FINAL PROJECT – TI 184833

ECONOMIC ANALYSIS ON THE IMPLEMENTATION OF DIGITAL PARKING SYSTEM (STUDY CASE: SIDOARJO REGENCY)

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INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA
2020

TUGAS AKHIR – TI 184833

ANALISIS EKONOMI PADA IMPLEMENTASI SISTEM PARKIR DIGITAL (STUDI KASUS: KABUPATEN SIDOARJO)

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APPROVAL SHEET

ECONOMIC ANALYSIS ON THE IMPLEMENTATION OF DIGITAL PARKING SYSTEM (STUDY CASE: SIDOARJO REGENCY)

FINAL PROJECT

Submitted as a Requirement to Achieve a Bachelor’s Degree from Department of
Industrial and System Engineering
Faculty of Industrial Technology and System Engineering
Institut Teknologi Sepuluh Nopember
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SURABAYA, AUGUST 2020

ABSTRAK

Fasilitas parkir yang dikelola oleh pemerintahan memiliki berbagai macam fungsi, salah satunya adalah sebagai sumber pemasukan untuk pemerintah daerah. Suatu permasalahan yang dialami dalam pengelolaan fasilitas parkir adalah sistem parkir yang kurang efektif dari segi pemungutan biaya serta kemacetan yang disebabkan oleh aktivitas pencarian parkir. Didukung dengan pertumbuhan teknologi yang pesat, pemerintah kabupaten Sidoarjo berniat untuk membuat sistem parkir baru yang selain akan menguntungkan masyarakat Sidoarjo, dapat pula memaksimalkan potensi keuntungan dari retribusi parkir. Pemerintah Daerah kabupaten Sidoarjo merencakan untuk mengaplikasikan sistem parkir digital, yang dapat disebut *e-parking,* dengan bantuan *digital application developer*. Untuk menentukan apakah sistem parkir *e-parking* memiliki dampak positif bagi perekonomian daerah Sidoarjo, penelitian ini akan membahas analisis ekonomi pada implementasi *digital parking system.* Analisis ekonomi yang dilakukan merupakan perbandingan antara *benefit* dan *cost* dari implementasi sistem *e-parking,* dimana *benefit* yang dimaksut adalah pemasukan dari retribusi parkir, penghematan Biaya Operasional Kendaraan dan nilai waktu. Parameter yang digunakan untuk mendeterminasi kelayakan ekonomi pada penelitian ini adalah *Benefit-Cost Ratio*. Analisis sensitivitas juga dilakukan untuk mengetahui kesensitivitas dari input variable yang digunakan dalam analisis ekonomi. Tujuan dari penelitian ini adalah menganalisis kelayakan ekonomi dari sistem parkir digital dan sebagai salah satu tolak ukur kelayakan implementasi sistem parkir digital di Kabupaten Sidoarjo. Hasil dari analisis ekonomi implementasi *digital parking system* adalah BCR sebesar 1,659 yang menandakan bahwa *digital parking system* layak diimplementasikan, dengan hasil analisis sensitivitas yang menyatakan bahwa minimal *parking users* adalah 70% dari total potensial dan maksimum 34 petugas parkir untuk mempertahankan kelayakan *digital parking system.*

Keywords: Sistem parkir digital, analisis ekonomi, biaya operasional kendaraan, nilai waktu, Benefit-Cost Ratio, Sensitivity Analysis

ABSTRACT

Parking facilities managed by the government has various functions, one of which is as a source of income for regional governments. A problem that occurs in managing parking facility is the ineffective parking system in terms of fee collection and congestion due to cruising activities to search for parking slots. Supported by the growth of technological development, Sidoarjo Regency regional government sought out to create a new parking system that not only will benefit the Sidoarjo community, but also maximize the potential revenue from parking retribution.The regional government has planned to apply a digital parking system, which can be referred to as e-parking, with the help of a digital application developer. To determine whether the parking system will be beneficial to economic welfare of Sidoarjo, this research will discuss the economic analysis of digital parking system implementation. Economic analysis in this research is in the form of comparison between the benefit and cost of e-parking implementation, where the benefits are income from parking retribution. savings in Vehicle Operating Cost and time value. Parameters used to determine the economic feasibility in this research is Benefit-Cost Ratio. Sensitivity analysis is also done to identify sensitivity of each input variable used in the economic analysis. The goal for this research is to analyze the economic feasibility of digital parking system and to act as one of the benchmarks to measure the feasibility of digital parking system implementation in Sidoarjo Regency. The result of the economic analysis on the implementation of digital parking system is a BCR value of 1.659 which indicates that the digital parking system is feasible, with the result of sensitivity analysis that states a minimum of 70% parking users out of the total potential and maximum of 34 parking officers to maintain the feasibility of the digital parking system.

Keywords: Digital parking system, economic analysis, vehicle operating cost, time value, Benefit-Cost Ratio, Sensitivity Analysis

ACKNOWLEDGEMENT

Thanks to God for His Blessings that enables the writer to finish this final report with the title “Economic Analysis on the Implementation of Digital Parking System (Study Case: Sidoarjo Regency)” in time. This final report will be proposed as one of the requirements in getting a bachelor’s degree in Industrial Engineering.

During the period of time to work on the final report, the writer has received tremendous support and help from various parties. In this chance, the writer would like to express her gratitude to:

1. Mr. Erwin Widodo, ST., M. Eng., Dr. Eng. as the writer’s supervisor who is always patient in giving input, advice, direction, and knowledge in the preparation of this final project.
2. Naning Aranti Wessiani, ST., MM. as the writer’s co-supervisor who is always responsive and patient in sharing knowledge as well as advice.
3. The writer’s family for all the understanding and constant support throughout the ups and downs, and for constantly giving positive encouragements.
4. Adhigana who has fought together throughout this challenging time.
5. Every lecturer in Department of Systems and Industrial Engineering for all the knowledge that has been shared to the writer throughout the last 4 years.

Hopefully this final report can be beneficial and the writer deeply apologizes for any mistakes and shortcomings that have happened throughout the process of the making of this final report.

Surabaya,   Juli 2020

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CHAPTER 1
INTRODUCTION

This chapter will explain about background of research, problem formulation, objective, benefit, limitation and assumption, and research outline that are used in the making of this research.

