

Service quality of transit and demand-supply forecasting for ride-hailing in the Jakarta Greater Area, Indonesia

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ABSTRACT

The extensive use of smartphones by individuals has led innovators to develop application-based transportation services. Ride-hailing systems have been extensively operated in more than 600 cities worldwide. With the competition between taxis and ride-hailing, the number of fleets must be regulated. Identifying factors that influence the demand of taxi and ride-hailing and how the quality transit service is very important. The aims of this research are to identify the factors that influence demand for taxis and ride-hailing and the service quality of taxis and ride-hailing service. The study identified socio-demographic and trip characteristics from 949 respondents in the Jakarta Greater area, Indonesia. Respondents interviewed about the waiting time, travel time and travel costs for the origin-destination of trips that are most often done using taxi, ride-hailing, and bus. The service quality of ride-hailing and taxi was analyzed based on the respondent's preferences from an important-performance analysis survey. The forecasting demand of taxi and ride-hailing in the Jakarta Greater area using demand-supply model is 71,660 vehicles. The research findings are that service quality of ride-hailing is better than conventional taxis based on waiting time, travel time and travel cost variable.

Key words: Ride-hailing; Taxi; Travel behavior; Demand-supply; Service attribute.

INTRODUCTION

Application of information and communications technology (ICT) is widely used in the transport sector (Csiszár & Földes, 2015; Circella & Mokhtarian, 2017). The emergence of new technologies in transportation systems has greatly impacted personal mobility. One of the

applications of ICT in transportation is the ride-hailing system, which expanded their operation to more than 600 cities worldwide (Kim et al., 2017). Ride-hailing services are distinguished from traditional mobility options, they match passengers to the nearest driver using specific algorithms (Rayle et al., 2016). The impact after ride-hailing service entered urban mobility, the number of passenger conventional taxis decreased. In New York City, conventional taxi rides reduced 25% per hour and taxi passengers decreased by 16 million passengers (Brodeur & Nield, 2018). Uber is a complement for the average transit agency, increasing ridership by 5% (Hall et al., 2018). Approximately one third of public transportation trips are potentially transferred to ride-hailing service (Oviedo et al., 2020).

The development of the demand model for transit developed after the operation of ride-hailing in several major cities in early 2010. In a previous study, six factors determine the number of taxi pickups and drop-offs: transit access time, population size, median age, percent of population educated beyond bachelor's degree, income per capita, and number of employment opportunities (Gonzales et al., 2014). Chang et al. (2010) using clustering algorithms to predict taxi demand distributions. Moreira-Matias et al. (2012) applied time series techniques to forecast taxi passenger demand. Gong et al. (2016) proposed a machine learning model to predict the number of taxis. Most of these efforts have focused on taxi trip demand, whereas the studies on ride-hailing service demand prediction have been relatively limited.

The aims of this research are to identify the factors that influence demand for taxis and ride-hailing and the quality of taxis and ride-hailing service. The novelty of this research is the development of a demand model for the number of taxis and ride-hailing using demand-supply approach and service quality of transit using importance-performance analysis (IPA).

METHODOLOGY

STUDY AREA AND RESEARCH STAGE

Location of the study in the Jakarta Greater area, Indonesia consists of nine regions, namely Jakarta Special Province, Bogor City, Bogor Regency, Depok City, Tangerang City, Tangerang

Regency, South Tangerang City, Bekasi City, and Bekasi Regency. The stages of the research are as follows: literature review, questionnaire design, collecting data, survey (household travel survey, service quality, demand-supply attribute, and importance-performance analysis/IPA, analysis data (IPA of taxi and IPA of ride-hailing, demand supply forecasting, modeling taxi and ride-hailing demand, sensitivity model). The stages of the research can be seen in Figure 1.

