Does Improved Level of Paratransit Service Improve Drivers' Quality of Life?

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Abstract: Our previous study showed that the current paratransit systems are not socially sustainable. In this study, it is aimed to clarify how the improvement of paratransit service affects drivers' quality of life (QOL). This was done by integrating the optimization results of a paratransit system (i.e., angkot) from a bi-level optimization model and the QOL evaluation results from a simultaneous-equation ordered probit model by using data collected in Bandung, Indonesia. As a result, it is found that minimizing the total cost of paratransit operation and users does not necessarily increase the operation frequency and total distance traveled for all routes, and the level of paratransit service surely affects drivers' QOL; however, improved paratransit services do not always improve drivers' QOL. It is concluded that driver's QOL needs to be reflected in decisions on paratransit operation.

Keywords: Paratransit Service, Quality of Life, Bi-level Optimization,
Simultaneous-equation Ordered Probit Model

1. INTRODUCTION

A minibus service, called angkot, in one of the Indonesian cities has been losing its patrons due to rapid private motorization, especially to motorcycles (Kawaguchi *et al*, 2012). In the case of Bandung City, more than 15.4% of users have a low probability to move away from paratransit, and are likely to use it in the future (Joewono *et al*, 2007). A study in Jabodetabek found that most respondents were using angkot as their main line haul and other types of paratransit as their access or egress modes, while a study in Surabaya city showed that most respondents were using angkot or other types of paratransit as their main modes and walking as their access/egress modes to commute (Weningtyas *et al*, 2011). Based on these findings, the existence of paratransit is considered important for the future. Hence, improvements need to be made in order to provide a better service to the users. Here, paratransit refers to angkot in this study.

In our previous research (Weningtyas *et al,* 2012a), we investigated the causal-effect relationships between work performance (as a proxy variable to indicate level of service (LOS)) and driver's life satisfaction (as a proxy variable to indicate QOL) and at the same time measured the relationship between work performance, gap revenue and work satisfaction. The most important finding from this study is that the current paratransit systems in Bandung City are not socially sustainable. It is found that by improving the paratransit LOS (here refers to increasing the work performance) would cause an increase in environmental impacts and worsen drivers' QOL. Work performance is explained by operation frequency, service time, drivers' waiting time for passengers, total distance serviced and gap revenue.

Kawaguchi *et al* (2012) stated that in the case of angkot in Bogor, it turns out that paratransit owners and drivers suffer operational, regulatory and financial problems. His study was conducted based on a so-called "angkot shift program", which purpose was to regulate the supply of angkot vehicles by assigning each of the vehicles into one of three shift groups, and only two shift groups are allowed to operate in a given day. Results showed that illegal competition among angkot vehicles was reduced, and owners' net income increased due to the reduction of maintenance costs while drivers could take additional leave.

From the above two studies, we can say that by reducing the paratransit service could cause positive impact on the drivers and more on the owners. This finding is interesting, which provides a contrary observation to recent studies (Cervero *et al,* 2007; Joewono *et al,* 2007; Tangphaisankun *et al,* 2009; Tarigan *et al,* 2010; Neumann *et al,* 2012) showing that the LOS should be increased based on user perceptions on satisfaction. Then, one question that is worth rising is that by balancing the needs of both supply and demand sides, whether the improvement of LOS is always better? Several existing studies clearly defined the LOS classification for public transportation, but no studies have clearly defined standards for classifying the level of paratransit services. Especially, little has been done to look at the role of drivers' QOL in decisions on paratransit services.

Motivated by the above observations, this study aimed to clarify how the improvement of paratransit service affects drivers' quality of life (QOL). This was done by integrating the optimization results of a paratransit system (i.e., angkot) from a bi-level optimization model (Weningtyas *et al,* 2012b) and the QOL evaluation results from a simultaneous-equation ordered probit model by using data collected in Bandung, Indonesia. The upper level in the bi-level model is to minimize paratransit system operation cost and user cost while the lower level deals with the user equilibrium of paratransit network. This study has significant policy implications, considering that paratransit drivers' economic sustainability is at stake and is expected to provide additional insights into policy making from the perspective of more effective use of paratransit, improved urban mobility and better quality of drivers' lives.

The remaining part of this paper is organized as follows. LOS of paratransit is described in Section 2 and QOL for paratransit drivers in Section 3, followed by explanations of the unresolved issues of paratransit studies in Section 4 and a methodology in Section 5. Model estimation results are illustrated and discussed in Section 6. Finally, the study is concluded in Section 7, together with a discussion about future research issues.

2. LEVEL OF SERVICE

Several existing studies provided the definition of Public Transportation's LOS classification. Unfortunately, to the authors' knowledge, none of the studies have clearly defined the LOS classification of paratransit.

2.1 Public Transportation LOS

TRB Transit Capacity and Quality of Service Manual (TCQSM) (2003) defined the public transportation LOS classifications as listed in Table 1, which shows the measures presented in the TCQSM. The measures are divided into six categories, corresponding to transit service availability and quality for transit stops, route segments, and systems. The measures shown in capital letters are the measures for which A-F levels of service are provided, while the remaining measures are discussed in details in the manual, but no levels of service are provided for them.

Table 1. The Quality of Service Framework in the TCQSM 2003

Category	**Service & Performance Measures**		
	Transit Stop	**Route Segment**	**System**
Availability	FREQUENCY accessibility passenger loads	HOURS OF SERVICE accessibility	SERVICE COVERAGE % person-minutes served indexes
Quality	PASSENGER LOADS amenities reliability	RELIABILITY travel speed transit/ auto travel time	TRANSIT/ AUTO TRAVEL TIME travel time safety

The question is, can we also use the same classification of LOS for the paratransit system? Table 2 and Table 3 present examples for service frequency classification and hours of service classification, respectively. Table 4 shows examples of existing paratransit frequency and hours of service. One can observe that if we use the same classification of LOS as the standard public transportation system, then all the paratransit services are already classified in the level A for frequency (headway < 4 min) and B for hours of service (17-18 hours). In other words, the current paratransit services do not need any improvements.