1.1 Background

Sidoarjo Regency is a regency located in East Java, Indonesia with an area of 719,63 km^2. Sidoarjo borders Surabaya and Gresik in its north border, Pasuruan in its south border, Mojokerto in the west border, and Madura Strait in the east border. In 2019, the population of Sidoarjo reaches 2.262.440 lives that consists of 1.140.627 male and 1.121.813 female with the population density of 2.750 lives per km^2. The population spreads within 18 sub-districts. The most populated sub-districts in Sidoarjo regency are Waru, Taman, and Sidoarjo, making up more than 30% of the whole population.

According to East Java Central Bureau of Statistics, from 2016 to 2017 Sidoarjo Regency has a population growth rate of 1.53. In comparison, from 2010-2016 the growth rate of population is 1.62. This shows that in recent years the population growth rate has increased significantly, in which the population growth of 6 years is the same as the increase in a single year. Stated in the portal of Sidoarjo regency government, the population growth increased not due to a high birth rate but due to urbanization caused by the growth of industrial sector in the regency. This situation leads to the growing number of people coming into Sidoarjo as a way to fulfill the need of labor that supports the ever-growing industrial sector in the regency. As the population continues to grow, so does the number of motorized vehicles that operate within the regency.

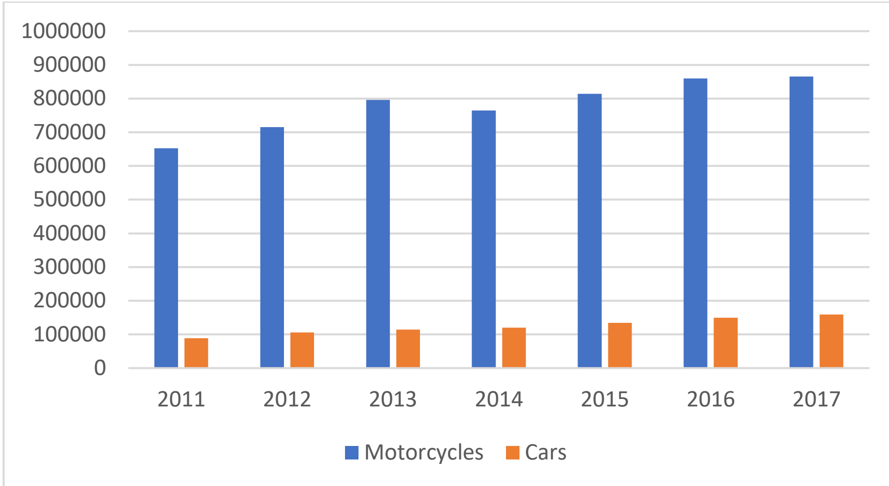

Figure 1. 1 Number of Motorcycles and Cars in Sidoarjo

(Source: Dinas Perhubungan Kabupaten Sidoarjo)

Each year the number of vehicles operating in Sidoarjo increases, as seen on the graphic above. Parking spaces play an important part in the country's transportation system, as vehicles require areas to stop and park. To accommodate the high number of vehicles in the country, the government reserves roadside parking spaces with a regulated price and parking officers who controls the parking area. Cars and motorcycles will be parked with the help of parking officers, and the vehicle owner will pay for the parking fee through the officers. The parking retributions contributes to the income of the governments in each region, including Sidoarjo. Parking retribution shows high potential in contributing to regional government income, with the number of vehicles that keeps increasing.

However, it has been proven that the system does not realize the target of income that is targeted from the government due to illegal levies by parking officers that does not align with the regulation. The comparison between target and realization of parking retribution is shown in figure 1.2.

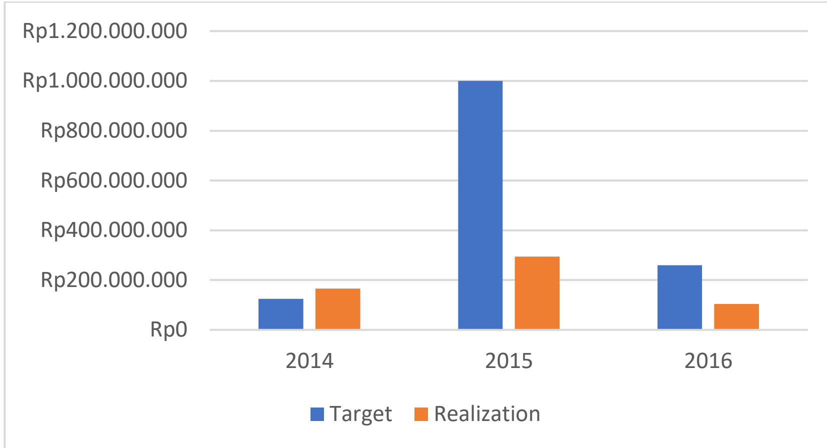

Figure 1. 2 Target and Realization of Parking Retribution in Sidoarjo

(Source: Dinas Perhubungan Kabupaten Sidoarjo)

Sidoarjo Regency Government introduced a new system of parking subscription stated in Local Regulation No. 8 Year 2008. The new concept had been applied since 2010, where vehicle-users are charged for parking subscriptions once for unlimited use in a period of time. However, this concept was not welcomed by the people, stating that the retribution fee of parking subscription is not comparable to the service given. Illegal levies were also imposed by parking officers despite the subscription. One way to solve the issue of ineffective parking system is to utilize the rapidly advancing technological developments.

Technological development is advancing rapidly in Indonesia, affecting most aspects of life. One way it has affected the society is in the form of e-government. E-government is the use of information technology to connect the government with society, supported by *Instruksi Presiden Republik Indonesia Nomor 3 Tahun 2003 tentang Kebijakan dan Strategi Nasional Pengembangan e-government.* The development of e-government is triggered by the globalization era followed by the fast-paced flow of information that requires governmental information to be spread in a short period of time. Through e-government, the government aims to increase the quality of public services and provide easier access to information and transaction for those services. The application of e-government is also supported by the number of populations with access to internet in Indonesia. According to APJII, the number of people with access to the internet has reached 171.17 million lives out of the total of 264 million people in April 2019. This means 64.8% of people in Indonesia has access to the internet, with the numbers rapidly growing each year.

The problem of ineffective parking system and the growth of technological development, especially in the form of e-government, leads to the formulation of a new parking system concept. The transactional aspect of e-government is used in this new concept. It consists of online transaction through application to ensure that the parking retribution fee is paid according to the regulation set on parking retribution fee. Applying online transaction is also expected to ensure that all retribution fee is received directly by the government and prevents illegal levies by parking officers. Online system is also expected to increase the quality of parking system and decrease traffic congestion, by the application of booking system which is planned to be a feature of the digital parking system.

