Lecture Notes in Civil Engineering

Han Ay Lie · Monty Sutrisna · Joewono Prasetijo · Bonaventura H.W. Hadikusumo · Leksmono Suryo Putranto *Editors*

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ICCIM 2021, 26 July 2021, Jakarta, Indonesia

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Preface

This new volume of Lecture Notes in Civil Engineering contains the proceedings of the Second International Conference of Construction, Infrastructure, and Materials (ICCIM 2021). This book presents the latest development in civil engineering on a global scale. It highlights the conference scopes, such as Structural Engineering, Construction Materials, Geotechnical Engineering, Transportation System and Engineering, Constructions Management, Water Resources Engineering, and Infrastructure Development. The 55 articles published in this book went through peer-review processes double-blindly and plagiarism check. Manuscript assessments by the expert reviewers were based on the organizer's technical criteria, including technical criteria, quality criteria, and presentation criteria.

The Second International Conference of Construction, Infrastructure, and Materials (ICCIM 2021) was hosted by the Civil Engineering Undergraduate Study Program of Universitas Tarumanagara, Indonesia, on 26 July 2021. The conference brought together national and international experts to share their researches, knowledge, and experiences. ICCIM 2021 carried the theme "Research and Technology in Civil Engineering to Enhance the Sustainability of the Built Environment".

Due to the global COVID-19 pandemic, which has impacted all activities globally, ICCIM 2021 was held as an online conference. ICCIM 2021 online conference aimed to capture a broader range of participants. The Conference was also expected to facilitate researchers, practitioners, and students in their respective fields of expertise to share information and exchange ideas about the current state of civil engineering development.

ICCIM 2021 was supported by Massey University, New Zealand; Universiti Tun Hussein Onn Malaysia, Malaysia; Nihon University, Japan; fib Indonesia; Diponegoro University, Indonesia; Soegijapranata Catholic University, Indonesia; Universitas Sebelas Maret, Indonesia; and Universitas Atma Jaya Yogyakarta, Indonesia.

ICCIM 2021 has received papers from various countries, such as Indonesia, Japan, Thailand, the United Kingdom, the United States of America, the

Philippines, India, Nigeria, and Bangladesh. More than 600 researchers, practitioners, and students from all over the world registered to attend the Conference.

We are likewise grateful to the keynote speakers for bringing the exciting topics to ICCIM 2021: Prof. Roesdiman Soegiarso (Universitas Tarumanagara, Indonesia); Prof. Monty Sutrisna (Massey University, New Zealand); Dr.-Ing. Joewono Prasetijo (Universiti Tun Hussein Onn Malaysia, Malaysia); and Dr. Tam Chat Tim (National University of Singapore, Singapore).

We would also like to extend our appreciation to the supporting institutions. Secondly, thank you to the sponsors for the utmost support and kind contribution: PT. Waskita Karya (Persero) Tbk, PT. Pamapersada Nusantara, and PT. Bank Negara Indonesia Tbk.

Many people have worked very hard for the organization of this Conference. Special thanks are needed to the Organizing Committee, Steering Committee, Editorial Board, and Scientific Committee. All of whom have generously worked to make this Conference rich in content and pleasant for the attendees. We would also like to thank all the authors who have contributed to the success of this Conference.

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Auckland, New Zealand — Monty Sutrisna
Panchor, Malaysia — Joewono Prasetijo
Klong Luang, Thailand — Bonaventura H. W. Hadikusumo
Jakarta Barat, Indonesia — Leksmono Suryo Putranto

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Single Tariff System to Provide Incentive for Longer Distance Users and to Keep Efficient Toll Gates Operations

Apta Sampoerna and Leksmono Suryo Putranto

Abstract Due to limited investment funds, the toll road construction usually should be in stages in several segments. The toll tariff of segments that were operated in the earlier stages may only be determined by the length of the segment in km multiplied by toll tariff per km. After all segments have been operated, we also need to consider additional factors, e.g., an incentive to longer distance users, efficient toll gate operations, and smooth toll gate services. Integrated toll road payment system usually implements open toll payment system with uniform tariff. Logistic vehicles which usually traveled longer distances will be subsidized by vehicles traveling shorter distances. The open toll payment system is usually implemented by payment in the upstream barrier toll gates. It will keep efficient toll gate operations by concentrating all payment equipment and officers in the upstream barrier toll gates. This paper will discuss the single tariff determination of Jakarta Outer Ring Road (JORR) 2 Area 1 connecting Jagorawi-Cinere-Serpong-Kunciran-Cengkareng. There were several factors considered, i.e., road user ability/willingness to pay, breakeven point based on predicted average an-nual daily traffic, and related regulations. The resulted single tariff was Rp. 20,000.-.