Table 2. LOS Classification based on Fixed-Route Service Frequency

LOS	Average Headway (min)	veh/ hr	Comments
A	<10	>6	Passengers do not need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/ train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during the hour
F	>60	<1	Service unattractive to all riders

Table 3. LOS Classification based on Fixed-Route Service Hours

LOS	Hours of Service	Comments
A	19-24	Passengers do not need schedules
B	17-18	Frequent service, passengers consult schedules
C	14-16	Maximum desirable time to wait if bus/ train missed
D	12-13	Service unattractive to choice riders
E	4-11	Service available during the hour
F	0-3	Service unattractive to all riders

With the above discussion, it seems necessary to provide another method for defining a better or improved level of paratransit services. In line with such consideration, one of our studies on paratransit system (Weningtyas *et al*, 2012b) made an effort based on a bi-level optimization model of service frequency, where the upper level minimizes the sum of paratransit operation cost and total user cost while the lower level is a transit assignment model with common lines which satisfy the user equilibrium.

Table 4. Paratransit Frequency and Hours of Service in Bandung City Year 2008

Route Code	Route Description	Operational Time	No of Fleet	Roundtrip Length (km)	Load Factor	Travel Time per Roundtrip (min)	Average Speed (km/h)	No of roundtrip (interview)	Passenger per Roundtrip	Average Headway (min)
1	Abdul Muis-Cicaheum via Binong	05:30-20:00	325	29.6	0.6	146.0	12.1	5.6	64.0	0.8
2	Abdul Muis-Cicaheum via Aceh	05.30-19:30	86	19.7	0.8	102.5	11.6	6.6	54.0	1.5
3	Abdul Muis-Dago	06:00-22.00	244	19.1	0.7	91.0	12.6	9.8	47.0	1.2
4	Abdul Muis-Ledeng	05:30-21:45	223	23.7	1.0	94.5	15.1	8.1	50.0	0.7
5	Abdul Muis-Elang	06:00-22:00	91	16.2	0.4	66.0	14.7	9.5	40.0	1.7
6	Cicaheum-Ledeng	05:30-20:00	159	26.7	0.9	111.5	14.4	5.6	47.0	0.7
7	Cicaheum-Ciroyom	05:00-21:00	191	26.8	0.8	122.5	13.2	6.1	72.0	2.6
8	Cicaheum-Ciwastra	05:00-18:30	169	29.2	0.6	128.0	13.7	6.0	69.0	0.8
9	Cicaheum-Cibaduyut	05:00-21:30	110	23.0	0.7	81.5	16.9	8.6	55.0	1.3
10	Stasiun Hall-Dago	05:30-21:00	43	15.5	0.7	64.3	14.4	10.0	41.0	3.4

Source: Direktorat Bina Sistem Transportasi Perkotaan, 2008

3. PARATRANSIT DRIVERS' QOL

The driver's task is mentally demanding because of having to cope with conflicting requests (Kompier, 1996). The company and the public want the driver to maintain good contact with passengers and to be service-oriented, for instance to travelers (providing information about timetables, routes, stops, fares, etc.). These are also important aspects for job satisfaction. In the operator's daily life, the demand for service by the individual passenger often conflicts with the need to keep to a tight schedule in dense traffic. The third demand on the driver, also conflicting with the other two, is the demand to drive safely according to traffic regulations (Kompier, 1996).

Kawaguchi *et al* (2012) stated that the total working days per month have decreased for drivers due to the aforementioned "angkot shift program". For example, roughly 70% of the drivers of a route and roughly 50% of the drivers of another route reported that their QOL had been improved because the time spent with their family members had increased. It was also reported that roughly 20% of drivers were working with another job, thus making use of the additional time off. In general, the free time created by the program had a positive impact on the drivers.

As stated in our previous study (Weningtyas *et al,* 2012a), drivers' job can be considered as a self-employed job, which is entirely different from company-based employment. Drivers make the entire decisions by themselves, independently of both owners and the government. They freely decide when to start or to stop the service. Their decisions are based on their acceptable daily earnings and each driver, in fact, has a different standard. This uncertain decision making however results in the service unreliability, where the service performance highly depends on filling in empty seats, rather than on fixed income that can guarantee a stable service (Susantono *et al*, 1997; Cervero, 2000).

Since paratransit drivers belong to the low-income group, meeting their basic needs may be given the top priority in their jobs and consequently other life domains may be regarded as secondary needs. In other words, QOL of paratransit drivers may mostly concern about fulfilling the basic needs before achieving higher level of needs. Therefore, it may be a good idea to divide the structure of life domains into two hierarchical levels: basic level and higher level of QOL (see Weningtyas *et al,* 2012a).

Life satisfaction, which is an overall assessment of feelings and attitudes about one's life at a particular point in time, is one of common core subjective elements (Phillips, 2006). The domains of life literature reveal that life can be combined as a general construct of many specific domains. Life satisfaction can be understood as the result of satisfaction in the domains of life, for example, the domains are specified as health, economic, job, family, friendship, personal, and community environment. With the above supporting evidence, here, drivers' job satisfaction is one of the domains in drivers' life satisfaction and driver's life satisfaction is used as a proxy of paratransit drivers' QOL. Considering the specific living conditions in Indonesia (Widyosiswoyo, 1991), six life domains are considered: work, residence, health, family, social life, and leisure (free time), where the first three correspond to the basic needs and the last three to the higher needs.

4. UNRESOLVED ISSUES

In our previous study (Weningtyas *et al*, 2012a), we applied a structural equation model (SEM) with latent variables to investigate the causal-effect relationships between work performance and driver's life satisfaction (as a proxy variable to indicate QOL) as well as environmental impacts. At the same time we also measured the relationship between work performance, gap revenue and work satisfaction. It is found that the current paratransit systems in Bandung City are not beneficial to both drivers and the environment. Earning more money requires drivers to work longer.

This finding has important policy implications. Improving the sustainability of paratransit system requires actions taken to change the current operation and contract systems of paratransit services. More effects should be made from the owner side of paratransit system, rather than from the driver side. Especially, in the analysis, reflecting the actual situations in Indonesia, drivers' quality of life was measured by classifying it into the basic level and higher level. Results confirmed that such hierarchical structure of QOL is statistically significant and such a "basic level of QOL"-centered cause-effect model structure is suitable to the evaluation of paratransit services.

Detailed result of SEM analysis is depicted in Figure 1. Observing the structural model, significant cause-effect relationships are observed from "work performance" to "individual attributes", from "work performance" to "environmental impacts", from "work performance" to "basic level of QOL", from "basic level of QOL" to "higher level of QOL". Unexpectedly, the cause-effect relationship between individual attributes and basic level of QOL is not statistically significant, suggesting that there is no significant difference of life satisfaction related to the basic level of QOL across individuals.