The digital parking system itself is a revenue-based project, focusing on garnering the revenue potential from parking activities in Sidoarjo. However, as a governmental project, it is crucial to know how the implementation of digital parking system will affect the society in Sidoarjo. According to a study by Inrix, in modern society 5-10 minutes is wasted to find a spot in a parking area, wasting 3.6 billion hours of time and 1.7 billion gallons of fuel annually. A reservation or booking feature that allows users to have information on the actual condition of the parking area can reduce those types of waste. By developing this feature, a digital parking system can benefit both the government by maximizing revenue as well as the society by reducing waste.

Economic analysis on the project can give insight to how much impact the new parking system gives to the society, and how it can affect the welfare of the citizen. Forecasting the effect of the new system will give opportunities for improvements and increasing efficiency as well as effectiveness, while also avoiding the infliction of loss. Economic benefit gained from improving parking system come in the form of vehicle operating cost and time value saving, while costs come in the form of capital and operational cost.

This research will analyze the total economic impact of the digital parking system that allows the maximization of potential in parking retribution and allows user to access information on parking area condition and availability thus allowing user to cut down on travel time and distance to cruise for parking spaces. The economic benefit is compared with the costs of the parking system to analyze the economic feasibility which will be evaluated by calculating Benefit-Cost Ratio. Benefit-Cost Ratio is commonly used to evaluate investment plans or determining between alternatives by quantifying benefits into monetary unit and comparing it with the cost needed to invest in a project.

1.2 Problem Formulation

Based on the background problem explained in the previous subchapter, the problem formulation in this research is to do an economic analysis of implementing a digital parking system in Sidoarjo by analyzing its benefits and cost for the economy.

1.3 Objective

Objective of the research are:

1. Calculate the potential revenue of parking activities based on potential parking users.
2. Calculate savings in vehicle operating cost and time value after implementation of digital parking system.
3. Analyze the economic feasibility of the digital parking system in Sidoarjo Regency using BCR analysis.

1.4 Benefit

This research is hoped to be beneficial by contributing as one of the benchmarks for determining the feasibility of digital parking system implementation in Sidoarjo from economic point of view.

1.5 **Scope of Research**

Assumptions and limitations for this research are explained in this subchapter.

1.5.1 Assumption

Assumptions used in this research are:

1. Benefit of the digital parking system are parking retribution from cars and motorcycles, Vehicle Operating Cost and time value savings.
2. The project lifetime of the digital parking system in Sidoarjo is assumed to be 15 years.
3. The digital parking system is used by 100% of the potential parking users.

1.5.2 Limitation

Limitation of this research are:

1. The observation object is limited to Gajah Mada Street with the length of 0.99 kilometers.
2. Data collected are secondary data from previous researches and studies.
3. VOC and time value savings are limited to class 1A vehicles or passenger cars.
4. Economic feasibility of the project is evaluated by BCR as the parameter.

1.6 **Research Outline**

Research outline used in this research report is as explained in this subchapter:

CHAPTER I INTRODUCTION

This chapter explains about the background of the research, problem formulation, objective, benefit, scope of research including assumption and limitation, and the research outline.

CHAPTER II LITERATURE REVIEW

This chapter explains about the literature review used to support the research. The theoretical concepts are used to help the researcher in undergoing the research. The literature review used in this research consists of explanation of parking system, vehicle operating cost, time value, and economic analysis.

CHAPTER III RESEARCH METHODOLOGY

This chapter explains about the research methodology used in the research. The methodology is explained systematically to ensure that the research is done accordingly to achieve the objective.

CHAPTER IV DATA COLLECTION AND PROCESSING

This chapter shows the data collection and processing in the research. The data collected and processed will be used as a base for further analysis.

CHAPTER V ECONOMIC ANALYSIS

This chapter shows the economic analysis and interpretation from the data collection and processing done in the previous chapter. The result of the research is shown in this chapter.

CHAPTER VI CONCLUSION AND RECOMMENDATION

This chapter shows the conclusion and recommendation of the research which answers the objective of the research. Recommendation is also given for the company and upcoming researches.

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CHAPTER 2
LITERATURE REVIEW

This chapter discusses the literature review used in the making of this research on the topics of parking systems, vehicle operating cost, time value, and economic analysis

2.1 **Parking Systems**

According to the Oxford Dictionary, parking can be defined as an act of bringing a vehicle to a halt and leaving it temporarily, typically in a parking space or by the side of the road. Another definition of parking is leaving a vehicle in a particular place for a period of time (Cambridge, n.d.). *Undang-Undang nomor 22 tahun 2009 Pasal 1 Ayat 15* states that parkir is "*keadaan Kendaraan berhenti atau tidak bergerak untuk beberapa saat dan ditinggalkan pengemudinya.*"

Parking facilities are formulated to manage any sort of parking activities. In Indonesia, parking facilities are regulated in *Undang-Undang nomor 22 tahun 2009 Pasal 43* and *Pasal 44.* The regulation states that parking facilities can be provided off-street in accordance of the permission granted. Parking facilities can be facilitated by either legal entities or individual Indonesian citizen. Parking facilities may be provided on-street in certain conditions, requiring the presence of traffic signs or road markings. Further explanation states that "Public Parking" refers to the space to park vehicles at a fee. It is also stated that parking location and construction of parking facilities are further regulated by regional governments in individual region of Indonesia.

2.1.1 Parking Systems in Sidoarjo

Parking systems in Sidoarjo are regulated by *Peraturan Daerah Kabupaten Sidoarjo No. 17 Tahun 2019 tentang Penyelenggaraan Parkir di Kabupaten Sidoarjo*. In *Pasal 2*, it is stated that parking facilities may be held by regional government or other parties apart from regional government. Parking facilities by regional government involves 2 types of parking, off-street and on-street parking.

On-street parking are parking spaces that is located at the side of street spaces. The location determination must be in accordance with the urban planning of the regency and meet the requirements that consists of not interfering with the safety and continuity of traffic or pedestrian and disabilities facilities. Incidental parking is allowed in the condition that parking spaces have exceeded capacity as long as it does not interfere with the aforementioned matters. Meanwhile, off-street parking are parking spaces that are outside of street spaces, developed by regional government. These parking spaces may be integrated with residential, office, industrial, and trade area.

2.1.2 Digital Parking System

Digital parking system is a parking system that utilizes the growth of technological development in its system. Innovation in parking systems are made to accommodate the growing number of population as well as maximize the potential of the system.