Keywords Single tariff · Incentive · Efficient introduction

1 Background

Building additional road segments might be considered as a non-sustainable transport supply program as it might encourage massive development along the road and at the end will create a congested car-dependent corridor. However, we cannot rely on a transport system on public transport provision only. The system is for passenger service. For goods transport (logistics) and for certain passenger

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movements (e.g., last-mile and first-mile transport) road transport is essential. Therefore, in a long-term plan of a city transport system, road network completeness, to avoid missing links and bottlenecks (including in toll road sub-systems) is a must.

Infrastructure (including toll road) development should be given priority in developing countries. However, the national budget is usually limited and/or should be distributed proportionally to other sub-sectors. Private-sector funding would be an alternatives source fund but might need time to be invested. Therefore, the toll road construction usually should be in stages in several segments.

The toll tariff of segments that were operated in the earlier stages may only be determined by the length of the segment in km multiplied by toll tariff per km. After all segments have been operated, we also need to consider additional factors, such as an incentive to longer distance users, efficient toll gate operations, and smooth toll gate services.

Integrated toll road payment system usually implements open toll payment system with uniform tariff regardless of the distance. Logistic vehicles which usually traveled longer distances should be provided with an incentive to support national welfare. They will be subsidized by vehicles traveling a shorter distance [1]. An open toll payment system is usually implemented by payment in the upstream barrier toll gates. It will keep efficient toll gate operations by concentrating all payment equipment and officers in the upstream barrier toll gates instead of distributing payment equipment in remote downstream tollgates. However, this may create a long queue in upstream barrier toll gates if no attention was not given to this matter. Nevertheless, the smoothness of toll gate services will not be covered by this paper. This paper will discuss the single tariff determination of Jakarta Outer Ring Road (JORR) 2 Area 1. Total observed length 50.43 km (Fig. 1). The reason to conduct this research was to balance benefits received by road users and toll investors. There were several factors considered, i.e., road user Ability to Pay (ATP), Willingness to Pay (WTP), breakeven point based on predicted Average Annual Daily Traffic (AADT), and related regulations.

1.1 Scopes

To include ATP and WTP analysis, the only group I vehicles (passenger car, jeep, pick-up, small truck, and bus) were observed (comprise of 80–90% of toll road users). ATP and WTP questionnaire items are not relevant to company vehicles which predominantly comprise heavy logistic vehicles (from group II to V). Hypothetically this will not significantly affect the resulted single tariff determination. Moreover, the variability of travel length of private light vehicle users is usually the highest among other toll road users and, therefore, more relevant in the determination of a single tariff.

Fig. 1 JORR 2 Area 1 (circled with green line)

2 Literature Review

2.1 Types of Toll Transaction System

There are three types of toll transaction systems [2], i.e.:

- Open transaction system (single tariff) and the payment conducted in off-ramp (downstream). Please refer to Fig. 2.
- Open transaction system (single tariff) and the payment conducted in on-ramp (upstream). Please refer to Fig. 3.
- Closed transaction system (based on distance) and therefore the vehicle should be identified in the on-ramp (upstream) and payment conducted in off-ramp (downstream) based on identified distance. Please refer to Fig. 4

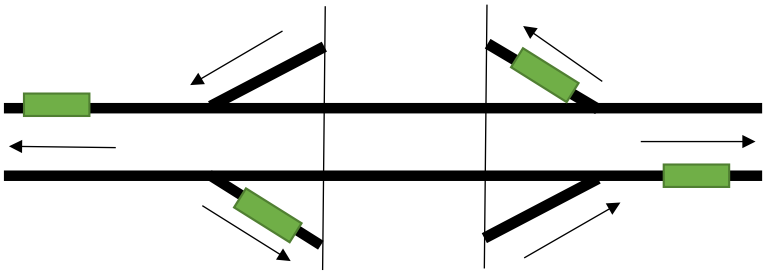

Fig. 2 Open transaction system (off-ramp payment)