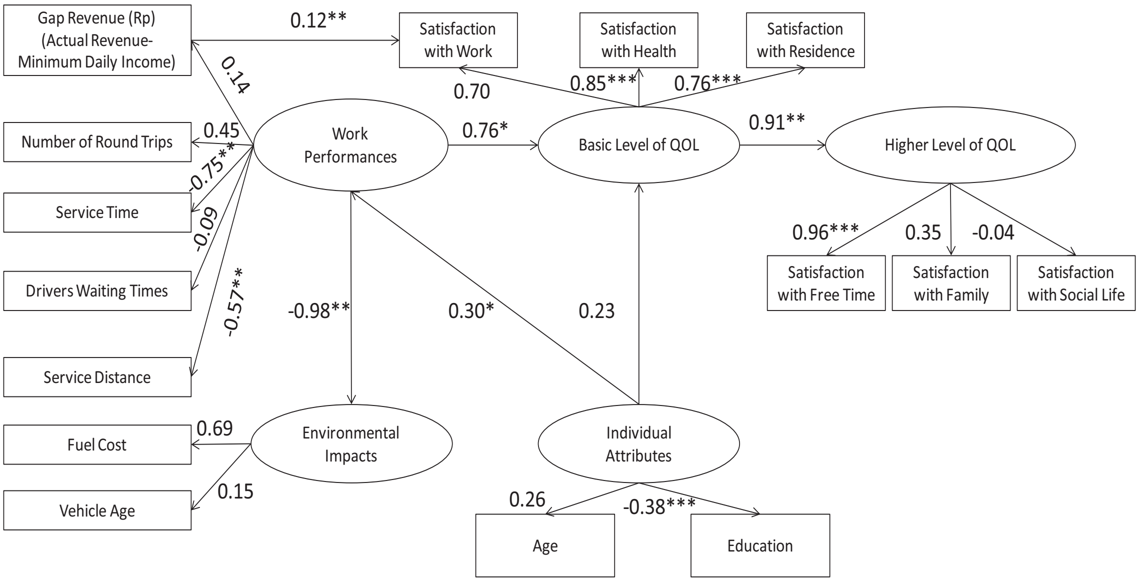

Figure 1. The Target Paratransit Network
(Source: Weningtyas et al, 2012a)

In our other study (Weningtyas *et al*, 2012b), we presented a sensitivity analysis from both demand and supply sides in Bandung City, Indonesia. The analysis was conducted based on a bi-level optimization model to decide the optimal operation frequency of paratransit system. The upper level is to minimize the total (generalized) cost of paratransit users and the operational cost for paratransit drivers where the lower level problem is a transit assignment model with common lines. Total user cost is the generalized cost that includes both the fare and monetary value of travel time and waiting time. The paratransit network is located in an area within 1.5 km radius from the central station in Bandung City. Figure 2 shows the targeted paratransit network and the distributions of boarding and alighting passengers in the study network. Node 15 corresponds to the central station (Station Hall) and Node 8 corresponds to the central railway station. There are 8 paratransit lines in the network which are observed in this study. The sensitivity analysis of different scenarios confirmed that passenger and operator costs in the current network are sensitive to the congestion level. Comparison of the current paratransit network and the model outputs from the scenarios confirmed that the current paratransit network is close to the Pareto front if the total costs for passengers and operators are adopted as objective functions. The suggested solutions of the optimized operation frequency and the comparison between total user cost for each solution is depicted in Figure 3.

Based on the results obtained from the second study, in fact, we cannot endogenously decide which solution provides the best option for the win-win situation between the paratransit operator and users. This means that some external indicators are required to decide the best option. In the bi-level framework, both operators' and users' behaviors are reflected; however the direct service providers are drivers of paratransit vehicles. If paratransit drivers could not provide satisfactory and reliable services, benefits for both operators and users would not be realized. If paratransit service provision could not improve drivers' QOL, drivers would not make efforts to provide satisfactory and reliable services. With the above consideration, this study suggests introducing drivers' QOL indicators to optimize the paratransit service. The unresolved issues are, however, 1) how the improved LOS of paratransit system influences drivers' QOL, and 2) how to quantitatively measure such influence. The first study introduced above clarified the case-effect relationship between LOS and drivers' QOL, but the SEM model is not suitable to the prediction. Therefore, it is required to develop a tool to predict the influence of the improved LOS of paratransit system on drivers' QOL.