In the digital parking system in Sidoarjo, vehicle users are required to download a parking application on their mobile phones. Upon arriving at the parking space, users will scan a QR code given by the parking attendants. User will then receive a parking ticket through their mobile application. When leaving the parking space, user will press on the “Parking Out” button on the parking ticket and scan the QR code from the parking attendants. This system eliminates physical transaction and reduces the possibility of illegal levies. The flow of digital parking system is shown in figure 2.1.

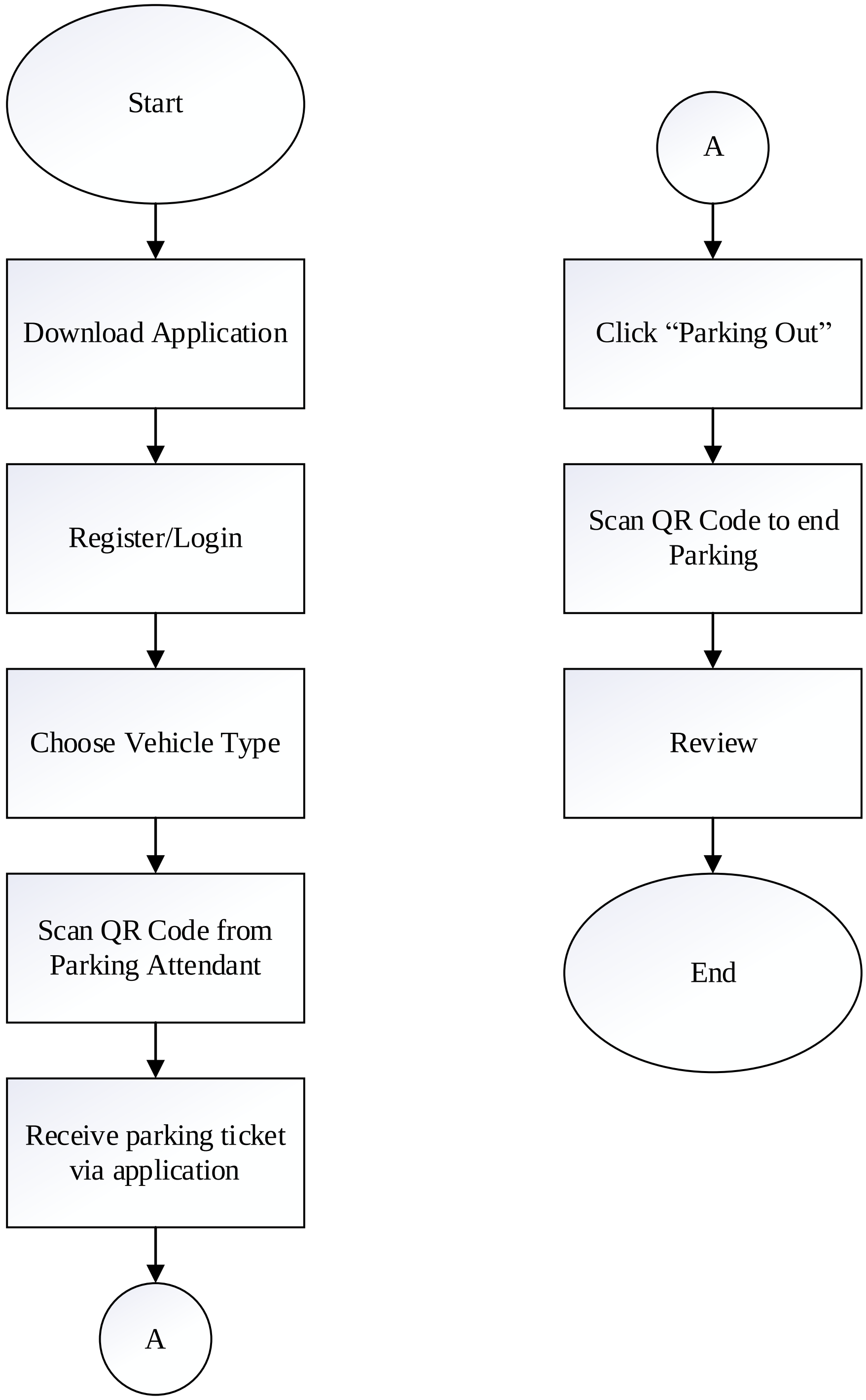

Figure 2. 1 Flow of Digital Parking Application

2.2 Vehicle Operating Cost

Vehicle operating cost refers to the expense spent when operating a vehicle. The cost is divided into fixed and variable cost. Fixed cost is also called the ownership cost and is unaffected by changes in service production volume. Meanwhile, variable cost consists of expenses that are affected by volume of service production (Litman, 2009). In short, vehicle operating cost is calculated using the following formula:

$$VOC = FC + VC$$

where:

VOC = Vehicle Operating Cost

FC = Fixed Cost

VC = Vehicle cost

2.2.1 Vehicle Operating Cost using PCI Model

One way to calculate Vehicle Operating Cost is by using the PCI (Pacific Consultant International) 1988 Model, which take into consideration the variable of speed. The VOC calculation uses the following cost components and formula for passenger cars:

1. Fuel Cost

   $$Y = 0{,}05693\ x\ S^2 - 6{,}42593\ x\ S + 269{,}18567$$

   where:

   Y = fuel consumption (liter/1000 km)

   S = vehicle speed (km/hour)

2. Lubricant Cost

   $$Y = 0{,}00037\ x\ S^2 - 0{,}04070\ x\ S + 2{,}20403$$

   where:

   Y = Lubricant consumption (liter/1000km)

   S = vehicle speed (km/hour)

3. Tire Usage

$$Y = 0{,}0008848\ x\ S - 0{,}004533$$

where:

Y = Tire consumption every 1000 km (tire/1000 km)

S = vehicle speed (km/hour)

4. Maintenance Cost

Maintenance cost consists of two components, spare part cost and mechanic cost.

a. Spare Part Cost

$$Y = 0{,}0000064\ x\ S + 0{,}0005567$$

where:

Y = maintenance cost every 1000 km

S = vehicle speed (km/hour)

b. Mechanic Cost

$$Y = 0{,}00362\ x\ S + 0{,}36267$$

where:

Y = service for every 1000 km

S = speed (km/hour)

5. Depreciation Cost

$$Y = \frac{1}{(2{,}5\ x\ S + 125)}$$

where:

Y = depreciation cost for every 1000 km

S = speed (km/hour)

6. Insurance Cost

$$Y = \frac{38}{500\ x\ S}$$

where:

Y = insurance cost every 1000 km

S = speed (km/hour)

7. Capital Interest

$$Y = \frac{150}{500\ x\ S}$$

where:

Y = capital interest cost every 1000 km

S = speed (km/hour)

2.3 Time Value

According to LAPI ITB (2002), time value or saving value of time is defined as the amount of monetary value that an individual willingly pay for to save travel time. The calculation of time value considers the region's Gross Regional Domestic Product.

$$Time\ Value = Max\{(k * basic\ time\ value); minimum\ time\ value\}$$

where the value of basic time value, minimum time value, and k are as shown from table 2.1, table 2.2, and table 2.3. The time value varies between regions.