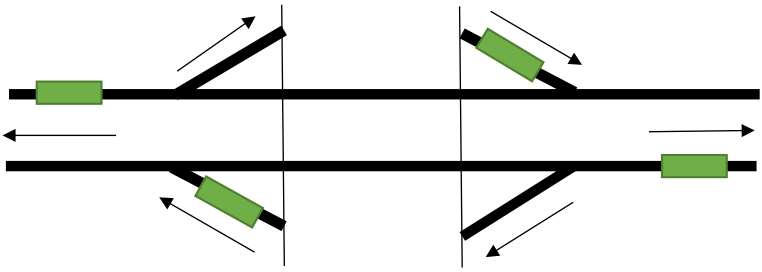

Fig. 3 Open transaction system (on-ramp payment)

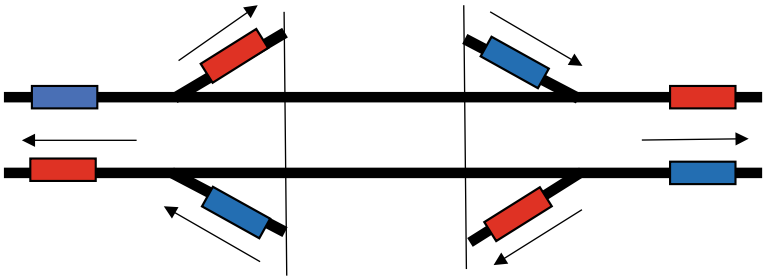

Fig. 4 Closed transaction system

2.2 ATP and WTP

ATP is the ability of someone to pay for the received services based on his/her wealth level. The approach used in ATP analysis is based on transport cost analysis from routine income earned. In other words, ATP is the ability of the public to pay his/her travel costs as stated by Tamin et al. [3]. According to Yulianto et al. [4], there were several factors affecting ATP, i.e., the amount of the income, transport demand, total transport cost, and percentage of income disbursed for transport cost.

WTP is the willingness of service users to pay for the received services. According to Hotmaida [5] and Nugroho et al. [6], several factors were affecting WTP, i.e., offered product, service quality, user utility of the transport services, and transport user behavior.

3 Method of Data Collection and Analysis

3.1 Method of Data Collection

There were two groups of data used in this paper, i.e., secondary data and primary data. The main secondary data was predicted AADT and regulations regarding toll road financing to calculate tariff based on breakeven point. Primary data was collected from group I vehicle users, consist of:

- General data (name, age, gender, educational attainment, and occupation).
- ATP data (monthly travel frequency, average travel time, travel period, monthly income, monthly toll road expenses, and travel purpose)
- WTP data (choice between 10, 20 and 30 min time saving for choice of tariff between twenty thousand rupiahs and thirty thousand rupiahs)

3.2 Method of Data Analysis

Figures 5, 6, and 7 describe the steps taken for determining the single tariff:

4 Profile of Respondents

There were 126 respondents (40 females and 86 males). However, only 122 responded to ATP-related questions and therefore, the ATP/ km data was only calculated from those 122 respondents. Their mean age was about 37 years old