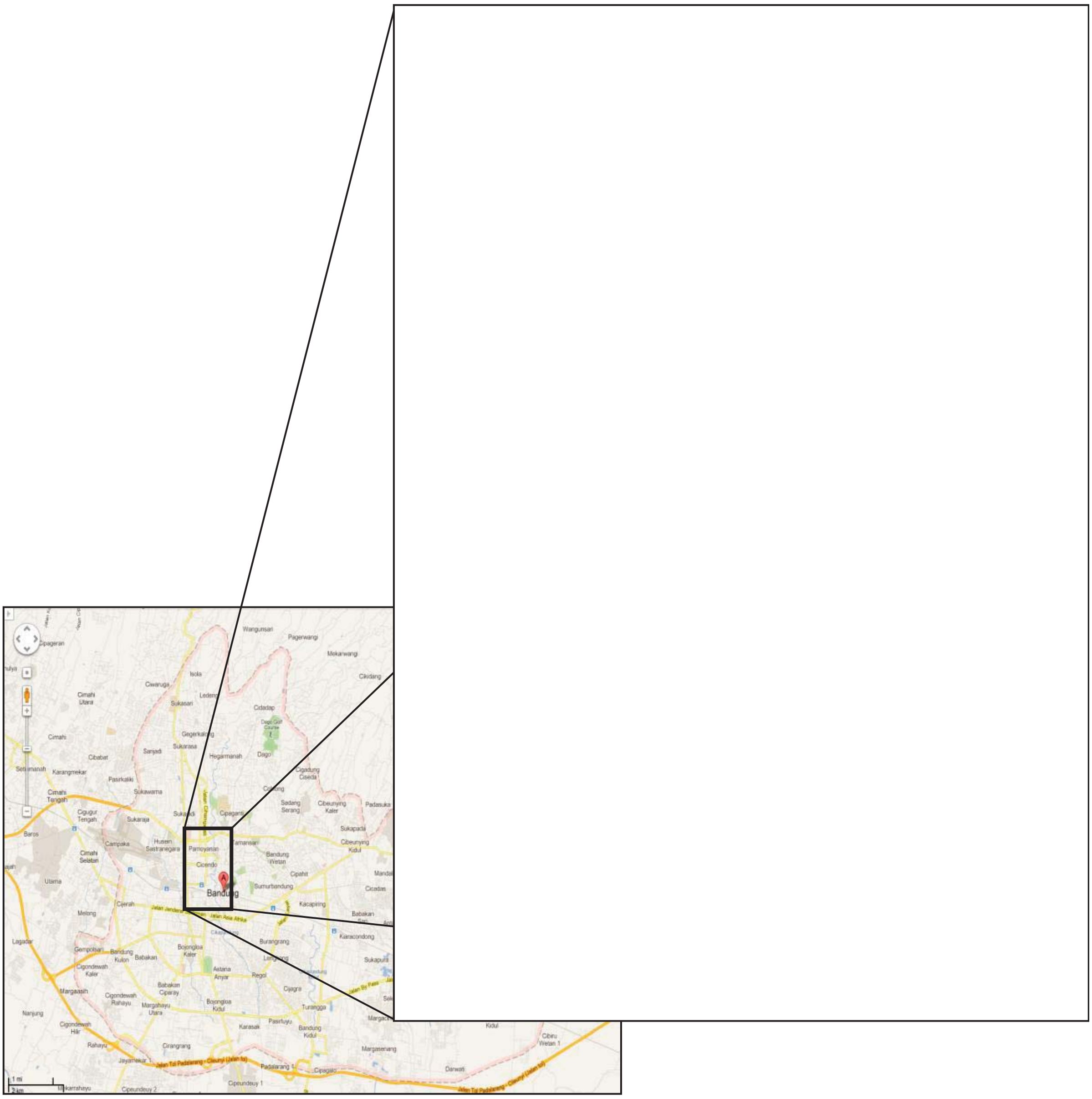

Figure 2. The Target Paratransit Network

5. METHODOLOGY

As stated before, our previous study (Weningtyas *et al*, 2012a) successfully investigated the causal-effect relationships between work performance and driver's QOL. Unfortunately, the adopted method, i.e., SEM, cannot be used for the prediction of dependent variables since SEM estimations are usually done by minimizing the discrepancy between observed and estimated variance-covariance matrices, rather than the discrepancy between observed and estimated dependent variables. Therefore, we propose to build a simultaneous-equation ordered probit model that can explicitly link the LOS variables with correlated drivers' QOL indicators (in this study, six QOL indicators), which were, in fact, identified in our previous study, as shown in Figure 1 (Weningtyas et al., 2012a). In order to simplify the analysis we only consider the LOS as explanatory variables and employing the paratransit drivers' life satisfaction (measured as ordered responses) with six life domains as dependent variables. The resulting functions for the simultaneous-equation ordered probit model (hereafter called QOL measurement model) are shown below.

The observed category of a life satisfaction indicator y_{ni} (n: driver; i: life domain) is defined via a latent variable y^{*}_{ni}, as follows:

$$\begin{aligned} &y_{n1} = 0 \ \ if \ \ y^{*}_{ni} \le 0 \\ &y_{n2} = 1 \ \ if \ \ 0 \le y^{*}_{ni} \le \gamma_{1} \\ &.... \\ &y_{nJ} = J \ \ if \ \ \gamma_{J-1} \le y^{*}_{ni} \end{aligned} \tag{1}$$

The latent variable y^{*}_{ni} is further specified for each life domain, by reflecting the hierarchical structure of between basic level and higher level of QOL, identified in our previous study (Weningtyas *et al*, 2012a), as follows:

$$y^{*}_{n1} = \eta_{n1} + \varepsilon_{n1}, with \ \ \varepsilon_{ni} \sim N(0,1) \tag{2}$$

$$y^{*}_{n2} = \lambda_{2}\eta_{n1} + \varepsilon_{n2}, with \ \ \varepsilon_{n2} \sim N(0,1) \tag{3}$$

$$y^{*}_{n3} = \lambda_{3}\eta_{n1} + \varepsilon_{n3}, with \ \ \varepsilon_{n3} \sim N(0,1) \tag{4}$$

$$y^{*}_{n4} = \eta_{n2} + \varepsilon_{n4}, with \ \ \varepsilon_{n4} \sim N(0,1) \tag{5}$$

$$y^{*}_{n5} = \lambda_{5}\eta_{n2} + \varepsilon_{n5}, with \ \ \varepsilon_{n5} \sim N(0,1) \tag{6}$$

$$y^{*}_{n6} = \lambda_{6}\eta_{n2} + \varepsilon_{n6}, with \ \ \varepsilon_{n6} \sim N(0,1) \tag{7}$$

$$\eta_{n1} = \beta_{1}x_{n1} + \beta_{2}x_{n2} + \beta_{3}x_{n3} + \beta_{4}x_{n4} + \beta_{5}x_{n5} \tag{8}$$

$$\eta_{n2} = \beta_{6}y_{n1} + \beta_{7}y_{n2} + \beta_{8}y_{n3} \tag{9}$$

where, all "x"s are explanatory variables and all "y"s are QOL indicators, all ε terms are error terms and others are unknown parameters.

In the first three functions for "Satisfaction with Work (y_{n1})", "Satisfaction with Health (y_{n2})", and "Satisfaction with Residence (y_{n3})" we introduce a common variable ($_{1}$) to describe the latent variable "Basic Level of QOL" as structurized in the SEM model depicted in Figure 1. This common variable is explained by five explanatory variables: "gap revenue (x_{1})", "number of round trips (x_{2}) (a proxy variable of operation frequency)", "service time (x_{3})", "drivers' waiting time (x_{4})" and also "service distance (x_{5})". For the later three utility functions: "Satisfaction with Free time (y_{n4})", "Satisfaction with Family (y_{n5})", and "Satisfaction with Social Life (y_{n6})", we introduced another common variable ($_{2}$) to describe the latent variable of "Higher level of QOL". This common variable is explained by "Satisfaction with Work (y_{n1})", "Satisfaction with Health (y_{n2})", and "Satisfaction with Residence (y_{n3})". We estimated the above six ordered probit models jointly based on the standard maximum likelihood estimation method.

The above QOL measurement model also includes another two sets of parameters: one are constant terms and the other are threshold parameters related to the assumed normal distribution.