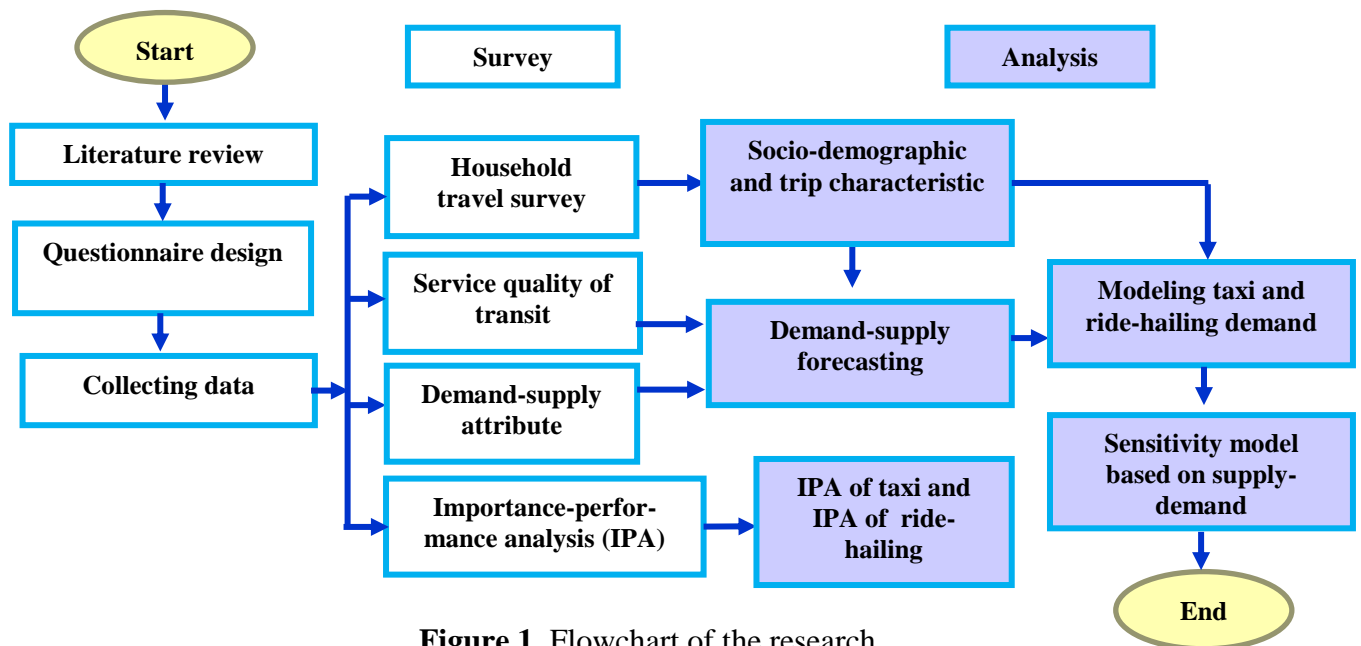


Figure 1. Flowchart of the research.

HOUSEHOLD SURVEY

The study identified socio-demographic and trip characteristics of the sample, a total of 949 respondents, 519 respondents for trip characteristics, 430 respondents for IPA. The socio-demographic includes gender, age, level of education, employment status, monthly income, and respondent's domicile. Trip characteristics include reasons to travel and frequency of use of mode. The study includes a comparison of travel time, travel cost and waiting time by taxi and ride-hailing for specific trips to the origin-destination of trips that are most often done.

IMPORTANCE-PERFORMANCE ANALYSIS

IPA was introduced by Martilla and James in 1977 as a method for analyzing business strategies. Since its origins, the IPA has been applied in different areas. Data on the service performance and level of importance of taxi is obtained from 220 respondents while for the ride-hailing from 210 respondents. The mean performance rating and mean importance rating

as a barrier between the quadrants in the Cartesian diagram. There are four possible locations for service attributes, namely quadrant I is concentrated here, quadrant II is to keep up the good work, quadrant III is low priority, or quadrant IV is possible overkill. Evaluation of the level of service for taxis is prepared referring to the Regulation of the Minister of Transportation Republic of Indonesia PM Number 44 of 2019. Evaluation of ride-hailing service is prepared referring to the Regulation of the Minister of Transportation Republic of Indonesia PM Number 17 of 2019. Six indicators studied were security, safety, comfort, affordability, equality, and regularity. For the taxi, six indicators were divided into 39 sub-indicators while for the ride-hailing were divided into 30 sub-indicators. Rating for importance obtained from a five-point Likert scale ranging from very unimportant (1) to very important (5). Rating for performance obtained from a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5) (Rial et al., 2008).

DEMAND-SUPPLY MODEL

New traffic assignment model based on the concept of shortest path betweenness centrality measure (Sugiyanto et al., 2016), hub and spoke network (Sugiyanto et al., 2020) borrowed from the domain of complex network analysis (Puzis et al., 2013). One of the fields most influenced by this evolving research thrust was the data-driven study of human mobility and its potential application for intelligent transportation systems (Altshuler et al., 2015). Demand of ride-hailing systems was expressed as a function of a variety of demographic, land use, and environmental factors (Gerte et al., 2018). In this research, the demand-supply model uses a calculation variable consisting of seven parameters: number of trips per day, percentage of mode share, average vehicle occupancy factors for taxi and ride-hailing, number of operating, waiting time of passenger, travel time, and waiting of the driver to find users. The calculation of taxi and ride-hailing demand based on the demand-supply model using equation 1.

$$N = \frac{\sum \text{Trips per day} \times MS}{AVO} \times \frac{WT_{pass} \times WT_{driver} \times TT}{\sum \text{Operating hours per day}} \quad (1)$$

Where:

N = transit demand (vehicle units).