Table 2. 1 Basic Time Value

Reference	Time Value (Rp/Hour/Vehicle)		
	Class I	Class IIA	Class IIB
PT Jasa Marga	12.287	18.543	13.768
Padalarang-Cileunyi (1996)	3.385-5.425	3.827-8.344	5.716
Semarang (1996)	3.144 - 6.221	14.541	1.506
IHCM (1995)	3.281	18.212	4.971
PCI (1979)	1.341	3.827	3.152
JIUTR Northern Extension (PCI, 1989)	7.067	14.670	3.659
Surabaya-Mojokerto (JICA, 1991)	8.880	7.960	7.980

Source: (LAPI-ITB 1997)

Minimum time value for regions in Indonesia are as shown in table 2.2.

Table 2. 2 Minimum Time Value

No	Region	Jasa Marga			JIUTR		
		Class I	Class IIA	Class IIB	Class I	Class IIA	Class IIB
1	Special Capital District	8200	12369	9188	8200	17022	4246
2	Other than SCD	6000	9051	6723	6000	12455	3170

Source: (LAPI-ITB 1997)

Correction score to adjust basic time value according to different regions in Indonesia are shown in table 2.3. The correction score is in comparison to Gross Regional Domestic Product of each region.

Table 2. 3 Correction Score (k)

Location	GRDP	Population	GRDP per capita (million rupiah)	Correction Score (k)
DKI Jakarta	60.638.217,00	9.113.000	6,65	1
Jawa Barat	60.940.114,00	39.207.000	1,55	0,23
Kodya Bandung	6.097.380,00	2.356.120	2,59	0,39
Jawa Tengah	39.125.322,52	29.653.000	1,32	0,2
Kodya Semarang	4.682.001,84	1.346.352	3,48	0,52
Jawa Timur	57.047.812,41	33.844.000	1,69	0,25
Kodya Surabaya	13.231.986,49	2.694.554	4,91	0,74
Sumatera Utara	21.802.507,84	11.115.000	1,96	0,29
Kodya Medan	5.478.923,73	1.800.000	3,04	0,46

Source: (LAPI-ITB 1997)

2.4 **Economic Analysis**

Economic analysis involves analyzing aspects related to the economic feasibility or evaluation of a project. The main purpose of economic analysis is to help design and select projects that contribute welfare of a country (Belli and Anderson, 1997). It is useful when done during the early stages of a project to prevent running a bad project. From economic analysis, the project's impact can be forecasted, and from that the project itself can be evaluated to maximize the expected impact. Economic feasibility can be evaluated by calculating BCR as parameter.

2.4.1 Benefit-Cost Ratio

Benefit-Cost Ratio is used to summarize the overall relationship between the relative cots and benefits of a project (Hayes, 2019). It compares the cost of investment in a project with the benefit it produces. It is commonly used in management evaluation process but does not close the possibility of being applied in planning process. BCR analysis is applicable in determining best alternatives as well as evaluating a planned project by comparing benefits and cost gained from

Benefits from calculating BCR and benefit cost analysis are generally categorized into economic and non-economic benefits. Economic benefits may be in the form of

2.4.2 Application of Benefit-Cost Ratio

In the application of BCR, benefits and cost of a project should be quantified into currency unit. A point of view should be chosen to determine the types of benefits that will be received and the cost that needs to be spent. Then the benefits and costs are quantified to equivalent currency to enable comparison.

The formula for calculating BCR is as follow:

$$BCR = \frac{Benefit}{Cost}$$

Where:

Benefit = user cost saving

Cost = investment and operational cost

BCR is used as an evaluation parameter for the feasibility of a project based on the following criteria:

a. BCR > 1, project benefit is greater than the cost, thus the project is feasible.
b. BCR = 1, project benefit is equal to the cost, thus project is feasible but not beneficial.
c. BCR < 1, project benefit is less than the cost, thus the project is not feasible.

2.5 Sensitivity Analysis

Sensitivity analysis is a method that measures how the impact of uncertainties of one or more input parameter can lead to uncertainties on the output parameter (C. Pichery,2014). It analyzes the outcome in changes to certain variable and measures the sensitivity of a variable towards certain changes. Sensitivity analysis may be applied at the planning process of an investment of a project to determine how certain changes in the value of variables may affects the feasibility of the project.

Application of sensitivity analysis is done by changing the value of some variables and see whether the change greatly impacts the output of a project. Sensitivity analysis is useful as planning process commonly use estimated values, and the analysis can create a prediction of how a deviation from the actual condition and the estimate may change the output result. Sensitivity analysis is also referred to the what-if analysis, which predicts the outcome of a decision with a change of range in variables.

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CHAPTER 3
RESEARCH METHODOLOGY

This chapter will show the methodology flowchart of this research and explain about the steps of methodology used in the research.