6. ANALYSIS

This study adopted data from a questionnaire survey implemented by a face-to-face interview in September 2011 with respect to 152 drivers who were randomly selected from the routes in Figure 2. The characteristics of data are summarized in Table 5. The survey includes four parts: one-day trip diary, vehicle operational cost (e.g., fuel cost, vehicle rent fee, fuel type), vehicle conditions (i.e., vehicle age), driver's individual attributes (e.g., age, gender), and driver's satisfaction with the six life domains (i.e., work, residence, health, family, social life, and leisure (free time)).

Table 5. Characteristics of Survey Data

Latent Variable	Observed Variable	Definitions	Mean	Std Dev
Individual Attributes	Age	< 55 years old = 0 (84%) ≥ 55 years old = 1 (16%)	43.00	10.10
	Education level	Lower than junior high school = 1 (68%) Higher than junior high school = 2 (32%)	1.29	0.45
Work Performance	Number of round trips	Number of round trips per day	7.92	0.82
	Service time (minutes) (Modeled in categorical)	The length of time a driver provides to passengers per day	694.73	80.20
	Driver's waiting time (minutes)	Average time to wait for passengers	24.10	6.33
	Gap revenue (Rp.)	Actual revenue – Minimum daily revenue	16,569	26,962
	Service distance (km)	Distance traveled per day	104.50	28.50
Environmental Impacts	Fuel cost (Rp.)	Fuel cost spent per day	84,160	10,401
	Vehicle age (years)	Vehicle age (years)	7.91	0.80
Basic Level of QOL	Satisfaction with Work	Measured with a 4-point scale: 1 – very dissatisfied; 2 – dissatisfied; 3 – neutral; 4 – satisfied;	2.83	0.36
	Satisfaction with Health		2.76	0.54
	Satisfaction with Residence		2.97	0.76
Higher Level of QOL	Satisfaction with Social Life		2.67	0.73
	Satisfaction with Free Time		2.75	0.59
	Satisfaction with Family		2.97	0.73

The results of the QOL measurement model are listed in Table 6. The model accuracy is good enough with the value of McFadden's Rho Squared being 0.745 and the adjusted value being 0.732. The significant LOS explanatory variables are drivers' waiting time, service time and service distance for the first three QOL indicators: satisfaction with work, health, and residence, These three indicators represent the basic QOL level, which is significantly influential to the later three life domains: social life, free time, and family.

Table 6. Estimation Results of the QOL Measurement Model

Explanatory Variable	**Parameter value**	**t-value**	
Gap Revenue	0.00004	0.705	
No. of Round Trips	-0.165	-1.004	
Driver Waiting Time	0.189	5.208	**
Service Time	-0.269	-2.183	**
Service Distance	-0.035	-4.178	**
Satisfaction with Work	0.373	2.687	**
Satisfaction with Health	1.117	3.594	**
Satisfaction with Residence	0.846	3.744	**
Constant term for Work	3.556	1.990	**
Constant term for Health	3.768	3.295	**
Constant term for Residence	3.033	4.327	**
Constant term for Free Time	-3.048	-4.246	**
Constant term for Family	0.840	1.416	
Constant term for Social Life	2.035	3.115	**
λ_2 in equation (2)	0.492	3.063	**
λ_3 in equation (3)	0.243	1.906	**
λ_4 in equation (5)	0.253	2.903	**
λ_5 in equation (6)	0.052	0.611	
Threshold γ_1 for Work	0.654	6.668	**
Threshold γ_2 for Work	1.359	15.558	**
Threshold γ_1 for Health	1.415	10.495	**
Threshold γ_2 for Health	1.539	18.715	**
Threshold γ_1 for Residence	1.407	10.442	**
Threshold γ_2 for Residence	1.049	15.552	**
Threshold γ_1 for Free Time	1.639	13.065	**
Threshold γ_2 for Free Time	1.760	19.279	**
Threshold γ_1 for Family	1.389	10.425	**
Threshold γ_2 for Family	1.132	17.113	**
Threshold γ_1 for Social Life	1.514	12.197	**
Threshold γ_2 for Social Life	1.075	15.513	**
Initial Log-likelihood	-2366.506		
Converge Log-likelihood	-603.600		
McFadden's Rho Squared	0.745		
Adjusted Mc Fadden's Rho Squared	0.732		
Number of Samples	152		

*** is significant at 1% level*

With the above estimation results, we will evaluate the influence of improved paratransit services (see Figures 3, 4, and 5) optimized in our previous study (Weningtyas *et al*, 2012b) on drivers' QOL. Figure 3 illustrates the suggested line frequencies of each Pareto solution while Figure 4 shows the components of user costs of each Pareto solution ranked by the line frequency. First, we identified which line frequency needs to be doubled, stabled, or halved or even halted based on Figure 3 and then these frequency changes were transferred to adjusted values of number of round trips and service distance obtained from the questionnaire survey while keeping service time and drivers' waiting time unchanged. It is assumed that service time does not need to be changed, since the optimization model did not include it. For drivers' waiting time, it is, in fact, very short due to the high frequency of actual operation (average headway is only 0.5 seconds). Therefore, we assume that the value will not change significantly although, for example, we halve or double the frequency. Observing from the Figure 5, we can know how much the operational cost is reduced due to the LOS optimization. This percentage of the reduction is used to adjust the gap revenue value from the data.