\sum Trips per day = the number of trips for passenger travel per day (trips/day).

MS = percentage of mode share for taxi and ride-hailing transport service (%).

AVO = average vehicle occupancy factors for taxi and ride-hailing (passengers per vehicle).

\sum Operating hours/day = number of operating hours from taxi or ride-hailing per day (hours).

WT_{Pass} = waiting time of passengers is the maximum tolerance of waiting time for passengers who order a taxi or ride-hailing (hours).

WT_{driver} = waiting time driver to find passengers (hours).

TT = travel time is distance from origin to destination location divided by speed (hours).

RESULTS AND DISCUSSION

HOUSEHOLD TRAVEL SURVEY RESULT

Based on the household travel survey result from 949 respondents, the profile of respondents are at most 37-42 years old, 317 respondents followed by 32-37 years old, 249 respondents. Taxi and ride-hailing users are generally consumers who have worked for several years so that they have the ability to pay for taxis and ride-hailing tariff relatively more expensive than public transport. Male taxi users tend to be more populated than women, 54.50% versus 45.50%. Based on the education level the most was at the undergraduate level 465 respondents followed by diploma programs 235 respondents, senior high school 162 respondents. Based on the monthly income of respondents, the most was at IDR7-9 million/month as much as 286 respondents, followed by IDR3-5 million/month, 240 respondents; IDR5-7 million/month, 230 respondents. Most of respondents use motorcycles (29.76%), followed by ride-hailing (17.64%), private cars (12.20%), city transport (11.55%), taxi (10.89%), commuter line (8.82%), BRT TransJakarta (6.66%). The number of respondents as many as 949 people traveled a total of 10,380 trips in a week. Motorcycles are the most frequently used mode, 3089 trips/week of the total trips of all respondents followed by ride-hailing as much as 1831 trips/week followed by private cars 1266 trips/week. The use of taxis, respectively, is 1130 trips per week. The trip characteristics and reasons to travel are at work as much as 191

respondents (36.80%), followed by others (22.93%), and business (19.65%). The socio-demographic and trip characteristics of the sample can be seen in Table 1.

Table 1. Socio-demographic and trip characteristics of the sample (N = 949).

| Characteristics | Description of variable | Frequency | Percent (%) |
|--|---------------------------------------|-----------|-------------|
| Socio-demographic characteristics | | | |
| Gender | Male | 517 | 54.50 |
| | Female | 432 | 45.50 |
| Age (years old) | 17-22 | 32 | 3.37 |
| | 22-27 | 43 | 4.53 |
| | 27-32 | 174 | 18.34 |
| | 32-37 | 249 | 26.24 |
| | 37-42 | 317 | 33.40 |
| | 42-47 | 90 | 9.48 |
| | 47-52 | 31 | 3.27 |
| | 52-57 | 7 | 0.74 |
| | 57-62 | 5 | 0.53 |
| | 62-67 | 1 | 0.11 |
| Level of education | Junior high school | 8 | 0.84 |
| | Senior high school | 162 | 17.07 |
| | Diploma program (D1, D2, D3, and D4) | 235 | 24.76 |
| | Undergraduate degree (S1) | 465 | 49.00 |
| | Master's and PhD (S2, S3) | 79 | 8.32 |
| Employment status | Student/College student | 39 | 4.11 |
| | Government employees/Soldier/Police | 95 | 10.01 |
| | Private employees/ BUMN | 435 | 45.84 |
| | Teachers/Lecturers/Academic | 98 | 10.33 |
| | Entrepreneurship | 84 | 8.85 |
| | Housewife | 67 | 7.06 |
| | Others | 131 | 13.80 |
| Monthly income (in million IDRs) | 3-5 | 240 | 25.29 |
| | 5-7 | 230 | 24.24 |
| | 7-9 | 286 | 30.14 |
| | 9-12 | 106 | 11.17 |
| | 12-15 | 44 | 4.64 |
| | 15-20 | 10 | 1.05 |
| | 20-25 | 7 | 0.74 |
| | 25-30 | 4 | 0.42 |
| | > 30 | 22 | 2.32 |
| Respondent's domicile | Jakarta Special Province | 315 | 33.19 |
| | Bogor City | 37 | 3.90 |
| | Bogor Regency | 140 | 14.75 |
| | Depok City | 82 | 8.64 |
| | Tangerang City | 71 | 7.48 |
| | Tangerang Regency | 103 | 10.85 |
| | South Tangerang City | 67 | 7.06 |
| | Bekasi City | 71 | 7.48 |
| | Bekasi Regency | 63 | 6.64 |
| Trip characteristics | | | |
| Reasons to travel (519 respondents) | Be at work | 191 | 36.80 |
| | Study (to school, campus, university) | 8 | 1.54 |
| | Business | 102 | 19.65 |
| | Tour (traveling) | 19 | 3.66 |
| | Shopping | 38 | 7.32 |
| | Family needs | 42 | 8.09 |
| | Others | 119 | 22.93 |
| Frequency of use of mode (trips per week) | Motorcycles | 3089 | 29.76 |
| | Private cars | 1266 | 12.20 |