3.1 Research Methodology Flowchart

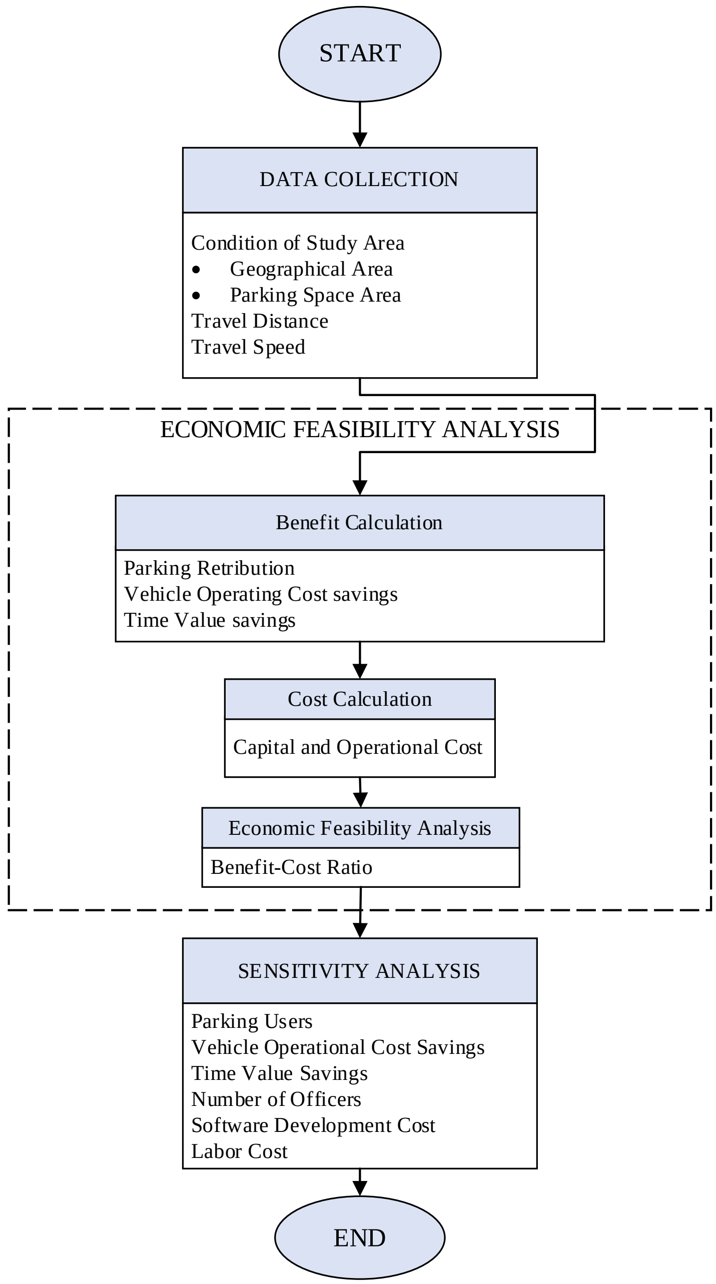

Figure 3. 1 Methodology Flowchart

3.2 Data Collection

Data collection for this research consists of secondary data from previous researches. The data needed for this research are geographical and parking area condition of Gajah Mada Street such as the length of Gajah Mada Street, number of parking slots and parking potentials. Other data are the travel distance and travel speed of vehicles in both the existing condition and after the implementation of digital parking system. Assumptions on some data are made due to limitation in possibility to conduct survey. These assumptions are supported by past studies involving reservation-based and smart parking systems.

3.3 Economic Analysis

3.3.1 Calculation of Parking Retribution Income

Parking retribution income is calculated by determining the potential number of vehicle units that utilizes the parking area facilities. The vehicles in consideration of this calculation are passenger cars (class 1A vehicles) and motorcycles. Total income potential from parking retribution is calculated by multiplying potential parking users with parking fee, resulting in the gross income.

3.3.2 Calculation of Vehicle Operating Cost and Saving

Vehicle Operating Cost is calculated using PCI method with the formulas as shown on subchapter 2.3. The calculation of vehicle operating cost savings is limited to passenger cars or vehicle class 1A as it is the type of vehicle that is most common to be cruising for parking, rather than motorcycles. Passenger cars are also the most significantly affected with the information of parking availability as well as a booking feature that is featured in the digital parking system application. Variable cost components to calculate the vehicle operating cost that will be used in the research are as shown in table 3.1.

Table 3. 1 Variable Cost Components

No	Cost Components	Unit	Unit Price (Rp)
1	Passenger car	Unit	210.000.000
2	Fuel	Liter	6.800
3	Tire	Unit	800.000
4	Lubricants	Liter	60.000
5	Maintenance	Unit	250.000
6	Mechanic	Hour	10.000

Vehicle Operating Cost is calculated for the existing condition and the condition with the implementation of digital parking system to determine the amount of saving that will be gained with the application of digital parking system.

3.3.3 Calculation of Time Value and Saving

Calculation of time value uses the time value from PT. Jasa Marga (1990-1996). Vehicle Operating Cost is calculated for the existing condition and the condition with the implementation of digital parking system. To calculate time value saving, first travel time should be determined considering travel distance and travel speed. Basic time value and minimum time value stated in the literature review should be converted to the present value by comparing the dollar exchange rate between 1996 and present. The largest value between basic time value and minimum time value will be applied as the time value.

3.3.4 Calculation of Investment and Operational Cost

Investment and Operational Cost for developing the digital parking system are calculated for later comparison with the benefit. Investment cost encompass the development cost for software, hardware, equipment, preparation cost, and others that will be further explained, which are needed to launch the project. Operational cost is made up of variable and fixed cost, which will be spent throughout the time of digital parking system implementation.

3.4 **Economic Feasibility Analysis**

Economic feasibility will be evaluating whether the digital parking system is worthy to be implemented through an economic point of view. The feasibility will be evaluated based on the calculation result of BCR using the vehicle operational cost and time value saving as the benefit of the project based on the assumption that the project lifetime is 15 years. The project will be determined economically feasible when the value of BCR is greater than 1 at the end of the 15 years lifetime, which indicates that the benefits gained from the parking system is greater than its cost spent.

3.5 **Sensitivity Analysis**

Sensitivity analysis is done on some input variables to know whether changes in those variables will affect the economic feasibility of the digital parking system. Some input variables that will be analyzed are parking users, VOC savings, time value savings, number of parking officers, software development cost, as well as labor cost.

The sensitivity analysis calculates changes in BCR to identify the impact of changes in each variable, and whether the changes will result in different conclusions. This is done to prepare for difference in data estimations compared to actual condition, as the data used in the research consists of mostly secondary data and assumptions due to limitations in ability for direct observations.

CHAPTER 4

DATA COLLECTION AND PROCESSING

This chapter consists of data collection and processing of condition of study area, travel speed, and travel distance which will then be used in further economic analysis in the research.

4.1 Condition of Study Area

This subchapter discusses the condition of the study area in this research, consisting of the geographical and parking area condition.

4.1.1 Geographical Condition

This research analyzes the impact of application of digital parking system in Sidoarjo, precisely in Gajah Mada Street of Sidoarjo District. The location of the street is as shown in Figure 4.1. Gajah Mada Street is a one-way street and one of the protocol streets in Sidoarjo with a total length of 0.99 KM.

Figure 4.1 Map of Gajah Mada Street
(Source: Google Maps)

Gajah Mada Street is chosen as the study area as it is one of the main protocol streets that often experience congestions especially in its peak hour and season, such as holiday seasons. The street is lined with various restaurants, shops, and other services that requires parking areas to be accessible by customers.

