherence to health protocols.

4 CONCLUSIONS

This study produced an overview of the mode choice behavior before and after the pandemic, and the results showed a change in the pattern of mobility concerning the choice of transportation mode. This finding shows the vulnerability of long-distance travellers to the spread of Covid-19 virus. These travellers are recommended to choose transportation modes with the lowest risk of transmission. Car sharing is more often used to travel long distances within the Timor region, while minibuses, with a 9-passenger capacity, were in second place. Although car sharing and minibuses are still categorized as public transportation, they are not for mass transportation. These results indicate that buses were used the least for inter-city travel during the pandemic, and this finding necessitates the attention of policymakers to improve the performance and use of bus services. Furthermore, passenger capacity can be concluded to be a factor that can influence the choice of public transportation modes for mobility.

Therefore, passenger capacity and its relationship to public transportation use during the pandemic, including the improvement of intercity bus services, can be studied in the future.

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