| | | |
|---------------------------------------|------|-------|
| Taxi | 1130 | 10.89 |
| City transport | 1199 | 11.55 |
| Ride-hailing (Grab, GoCar) | 1831 | 17.64 |
| Bus Rapid Transit (BRT) Trans Jakarta | 691 | 6.66 |
| Commuter line | 915 | 8.82 |
| Light Rail Transit | 81 | 0.78 |
| Mass Rapid Transit | 178 | 1.71 |

SERVICE QUALITY OF TRANSIT

Three parameter in service quality of taxi, ride-hailing and bus include waiting time, travel time and travel costs. A comparison of waiting time, travel time and travel costs for 519 respondents when asked about these trips that are most often done. The average waiting time of taxi is 10.57 minutes and 9.08 minutes for ride-hailing. Average travel time of taxi is 41.54 minutes, 38.87 minutes for ride-hailing, and 59.45 minutes for bus. The average travel cost for taxi is IDR67,842 per trip, IDR56,940 per trip for ride-hailing, and IDR30,697 per trip for bus. Waiting time of ride-hailing users faster 14.08% than taxi. Travel time with ride-hailing is 2.66 minutes lower than taxi (6.41% faster than travel time by taxi). In terms of travel costs, using a ride-hailing is cheaper than using a taxi. An average travel cost for ride-hailing is IDR56,940 pertrip, taxi IDR67,842 per trip, and bus IDR30,697 per trip. Average travel costs per trip for ride-hailing is IDR10,901 cheaper than taxi (16.07%). Average travel cost per trip using the bus is cheaper than ride-hailing and taxis. This result is similar with study Alonso et al. (2018), waiting time is the most important factor for frequent users and journey time is highly valued by almost all users, followed by accessibility and comfort. This result is similar with study Wang and Ross (2019) which discuss about the relationship between taxi and transit in New York. Transit-extending taxi trips have significantly shorter average trip lengths and larger proportions of people paying with cash than other trip types. Amount 15% of the taxi fleet can serve 98% of the demand within average waiting time 2.8 minutes (Alonso-Mora et al., 2017).

IMPORTANCE-PERFORMANCE ANALYSIS (IPA)

A. IPA of taxi

IPA results of taxi users for 39 service attributes can be seen in Table 2 and plotted into an IPA matrix, as shown in Figure 2. Mean performance rating is 3.18 and mean importance rating is 3.77. Gap analysis is mean importance rating minus (-) mean performance rating.

Table 2. Importance-performance ratings for taxi service of the sample (N = 220).