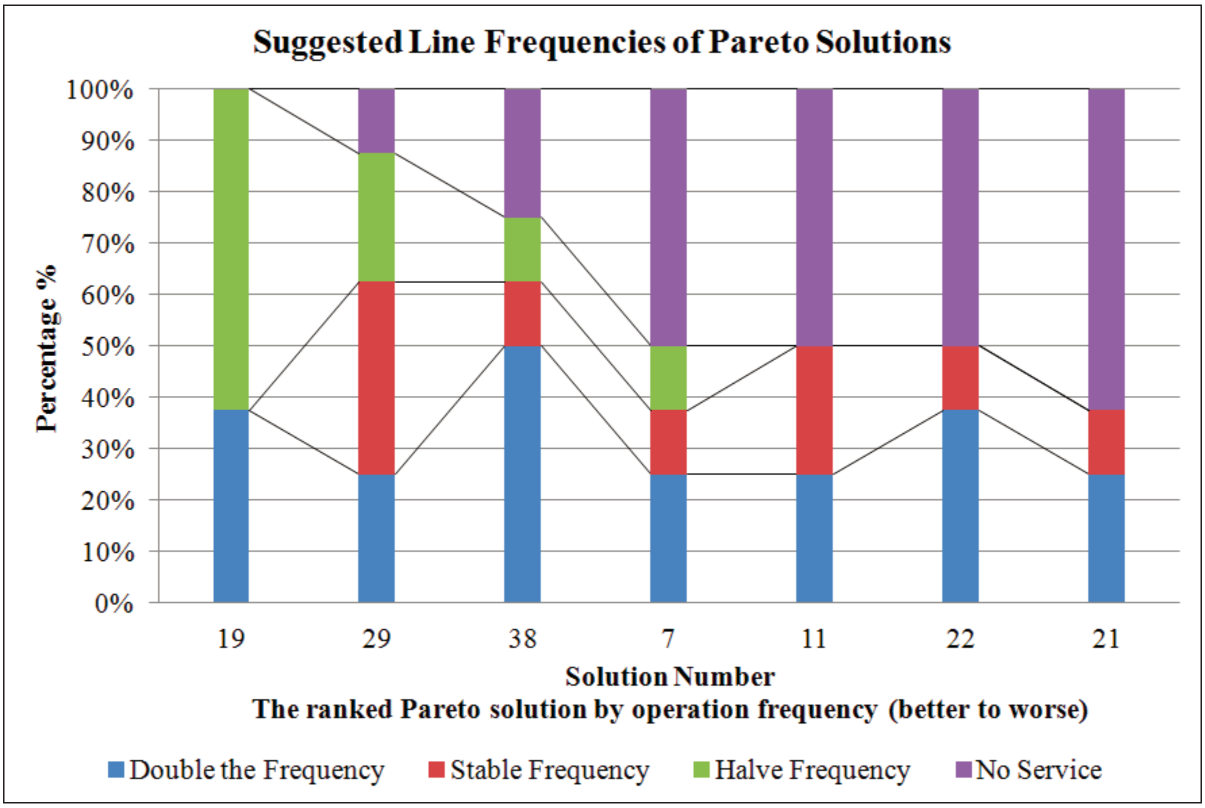

Figure 3. Suggested Line Frequencies of Pareto Solutions
(Source: Weningtyas et al, 2012b)

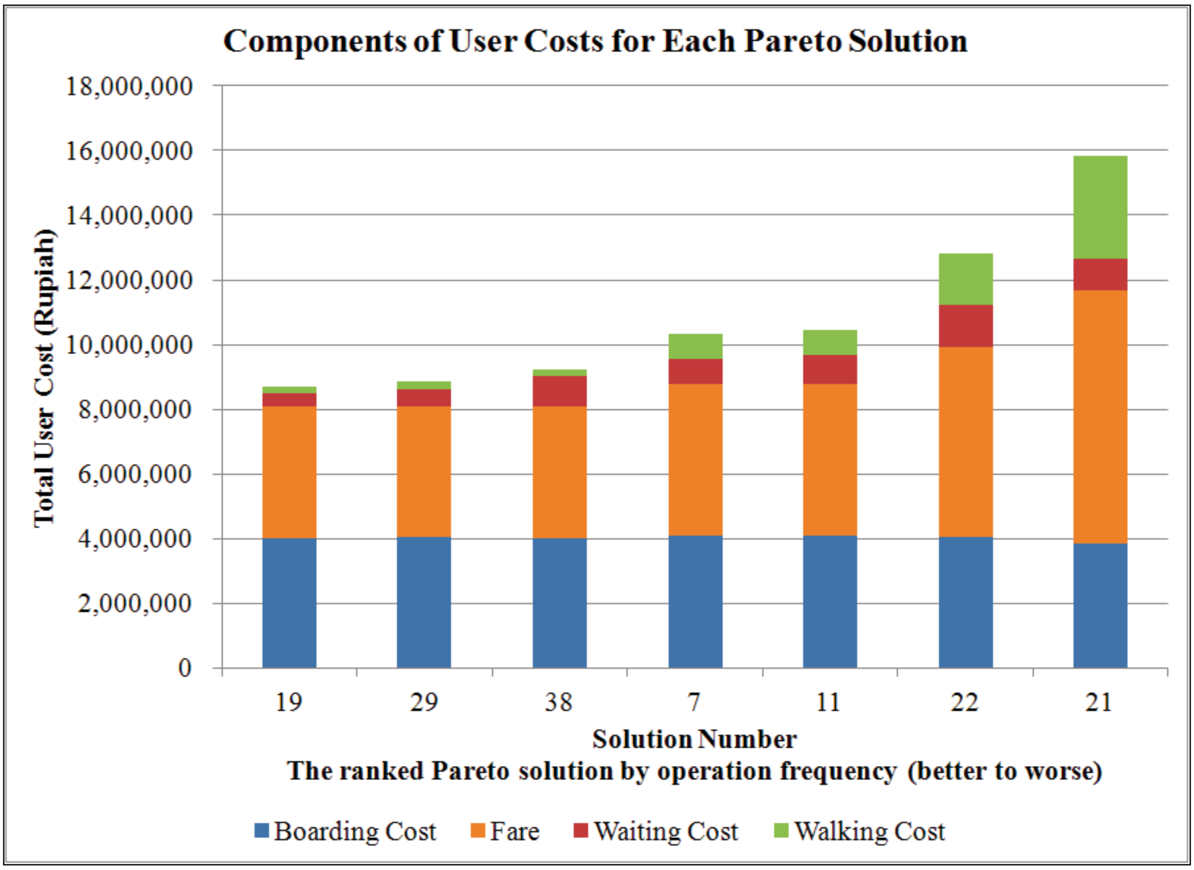

Figure 4. Components of User Costs for Each Pareto Solution

(Source: Weningtyas et al, 2012b)

From Figure 5, it is obvious that the three Pareto solutions (Solutions 19, 29, and 38) shown in the left part are close to the existing condition (i.e., the red dot), where the suggested solutions are in green triangles. In order to evaluate which solutions could give a better driver QOL, the effects of optimized LOS on drivers' QOL are compared. The comparison is done for the aforementioned three suggested solutions. It can be easily observed that the operation cost for the three solutions are more sensitive than the total user cost. While starting from the 4th solution counted from the left part, the sensitivity of total user cost is much higher than the operation cost because the service becomes worse and worse from the left to the right. For instance, the 1st suggested solution is the best operation where no line frequency is halted or the service is stopped. While in the last suggested solution, there are more lines that are halted or no service is provided. The reason why some lines was are suggested to be halted is because there are several routes which are overlapped. This means that when some lines are halted, the other lines perform as a substitute.