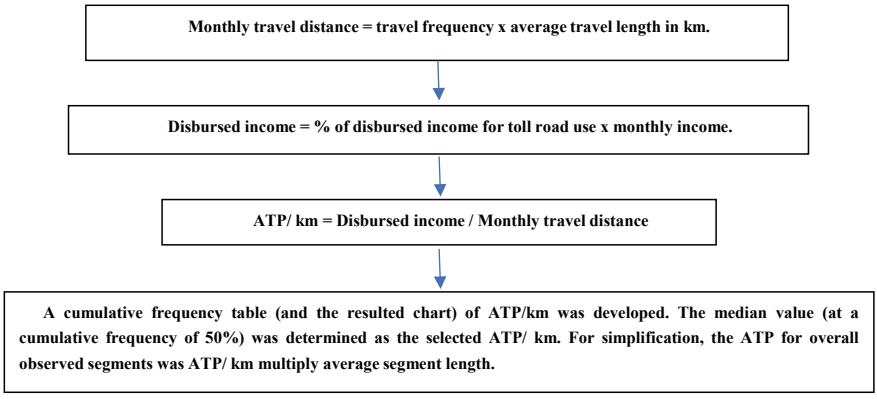

Fig. 5 Determination of ATP

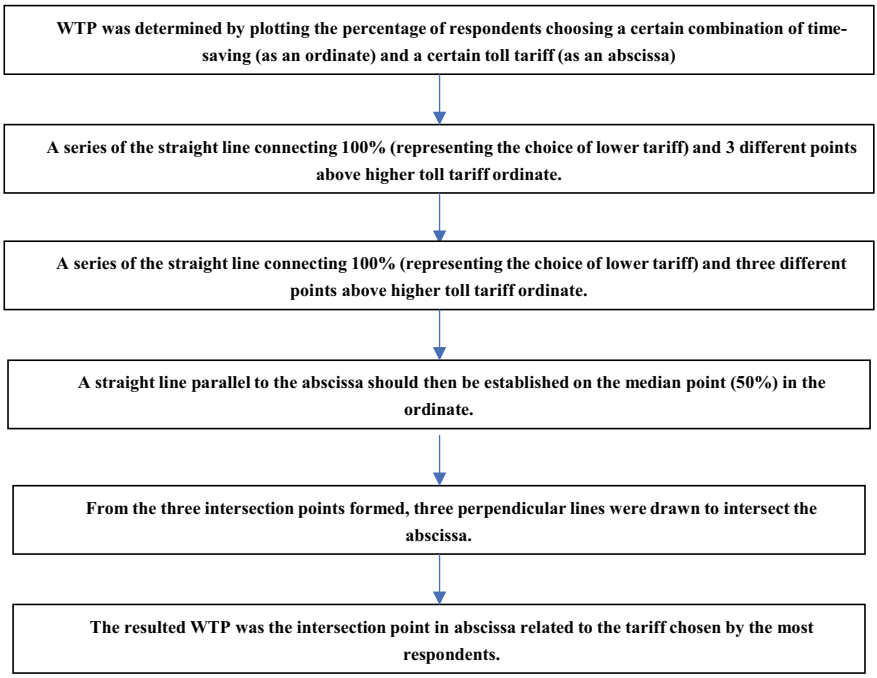

Fig. 6 Determination of WTP

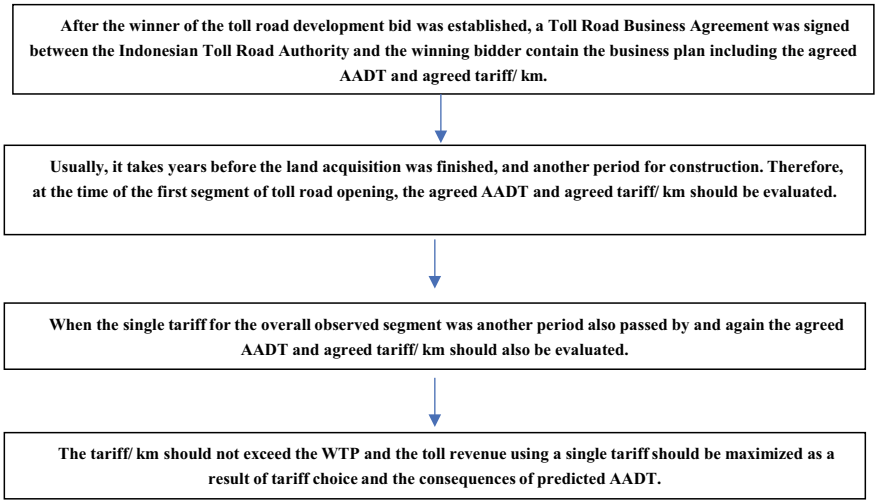

Fig. 7 Adjustment of selected single tariff

(standard deviation of 12) and ranged between 19 and 64 years old. Most of them (about 55%) earned less than 10 million rupiahs (USD 696 as 22 May 2021 exchange rate) monthly, about 33% earned above 10 million rupiahs up to 20 million rupiahs (USD 1392) monthly, about 8% earned above 20 million rupiahs up to 30 million rupiahs (USD 2088) monthly, and less than 5% earned above 30 million rupiahs monthly. About 31% of them spend less than 1 million rupiahs (USD 70) on toll roads monthly, about 27% spend more than 1 million rupiahs up to 3 million rupiahs (USD 209) monthly and most of them (about 42%) spend more than 3 million rupiahs monthly. The monthly travel frequency of most of them (54%) was more than seven times while the rest travel less. Travel time on the toll of most of them (about 63%) spends 30 to 60 min while the rest travel with a less or longer period. Most of the respondents travel on toll roads during morning and afternoon peak hours. Most of them (66%) travel on the toll road for work/ business purposes and the rest for various non-work purposes.