| Attribute code | Service attribute | Mean importance rating | Mean performance rating | Gap analysis |
|----------------|---|------------------------|-------------------------|--------------|
| A. | Security (11 attributes) | | | |
| 1 | Availability of driver's identity | 3.80 | 2.91 | 0.89 |
| 2 | Driver's identification card | 3.51 | 3.10 | 0.41 |
| 3 | Customer service | 3.73 | 3.03 | 0.70 |
| 4 | Availability of hazard lights | 3.53 | 2.92 | 0.61 |
| 5 | A set of communication tools | 3.67 | 3.01 | 0.66 |
| 6 | Vehicle identity: taxi trademark | 3.55 | 3.20 | 0.34 |
| 7 | Vehicle identity: serial number | 3.62 | 3.23 | 0.39 |
| 8 | Taxi service complaint telephone number | 3.76 | 3.22 | 0.54 |
| 9 | Door lock buttons | 3.90 | 3.20 | 0.70 |
| 10 | Darkest window film maximum 40% | 4.08 | 3.66 | 0.42 |
| 11 | Availability of a taxi sign | 3.44 | 3.19 | 0.25 |
| B. | Safety (16 attributes) | | | |
| 12 | Driver physically and mentally healthy | 4.65 | 3.86 | 0.78 |
| 13 | Drivers have competencies | 3.89 | 3.33 | 0.56 |
| 14 | Drivers rest 15 minutes after driving 2 hours. | 3.58 | 3.24 | 0.34 |
| 15 | Availability of first aid kit box | 3.79 | 3.12 | 0.66 |
| 16 | Availability of vehicle speed controllers | 4.00 | 3.10 | 0.89 |
| 17 | The front tires are not allowed to use retread tires | 3.47 | 3.09 | 0.38 |
| 18 | Availability of a glass beater/breaker: hammer on window | 3.99 | 3.02 | 0.97 |
| 19 | Availability of light fire extinguishers | 3.97 | 3.02 | 0.95 |
| 20 | Electrical for audio visual | 3.51 | 3.06 | 0.45 |
| 21 | Safety belt at least 2 points | 3.60 | 3.20 | 0.40 |
| 22 | Global Positioning System/GPS | 4.11 | 3.23 | 0.88 |
| 23 | Flashlight as a lighting aid | 3.30 | 3.04 | 0.27 |
| 24 | Traffic accident insurance | 4.63 | 3.37 | 1.26 |
| 25 | Check vehicle worthiness | 3.49 | 3.15 | 0.34 |
| 26 | Maximum age of vehicle 10 (ten) years | 3.50 | 3.20 | 0.29 |
| 27 | Maintenance facilities (pool) | 3.83 | 3.22 | 0.60 |
| C. | Convenience (5 attributes) | | | |
| 28 | Driver understand area of operation | 3.82 | 3.17 | 0.64 |
| 29 | Driver and passengers can communicate | 3.70 | 3.42 | 0.27 |
| 30 | Driver expected to understand SOP taxi service ethics | 4.10 | 3.37 | 0.73 |
| 31 | Air controllers, temperature in vehicle is 20-22 ^o C | 3.98 | 3.30 | 0.68 |
| 32 | Sticker "No Smoking" | 3.44 | 3.18 | 0.26 |
| D. | Affordability (2 attributes) | | | |
| 33 | Taxi service minimum 12 hours all cities | 3.69 | 3.17 | 0.52 |
| 34 | Accessibility makes it easy for passengers to get services | 3.73 | 3.15 | 0.58 |
| E. | Equality (2 attributes) | | | |
| 35 | Priority service getting on/off for people with disabilities | 3.88 | 3.07 | 0.81 |
| 36 | Special space in the trunk for wheelchair storage | 3.55 | 3.04 | 0.51 |
| F. | Regularity (3 attributes) | | | |

| | | | | |
|----|--|-------------|-------------|-------------|
| 37 | Information basic rates, waiting, distance rates | 3.80 | 3.07 | 0.73 |
| 38 | Taximeter is functioning properly | 3.68 | 3.14 | 0.54 |
| 39 | Time of operation or service of people transport by taxi | 3.75 | 3.13 | 0.62 |
| | Average | 3.77 | 3.18 | 0.59 |

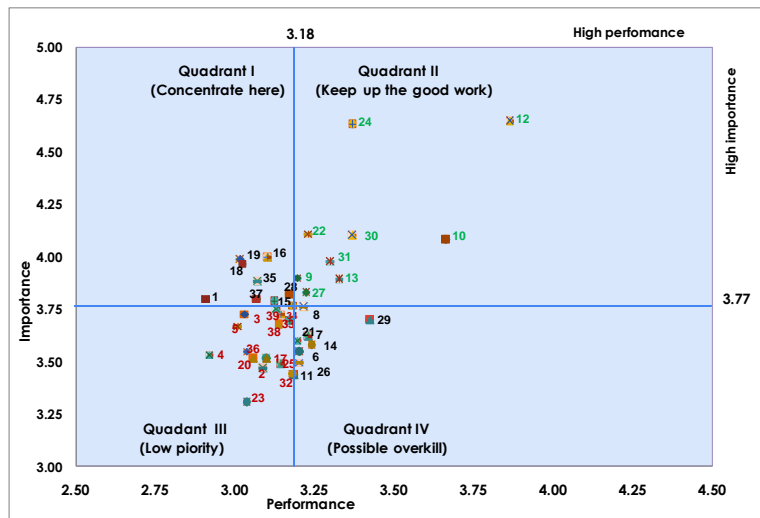


Figure 2. Taxi service levels based on importance-performance analysis.

Based on Figure 2, from 39 service attributes of taxi, 8 attributes are located in quadrant I, namely attribute no.1, 15, 16, 18, 19, 28, 35, and 37. Eight attributes should be given top priority because they are considered very important for taxi users. Nine attributes are located in quadrant II, namely attribute no.9, 10, 12, 13, 22, 24, 27, 30, and 31. These nine attributes must be managed properly by the taxi company. In quadrant III there are 14 attributes, namely attribute no.2, 3, 4, 5, 17, 20, 23, 25, 32, 33, 34, 36, 38, and 39. These fourteen attributes fall into low priority and must be managed and improved in service. In quadrant IV there are 8 attributes, namely attribute no.6, 7, 8, 11, 14, 21, 26, and 29. Eight service attributes can be reduced in service so that taxi companies can save costs.