4.1.2 Parking Area Condition

Gajah Mada street consists of on-street parking for both cars and motorcycle on one side of the street. The extensive number of shops, restaurants, and other stores along the road with limited land area is one of the causes of such parking method. The parking areas are divided into 10 blocks with parking areas described in table 4.1.

Table 4. 1 Parking Blocks

Parking Blocks	Description	Square Area (Meter)
I	Counter Oppo - KTV & Pool	80
II	Sop Ayam Klaten - RJ Steel	191
III	Jamu Iboe - Seb. Utara Buk Wedi	25
IV	Toko Sinar Mas - Apotik Pangestu	84
V	Indomart Gama - Apotek 7	108
VI	Tk Gunung Mas - Cwiemie Malang	68,5
VII	Bata - Homemart	62
VIII	Toko Benang - BNI Syariah	80
IX	Toko Nazir - Pusat Kuliner Baru	38
X	Tk Nusantar - Anugrah Baru Karpet	90
TOTAL		826,5

To manage the on-street parking activities along Gajah Mada street, parking officers are assigned with the appropriate number as needed for each parking block. The parking officers work according to the shifts specified for their parking block. The working hour of parking officers is 07.00-21.00, with each shift consisting of 7 hours. The first shift has a working hour of 07.00-14.00 and the second shift with the working hours of 14.00-21.00.

Table 4. 2 Parking Officers

Parking Blocks	Parking Officer	Shifts
I	2	2
II	4	2
III	1	2
IV	2	2
V	2	2
VI	2	2
VII	2	2
VIII	2	2
IX	1	2
X	1	2
TOTAL	19	

Each parking block, in accordance with its own square area, has certain parking slot units. These are the number of parking slots available for the parking activities. Parking potential indicates the number of vehicles that utilizes the parking slot units per day. This correlates with how long vehicles use up parking slots. Based on past research and survey, the parking space units and daily potential for each parking block is as shown in table 4.3. The parking spaces for cars and motorcycles are dedicated, which means the slots are not interchangeable. Spaces for motorcycles are separated by traffic signs and barriers to prevent other vehicles to occupy said spaces.

Table 4. 3 Parking Potential

Parking Blocks	Cars		Motorcycles	
	Parking Space Units	Potential	Parking Space Units	Potential
I	31	62	105	110
II	76	87	255	300
III	12	26	33	66
IV	34	69	112	132
V	43	84	144	200
VI	27	54	91	167

Table 4. 4 Cont. Parking Potential

Parking Blocks	Cars		Motorcycles	
	Parking Space Units	Potential	Parking Space Units	Potential
VII	25	50	83	161
VIII	32	63	107	110
IX	15	30	51	102
X	18	36	60	120
TOTAL	313	561	1041	1468

The increase of vehicle number in Sidoarjo causes number of parking space daily usage potential to increase as well. Each year the daily potential of parking space usage is assumed to increase by 1%. The assumption indicates that annually, the number of users that willingly utilizes the digital parking system increases. The number of daily potentials for 15 years is summarized in table 4.4.

Table 4. 5 Complete Parking Potential

Year	Vehicle Unit Daily Potential	
	Cars	Motorcycles
2020	561	1468
2021	567	1483
2022	573	1498
2023	579	1513
2024	585	1529
2025	591	1545
2026	597	1561
2027	603	1577
2028	610	1593
2029	617	1609
2030	624	1626
2031	631	1643
2032	638	1660
2033	645	1677
2034	652	1694
2035	659	1711

4.2 Travel Distance

Travel distance in this research is the distance a vehicle goes through to arrive at a parking space, starting from the beginning of Gajah Mada Street. The length of Gajah Mada Road is registered as 0.99 KM from the beginning to the end by *Balai Besar Pelaksanaan Jalan Nasional.* Travel distance data is used to analyze the vehicle operational cost savings which is one of the social benefits in the application of digital parking system.

Gajah Mada street is a one-way and protocol street in Sidoarjo. This condition affects the existing parking activities in several ways. As a protocol street, there have been many news reports calling out the inadequate amount of parking spaces that causes traffic and urges for larger space. The one-way street system also causes vehicles to take longer travel distance to cruise for driving spaces. Cruising activity involves vehicles driving around the parking area to find available parking space.

Travel distance in the existing condition is assumed to be 1 km, considering the condition where Gajah Mada Street is a one-way street that do not enable drivers to turn around and instead having to drive around the block. Travel distance with the application of booking system in the parking system allows vehicles to know ahead of time about the condition of the parking area, thus eliminating cruising activity to find a parking space. A study done by Wang (2011) ran a simulation on traffic searching for parking, resulting in a condition where reservation policy causes decrease in travel distance. The situation is due to users ability to access information on the empty parking spaces closest to the entrance. Considering the longest distance for a vehicle to a parking space of the farthest Gajah Mada street is 0.99 km, the average travel distance with the digital parking system is assumed to be an average of 0.5 km.

4.3 Travel Speed

Travel speed refers to the speed a vehicle travels in, in this research specifically when cruising for a parking space. Past studies have proven by a survey that vehicles in parking garages with no information of parking space travels slower than vehicles that has information on parking availability to cruise for available parking spaces (Zhu, 2020). This is due to the need for drivers, especially ones without passengers, to check over every parking slots that are Assumptions are made on the travel speed based on that information. With the existing condition, vehicles travel at an average speed of 25 km/h while vehicles with information on parking availability and condition travel at a speed of 35 km/h.

CHAPTER 5
ECONOMIC ANALYSIS

This chapter contains the analysis and interpretation of the data gathered to form an economic analysis. The content consists of calculation of Parking Retribution, Vehicle Operational Cost savings, Time Value Savings, Capital, and Operational Cost, as well as BCR and sensitivity analysis.

5.1 Parking Retribution Income

Parking retribution refers to the parking fee for a vehicle to park in a parking space. Total parking retribution is calculated by considering the potential number of vehicles that utilizes the parking facilities provided by the government and the parking fee of each vehicle. Parking fee for cars is Rp 4000 while parking fees for motorcycles is Rp 2000 each, pre-determined by the government.