5 Results

5.1 ATP Analysis

Figure 8 shows that the 50-percentile of ATP was Rp. 2,800.-/ km. Therefore the ATP of each segment was Rp. 39,732.- (Jagorawi-Cinere), Rp. 28,392.- (Cinere-Serpong), Rp. 31,920.- (Serpong-Kunciran) and Rp. 39,732.- (Kunciran-Cengkareng) respectively. To simplify the overall ATP determination, an average of ATP of overall JORR 2 Area 1 weighted by each segment length was established as representative ATP, i.e., Rp. 36,102.-

5.2 WTP Analysis

Table 1 shows the number and percentage of respondents choosing each pair of time-saving and toll tariff. The lowest choice tariff (Rp. 20,000.-) was assumed to be chosen by 100% of the respondent while the percentage higher choice of tariff (Rp. 30,000.-) was calculated by dividing the number of respondents choosing it divided by the total respondent choosing the particular time-saving.

Figure 9 shows the WTP for all segments in the observed JORR 2 Area 1.

The determination of WTP at three different time-savings was by selecting the value chosen by most respondents. In this case, it was Rp. 29,000.- for a time-saving of 30 min.

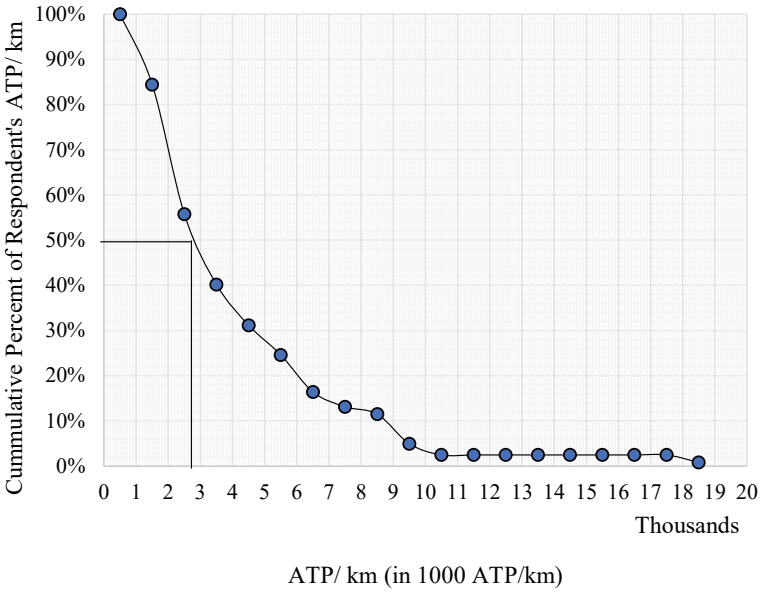

Fig. 8 50-percentile of ATP, i.e. Rp. 2,800.-/ km

Table 1 Number and percentage of respondents choosing certain pair of time-saving and toll-tariff

Ruas		Percentage of respondent (%)			Number of respondents		
		10 min	20 min	30 min	10 min	20 min	30 min
JORR 2 Area 1 (50.43 km)							
Tariff	20,000	100.0	100.0	100.0	93	140	162
Tariff	30,000	34.4	39.3	44.4	32	55	72

5.3 Single Tariff Adjustment

After the Toll Road Business Agreement was signed between the Indonesian Toll Road Authority and the winning bidder, a business plan containing an agreed AADT and an agreed toll tariff was established. Table 2 shows the agreed figures in this stage, let's call it stage 1.

Stage 2 was adjusted business plan after the opening of the first segment, as shown in Table 3.