B. IPA of ride-hailing services

The IPA results and expectations of ride-hailing users for 30 service attributes can be seen in Table 3 and Figure 3. Mean performance rating is 3.21 and mean importance rating is 3.84.

Table 3. Importance-performance ratings for ride-hailing service of the sample (N = 210).

| Attribute code | Service attribute | Mean importance rating | Mean performance rating | Gap analysis |
|----------------|--------------------------------------|------------------------|-------------------------|--------------|
| A. | Security (4 attributes) | | | |
| 1 | Identity of service users who orders | 3.82 | 2.87 | 0.95 |
| 2 | Availability of driver's identity | 3.71 | 3.02 | 0.69 |

| | | | | |
|-----------|---|-------------|-------------|-------------|
| 3 | Security disturbance information | 4.11 | 3.19 | 0.93 |
| 4 | Darkest window film maximum 40% | 4.28 | 3.51 | 0.77 |
| B. | Safety (11 attributes) | | | |
| 5 | Driver physically and mentally healthy | 4.66 | 3.73 | 0.93 |
| 6 | Driver has the competence | 4.38 | 3.44 | 0.94 |
| 7 | Maximum working for driver is 8 hours | 3.42 | 3.18 | 0.23 |
| 8 | Drivers rest 30 minutes after driving vehicle every 4 hours | 3.56 | 3.14 | 0.42 |
| 9 | Availability of flashlights or lighting aids | 3.38 | 3.03 | 0.34 |
| 10 | Availability of first aid kit in case of accident | 4.26 | 3.31 | 0.95 |
| 11 | Availability of a light fire extinguisher in the vehicle | 4.22 | 3.19 | 1.03 |
| 12 | Availability of safety belts at least 2 points | 3.53 | 3.20 | 0.33 |
| 13 | Checks the vehicle to be operated | 3.47 | 3.13 | 0.33 |
| 14 | Traffic accident insurance | 4.37 | 3.31 | 1.06 |
| 15 | Maximum age of vehicle is 5 years | 3.46 | 3.12 | 0.33 |
| C. | Convenience (10 attributes) | | | |
| 16 | Number of passengers according to the carrying capacity | 3.55 | 3.20 | 0.35 |
| 17 | Driver doesn't bring other than passenger who book | 3.77 | 3.19 | 0.58 |
| 18 | Availability of an AC, the highest air temperature is 25°C | 3.86 | 3.10 | 0.75 |
| 19 | Availability of baggage | 3.50 | 3.38 | 0.12 |
| 20 | Availability of cleanliness facilities | 4.05 | 3.30 | 0.75 |
| 21 | The driver wears modest clothing | 4.28 | 3.48 | 0.80 |
| 22 | Driver behavior is friendly and polite | 4.29 | 3.42 | 0.87 |
| 23 | Audio visual facilities in passenger room | 3.56 | 3.19 | 0.37 |
| 24 | Availability of cell phone battery charging facilities. | 3.48 | 3.05 | 0.43 |
| 25 | Sticker "No Smoking" | 3.48 | 3.10 | 0.38 |
| D. | Affordability (2 attributes) | | | |
| 26 | Accessibility: services according to the route listed | 3.72 | 3.15 | 0.57 |
| 27 | Applying rates according to upper and lower limit rate | 3.76 | 3.16 | 0.60 |
| E. | Equality (2 attributes) | | | |
| 28 | Priority service getting on or off for disabilities. | 3.71 | 3.07 | 0.64 |
| 29 | Accessibility facilities for people who have disabilities. | 3.73 | 3.05 | 0.68 |
| F. | Regularity (1 attribute) | | | |
| 30 | Service time according to the order | 3.73 | 3.12 | 0.60 |
| | Average | 3.84 | 3.21 | 0.63 |

Based on Figure 3, from 30 ride-hailing service attributes, 3 attributes are located in quadrant I, namely attribute no.3, 11, and 18. Three attributes should be given top priority by service providers because they are considered very important for ride-hailing users. Eight attributes are located in quadrant II, namely attribute no.4, 5, 6, 10, 14, 20, 21, and 22. These eight attributes should continue to be properly managed by a ride-hailing company. In quadrant III there are 18 attributes, namely attribute no.1, 2, 7, 8, 9, 12, 13, 15, 16, 17, 23, 24, 25, 26, 27, 28, 29, and 30. The eighteen attributes fall into low priority and must be managed and improved in service. In quadrant IV, only one attribute no. 19 can be reduced to save operation costs.