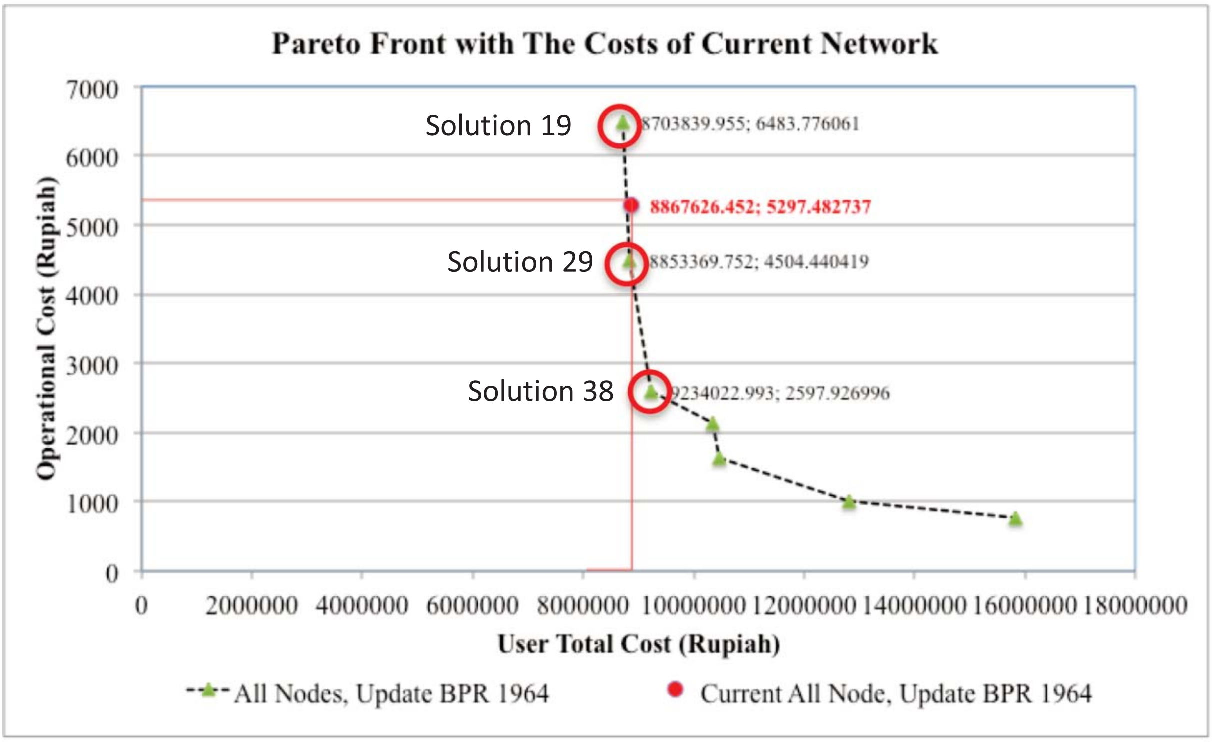

Figure 5. Pareto Solutions for Optimized Paratransit Network
(Source: Weningtyas et al, 2012b)

Table 7 shows the optimized frequency for each line. Looking at Solution 19, the operation frequency should be doubled for 35% of the lines (i.e., Routes 2, 4, and 5) and reduced by half for the remaining 65% of the lines (i.e., Routes 1, 3, 6, 7, and 8). There are no route lines being halted. Observing Solution 29, the frequency should be doubled for 25% of the lines (i.e., Routes 1, 3, and 5), kepted unchanged for 44% of the lines (i.e., Routes 4 and 7), reduced by half for 11% of the lines, and reduced to zero for 20% of the lines (i.e., Routes 2 and 7). While in the last suggested Solution 21, Routes 7 and 8 are doubled and Route 4 is stabled while the rest are halted. The reason why the costs are also changing is because the number of vehicle units for each line are different. For example, Routes 3, 1 and 5 have the higher number of units than the other routes. Therefore substituting these routes with the other routes would result in greater effects on the costs.

Table 7. Optimized Frequency for Each Line

Route Line	No. 19	No. 29	No. 38	No. 7	No. 11	No. 22	No. 21
1	0.5	2	2	2	2	n/a	n/a
2	2	n/a	n/a	n/a	n/a	n/a	n/a
3	0.5	1	2	1	1	2	n/a
4	2	1	0.5	n/a	n/a	1	1
5	2	2	2	n/a	n/a	n/a	n/a
6	0.5	1	1	0.5	1	n/a	n/a
7	0.5	n/a	n/a	n/a	n/a	2	2
8	0.5	0.5	2	2	2	2	2

** 2 = Doubled, 1 = stabled, 0.5 = halved, n/a = halted*

In Solution 19 and Solution 38, the number of round trips is increased: 6.25% of the existing frequency in Solution 19 and 18.75% in Solution 38. Meanwhile in Solution 29 the existing frequency is decreased by 6.25% and as a result the gap revenue is also increased due to the operational cost is reduced by 15% as depicted in Figure 5. Although in Solution 38 the operational cost is reduced significantly but drivers' QOL somehow decreases. This result might be reasonable because a very high frequency would mean that drivers need to work longer. This may be arguable on the other hand. How the increased frequency results in decreased operational cost? As depicted in Table 7, the lines that are suggested to be increased have shorter travel distance and lower frequency. In this sense, this result is understandable.