At stage 3, the adjustment was conducted using a trial and error process to maximize re- venue whilst keeping the tariff below the WTP as can be seen in Tables 4, 5, 6, and 7. The AADT in Tables 5, 6, and 7 was adjusted inversely to the

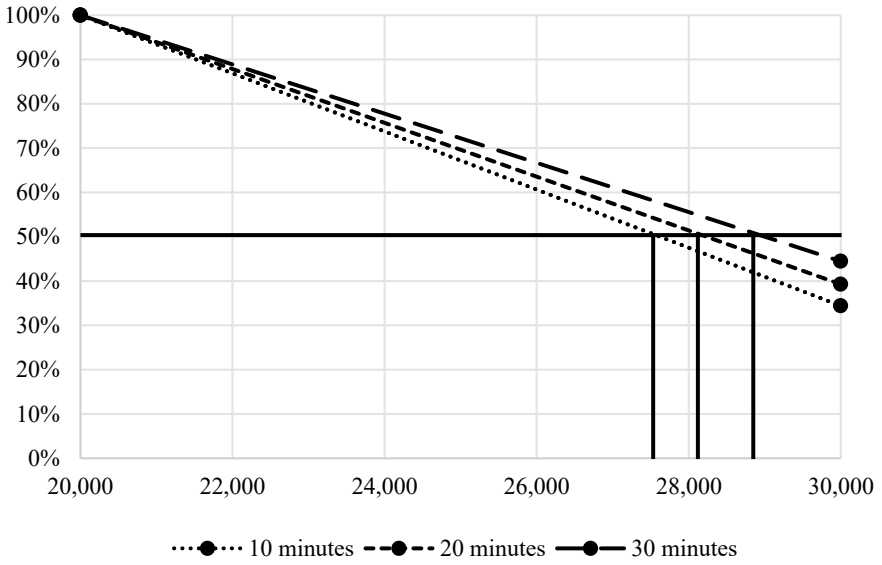

Fig. 9 WTP for all segments in the observed JORR 2 Area 1

Table 2 Toll road business plan at stage 1

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
42,084	22,000	333,305,280,000
52,911	17,500	333,339,300,000
62,843	17,500	395,390,910,000
44,314	19,500	311,084,280,000
Total revenue in Rupiah		1,373,639,760,000

Table 3 Toll road business plan at stage 2

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
26,697	22,000	211,440,240,000
31,977	17,500	201,455,100,000
24,732	17,500	155,811,600,000
41,313	19,500	290,017,260,000
Total revenue in Rupiah		858,724,200,000

toll tariff on trial. The trial in this stage stop at Table 7 as the total revenue has reached its maximum value in Table 6. Therefore, the resulting single tariff was Rp. 20,000.-. The value was acceptable as it was still under the WTP (Rp. 29,000.-).

Table 4 Toll road business plan at stage 3-trial 1

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
29,540	15,000	159,516,000,000
35,383	15,000	191,068,200,000
27,366	15,000	147,776,400,000
45,713	15,000	246,850,200,000
Total revenue in Rupiah		745,210,800,000

Table 5 Toll road business plan at stage 3-trial 2

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
25,490	17,500	160,587,000,000
30,531	17,500	192,345,300,000
23,614	17,500	148,768,200,000
39,445	17,500	248,503,500,000
Total revenue in Rupiah		750,204,000,000

Table 6 Toll road business plan at stage 3-trial 3

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
22,379	20,000	161,128,800,000
26,805	20,000	192,996,000,000
20,731	20,000	149,263,200,000
34,631	20,000	249,343,200,000
Total revenue in Rupiah		752,731,200,000

Table 7 Toll road business plan at stage 3-trial 4

AADT	Toll tariff in Rupiah	Toll revenue in Rupiah
19,715	22,500	159,691,500,000
23,615	22,500	191,281,500,000
18,265	22,500	147,946,500,000
30,510	22,500	247,131,000,000
Total revenue in Rupiah		746,050,500,000

6 Conclusions and Recommendations

Based on the analysis in this paper, several conclusions can be made as follow:

1. The ATP/ km for JORR 2 Area 1 was Rp. 2,800.-/ km.
2. The overall ATP for JORR 2 Area 1 was Rp. 36,102.-.
3. The WTP for JORR 2 Area 1 was Rp. 29,000.-.
4. After conducting three stages of tariff adjustment, the resulting single tariff was Rp. 20,000.- which was still less than WTP and therefore can be applied.

The recommended toll transaction system is an open transaction system with on-ramp payment to avoid the provision of transaction equipment in remote gates from the upstream barrier gate. Therefore, the toll gate operation will be more efficient.

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