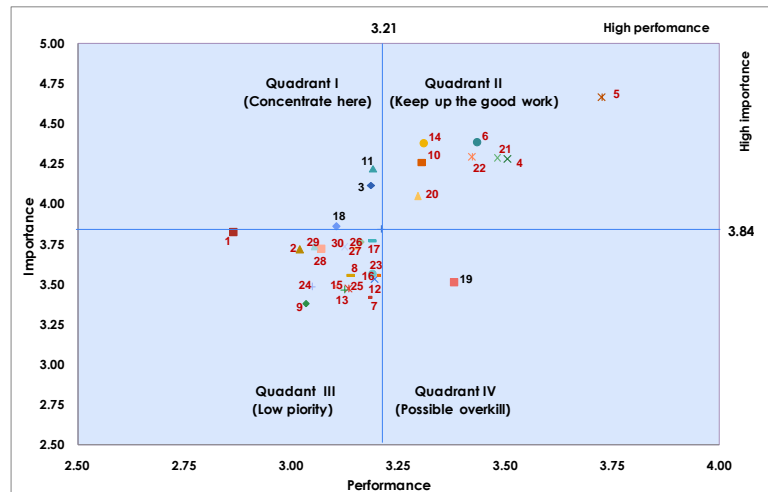


Figure 3. Ride-hailing service levels based on importance-performance analysis.

DEMAND-SUPPLY FORECASTING

Seven parameters are used to forecast taxi and ride-hailing service demand. Each parameter value based on transportation user survey in the Jakarta Greater area in July 2020 is as follows.

1. The number of trips per day based on data from the origin-destinations survey of national transportation for passengers in Indonesia in 2018. The number of trips for passengers in the Jakarta Greater area in 2018 was 62,397,792 trips per day (Ministry of Transportation, 2018). Using the assumption of a growth rate of 5% per year, it is estimated that trips per day for all transportation modes in 2019 will be 65,517,682 trips/day.
2. Percentage of mode share for taxi and ride-hailing in the Jakarta Greater area is 1.75%.
3. Average vehicle occupancy factors are assumed to be filled with 2 passengers per vehicle.
4. Number of operating hours per day based on the survey varies from 12-24 hours. In this case, taking into account the traffic safety and driver physical condition, operating hours are 16 hours with 2 drivers (each driver works eight hours per day).
5. Waiting time of passengers is the time tolerance for customer waiting. Using data from the survey results, the average user getting a taxi is 10.57 minutes and ride-hailing service is 9.08 minutes. The number of taxis in the Jakarta Greater area in July 2020 was 17,268 units and ride-hailing was 33,133 units. The average waiting time of passengers for taxi and ride-hailing service is calculated based on the comparison of the number of fleets and waiting times for taxis and ride-hailing service, obtained at 0.1598 hour.

6. Average travel time by taxi and ride-hailing is 38.87 minutes for ride-hailing and 41.54 minutes for taxi. Average travel time for taxi and ride-hailing is 0.6631 hour.
7. Waiting time driver. The time it takes to get passengers from the driver's side is determined based on the results of an interview survey of taxi and ride hailing companies. The information obtained is the number of vehicle trips per day and operating time per day. Number of trips per day varies with the range of 7-8 trips/day. Number of operating hours per day is 16 hours and the number of trips is 8 trips/day. Average waiting time from passengers is 9.591 minutes and the average travel time for taxi and ride-hailing service users is 39.785 minutes. Waiting time for the driver to find a passenger is 1.1770 hours.

Based on the value of each parameter, using equation 1, calculations of the taxi and ride-hailing demand in the Jakarta Greater area is 71,660 vehicles. Significant variables in the calculation are the number of operating hours per day, number of trips per day, waiting time and travel time. The fares of Transmilenio was reduced and implemented fare discrimination between peak hours and off-peak hours to balance the daily demand distribution in the BRT system (Guzman et al., 2018). Çam and Sezen (2020) using vehicle routing problems to minimize the total idle time. Another study by Giri and Dey (2020) using a closed-loop supply chain with stochastic demand. Zhang et al. (2019) using a dual-channel retailer to identify whether the strategy is beneficial for improving retailer's market share.