From Table 8, one can observe that QOL varies sensitively with different solutions of optimized LOS. Solution 29 gives a better QOL value than the existing condition, while Solution 19 worsens the QOL and the worst QOL is observed in Solution 38, which reduces the QOL value by 13% in the worst case. From the driver viewpoint, one can say that Solution 29 is the best solution, since it not only gives a better QOL value but also leads to a bigger value of gap revenue than the existing condition. Moreover, Solution 29 is also a better solution from the user viewpoint since the total user cost is less than the existing condition

Table 8. Evaluation on Drivers' QOL based on Optimized Paratransit Services

	Existing Condition	Solution 19		Solution 29		Solution 38	
Explanatory Variables							
Gap Revenue (Rp.)	16,569		-1,061		30,919		61,133
No. of Round Trips	7.919		8.415		7.425		9.405
Driver Waiting Time (min)	24.098		-		-		-
Service Time (categorical value)	6.839		-		-		-
Service Distance (km)	104.384		110.908		97.859		123.956
QOL Variables							
Satisfaction with Work	1.260	1.008	(-20.0%)	3.195	(38.7%)	3.153	(-50.6%)
Satisfaction with Health	2.638	2.514	(-4.5%)	3.469	(9.1%)	3.449	(-11.9%)
Satisfaction with Residence	2.475	2.415	(-2.5%)	2.839	(4.8%)	2.830	(-6.3%)
Satisfaction with Free Time	2.465	2.180	(-11.5%)	4.449	(22.3%)	4.404	(-29.2%)
Satisfaction with Family	2.234	2.163	(-3.2%)	2.756	(6.2%)	2.745	(-8.2%)
Satisfaction with Social Life	2.321	2.306	(-0.6%)	2.423	(1.2%)	2.421	(-1.6%)
Latent Variables							
Basic QOL	-2.853	-2.583	(9.5%)	-0.77	(73.1%)	-0.88	(69.3%)
Higher QOL	5.513	5.229	(-5.1%)	6.062	(10.0%)	4.793	(-13.1%)

Note: values in the parentheses indicate changes of QOL.

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Using the QOL measurement model we could also observe the changes of the shares of drivers with different QOL categories, as detailed in Table 9. More than 60% of drivers show neutral feelings with their jobs and more than 15% were satisfied with their jobs. This result suggests that most drivers are keen with their work. This is important because it means that the job is suitable to most drivers. Unfortunately, for other life domains the situation is totally different. In general almost more than 40% of drivers are neutral and more than 30% is not satisfied with these life domains. Concretely, more than 30% is not satisfied with health and more than 50% are dissatisfied with free time. All these life domains need further attention. It is true that these drivers are very prone to experience more health risk due to the long driving which is associated with stress-related health effects and physical ailments such as back pain and heart disease. It is also true that these paratransit drivers are lack of free time due to the very long service hours and since they depend on daily income it is very more likely to work every day without having a holiday. These evaluations successfully captured the existing condition of paratransit drivers from the perspective of QOL.

Table 9. Shares of Drivers with Different QOL Categories

	Existing Condition	Solution 19	Solution 29	Solution 38
Probability QOL				
Satisfaction with Work				
1 – very dissatisfied;	10.4%	15.7%	4.0%	26.7%
2 – dissatisfied;	9.9%	12.4%	5.3%	15.6%
3 – neutral;	64.2%	61.7%	60.8%	52.8%
4 – satisfied;	15.5%	10.2%	29.8%	4.9%
Satisfaction with Health				
1 – very dissatisfied;	0.4%	0.6%	0.2%	1.0%
2 – dissatisfied;	25.8%	29.8%	18.8%	36.4%
3 – neutral;	69.6%	66.4%	74.2%	60.6%
4 – satisfied;	4.2%	3.2%	6.8%	2.0%
Satisfaction with Residence				
1 – very dissatisfied;	0.7%	0.8%	0.5%	1.0%
2 – dissatisfied;	30.3%	32.3%	26.4%	35.6%
3 – neutral;	41.7%	41.5%	41.7%	41.0%
4 – satisfied;	27.3%	25.3%	31.4%	22.4%
Satisfaction with Free Time				
1 – very dissatisfied;	0.7%	1.5%	0.1%	4.1%
2 – dissatisfied;	58.1%	67.9%	37.0%	78.6%
3 – neutral;	41.2%	30.7%	62.6%	17.3%
4 – satisfied;	0.0%	0.0%	0.3%	0.0%
Satisfaction with Family				
1 – very dissatisfied;	1.3%	1.5%	0.9%	2.0%
2 – dissatisfied;	36.8%	39.3%	32.0%	43.1%
3 – neutral;	45.5%	44.5%	47.0%	42.5%
4 – satisfied;	16.5%	14.7%	20.1%	12.4%
Satisfaction with Social Life				
1 – very dissatisfied;	1.0%	1.1%	0.9%	1.1%
2 – dissatisfied;	47.8%	48.4%	46.8%	49.2%
3 – neutral;	38.2%	37.9%	38.7%	37.4%
4 – satisfied;	13.0%	12.7%	13.6%	12.2%

7. CONCLUSIONS

Generally, improvements of public transportation services are commonly equal to increasing the service, e.g., higher frequency, longer service time, and longer service distance. But, this is not always the case in paratransit services. To the authors' knowledge, there has been no literature of specifying the level of paratransit service. It is therefore hard to determine how to improve the level of paratransit service. There is no doubt that paratransit services need to be improved. If paratransit drivers could not provide satisfactory and reliable services, benefits for both operators and users would not be realized. If paratransit service provision could not improve drivers' QOL, drivers would not make efforts to provide satisfactory and reliable services.

This study provided additional evidence on how improvements of paratransit services do not necessarily increase the operation frequency and total distance traveled for all routes, and the level of paratransit service surely affects drivers' QOL. This was done by using two models: the one is a bi-level optimization model of paratransit service frequency that minimizes the operation cost and the total user cost, and the other is a simultaneous-equation ordered probit model that measures drivers' QOL with six life domains. The bi-level model was developed in one of our previous studies (Weningtyas *et al*, 2012b) and the ordered probit model was newly developed in this study for predicting the values of QOL indicators with an interrelated structure that were identified in the other of our previous studies (Weningtyas *et al*, 2012b). The conclusion that can be derived from this study is that the improvement of paratransit LOS in this specific case of paratransit network does not always improve drivers' QOL. It is further concluded that driver's QOL needs to be reflected in decisions on paratransit operation.

It must be emphasized that the job of paratransit drivers plays an important role in providing employment opportunities for low-income and low-skilled people in developing countries. However, since this job is, in fact, self-employed, paratransit services are basically depending on drivers' efforts, which are essential to their QOL. Therefore actions must be taken by the government to solve this revolving issue between paratransit services and drivers' QOL. We may suggest two options to solve this problem. One is that the government must re-evaluate the agreement contract system, where the daily rental fee is set by the owner and actually accounts for a huge part of drivers' expenses. The other option is that the government could try to "buy the service" (Agency of Transportation, 2012) using the local government budget. With such a "buy the service" policy, the government may effectively control the entire operation by paying drivers' salary based on their performance and operators' operation cost based on better service coverage and management.

Future studies should be done by collecting more samples in more cities in order to generalize our findings.

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