MODELING TAXI AND RIDE-HAILING DEMAND

In this research, the demand of taxis and ride-hailing services is forecast using the demand-supply model. There are seven factors that influence the demand on taxi and ride-hailing: number of trips per day, average vehicle occupancy factors, percentage of mode share, number of operating hours per day, waiting time of passengers, travel time, and waiting for the driver to find users. As mentioned by Gerte et al. (2018), the demand of ride-hailing systems was expressed as a function of a variety of demographic, environmental factors, and land use. The demand of taxis and ride-hailing service is compared with the number of transit services in July

2020. The number of taxis in the Jakarta Greater area in July was 17,268 vehicle units and the number of ride-hailing was 33,133 vehicles, a total 50,401 vehicles. Percentage of mode share for taxis and ride-hailing is variation from 1.1 to 2% to know the sensitivity of this variable. If the number percentage of mode share for taxi and ride-hailing services is 1.1%, the number of taxi and ride-hailing services is 45,043 vehicles. Percentage of mode share 1.2% gets the number of taxi and ride-hailing 49,138 vehicle units. For the value percentage of mode share more than 1.3%, the forecasting demand of taxi and ride-hailing services is more than the number in existing condition (50,401 vehicles). Demand of taxi and ride-hailing service based on percentage of mode share variation from 1.1 to 2.0% is shown in Figure 4.

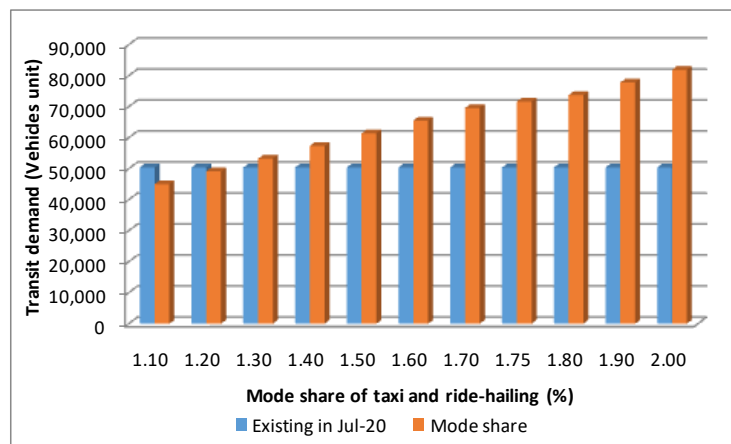


Figure 4. Transit demand based on percentage of mode share variation from 1.1 to 2.0%.

Several determinants of ride-hailing transport, including built environment, socio-economic attributes (Sugiyanto, 2018), trip characteristics (Wang & Mu, 2018), attitudinal factors (Alemi et al., 2018), and lifestyle (Lavieri & Bhat, 2019). Gender, age, and education level as the key socio-demographic characteristics in modeling taxi demand (Zhang et al., 2016). Anti-shared mobility, cost-effectiveness, trip security, and technology-oriented riders have a significant impact on ride-hailing trips (Ghasrodashti & Hamidi, 2019). Schreffler (2018) studies quantify the level of satisfaction perceived by taxi users and how users choose their transportation mode. Wang (2017) using the gap analysis between rider demands and driver supply in a given time period. Accurate prediction of ride-hailing demand helps companies and drivers make informed decisions to reduce traffic congestion, vehicle miles traveled (Hennessy &

Wiesenthal, 1999), higher propensity for accidents (Sugiyanto et al., 2019). In major cities in the United States, 21% of adults use ride-hailing services (Clewlow & Mishra, 2017). Based on the International Association of Public Transport, an average of 1 taxi unit serves 291 people. The highest in Izmir, 1 taxi unit serves 1232 people and the lowest is in New York, 1 taxi serves only 108 people (Yildizgoz, 2018). The population of the Jakarta Greater area is 31,679,179 people. With the number of taxis 17,268 vehicles and ride-hailing 33,133 vehicles, total 50,401, every 1000 residents are served by 1.59 taxis or 1 taxi unit serves 629 people.

CONCLUSIONS AND FURTHER RESEARCH

This study identifies the service quality of transit and forecasting demand of taxis and ride-hailing using the demand-supply model. Through this study, the ride-hailing service is better than conventional taxis based on waiting time, travel time, and travel cost. Waiting time of ride-hailing is 14.08% faster than taxi, travel time ride-hailing is 6.41% faster than taxi, and travel costs per trip ride-hailing is 16.07% cheaper than taxi. Average travel cost per trip using a bus is cheaper than ride-hailing and taxis. Factors that influence taxi and ride-hailing service demand are the number of operating hours per day, number of trips per day, waiting time, and travel time. The forecasting of taxi and ride-hailing demand in the Jakarta Greater area based on demand-supply model is 71,660 vehicles.

The further research is modeling taxi and ride-hailing demand using global positioning system data and transit schedule information and forecasting transit demand using dynamic models.

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