To calculate the annual income from parking retribution, the following formula is used, with example of income from year 2020:

$$\begin{aligned}&Annual\ Parking\ Income\\&= ((Daily\ Car\ Potential\ x\ Car\ Parking\ fee)\ x\ 365)\\&+ ((Daily\ Motorcycle\ Potential\ x\ Motorcycle\ Parking\ fee)\ x\ 365)\end{aligned}$$

$$Annual\ Parking\ Income = ((561\ x\ Rp\ 4000) x\ 365) + ((1468 x Rp\ 2000)\ x\ 365)$$

$$Annual\ Parking\ Income = Rp\ 819.060.000 + Rp\ 1.071.640.000$$

$$Annual\ Parking\ Income = Rp\ 1.890.700.000$$

The total parking income from both cars and motorcycles are further calculated and summarized in table 5.1, with the assumption that the parking retribution fee does not increase within the 15 years of digital parking system lifetime. The income from parking retribution takes into account that the parking fee is constant for the next 15 years, with increase of 1% vehicle unit each year. The income in the table is the gross income of the retribution of parking activities.

Table 5. 1 Income from Parking Retribution

Year	Cars		Motorcycles		Total
	Vehicle Unit	Parking Retribution	Vehicle Unit	Parking Retribution	
2020	561	Rp 819.060.000	1468	Rp 1.071.640.000	Rp 1.890.700.000
2021	567	Rp 827.820.000	1483	Rp 1.082.590.000	Rp 1.910.410.000
2022	573	Rp 836.580.000	1498	Rp 1.093.540.000	Rp 1.930.120.000
2023	579	Rp 845.340.000	1513	Rp 1.104.490.000	Rp 1.949.830.000
2024	585	Rp 854.100.000	1529	Rp 1.116.170.000	Rp 1.970.270.000
2025	591	Rp 862.860.000	1545	Rp 1.127.850.000	Rp 1.990.710.000
2026	597	Rp 871.620.000	1561	Rp 1.139.530.000	Rp 2.011.150.000
2027	603	Rp 880.380.000	1577	Rp 1.151.210.000	Rp 2.031.590.000
2028	610	Rp 890.600.000	1593	Rp 1.162.890.000	Rp 2.053.490.000
2029	617	Rp 900.820.000	1609	Rp 1.174.570.000	Rp 2.075.390.000
2030	624	Rp 911.040.000	1626	Rp 1.186.980.000	Rp 2.098.020.000
2031	631	Rp 921.260.000	1643	Rp 1.199.390.000	Rp 2.120.650.000
2032	638	Rp 931.480.000	1660	Rp 1.211.800.000	Rp 2.143.280.000
2033	645	Rp 941.700.000	1677	Rp 1.224.210.000	Rp 2.165.910.000
2034	652	Rp 951.920.000	1694	Rp 1.236.620.000	Rp 2.188.540.000
2035	659	Rp 962.140.000	1711	Rp 1.249.030.000	Rp 2.211.170.000

5.2 Vehicle Operational Cost

Another benefit of the application of digital parking system is the minimization of travel distance and optimizing travel speed, resulting in vehicle operational cost savings. Vehicle Operational Cost (VOC) is the cost of operating a vehicle, considering its fixed and variable cost. In this research, the method used to calculate the VOC is the PCI method. In the calculation of VOC, only class 1A vehicles or passenger cars are considered, as motorcycles are not significantly affected in terms of travel distance and travel speed by the parking system.

The calculations are based on the cost components in table 5.2. Passenger car unit price is used to calculate fixed cost such as depreciation, insurance, and capital interest while price of fuel, tire, lubricants, maintenance, and mechanics are used to calculate variable cost.

Table 5. 2 Vehicle Cost Components

No	Cost Components	Unit	Unit Price
1	Passenger car	Unit	Rp 210.000.000
2	Fuel	Litre	Rp 10.000
3	Tire	Unit	Rp 800.000
4	Lubricants	Litre	Rp 60.000
5	Maintenance	Unit	Rp 250.000
6	Mechanics	Hour	Rp 10.000

Using the PCI method formulas, the vehicle operating cost calculation of vehicle class I of the existing condition based on the cost components and travel speed are as shown in detail below:

1. Fuel Consumption

Fuel consumption per 1000 km per vehicle:

$$Fuel\ consumption = 0{,}05693\ x\ S^2 - 6{,}42593\ x\ S + 269{,}18567$$

$$Fuel\ consumption = 0{,}05693\ x\ 25^2 - 6{,}42593\ x\ 25 + 269{,}18567$$

$$Fuel\ consumption = 144{,}11867\ liter/1000\ \text{km}$$

Fuel consumption cost per 1000 km per vehicle:

$$Fuel\ consumption\ cost = 144{,}11867\ x\ fuel\ cost$$

$$Fuel\ consumption\ cost = 144{,}11867\ x\ \ Rp\ 10.000$$

$$Fuel\ consumption\ cost = Rp\ 1.441.187$$

2. Lubricant Consumption

Lubricant consumption per 1000 km per vehicle:

$$Lubricant\ consumption = 0{,}00037\ x\ S^2 - 0{,}0407\ x\ S + 2{,}20403$$

$$Lubricant\ consumption = 0{,}00037\ x\ 25^2 - 0{,}0407\ x\ 25 + 2{,}20403$$

$$Lubricant\ consumption = 1{,}41778$$

Lubricant consumption cost per 1000 km per vehicle:

$$Lubricant\ consumption\ cost = 1{,}41778\ x\ lubricant\ cost$$

$$Lubricant\ consumption\ cost = 1{,}41778\ x\ Rp\ 60.000$$

$$Lubricant\ consumption\ cost = Rp\ 1.134.224$$

3. Tire Consumption

Tire consumption per 1000 km per vehicle:

$$Tire\ consumption = 0{,}0008848\ x\ S - 0{,}004533$$

$$Tire\ consumption = 0{,}0008848\ x\ 25 - 0{,}004533$$

$$Tire\ consumption = 0{,}017587$$

Tire consumption cost per 1000 km per vehicle:

$$Tire\ consumption\ cost = 0{,}017587\ x\ tire\ cost$$

$$Tire\ consumption\ cost = 0{,}017587\ x\ Rp\ 800.000$$

$$Tire\ consumption\ cost = Rp\ 1.055$$

4. Spare Part

Spare part maintenance per 1000 km per vehicle:

$$Spare\ part\ maintenance = 0{,}0000064\ x\ S - 0{,}0005567$$

$$Spare\ part\ maintenance = 0{,}0000064\ x\ 25 - 0{,}0005567$$

$$Spare\ part\ maintenance = 0{,}0007167$$

Spare part maintenance cost per 1000 km per vehicle:

$$Spare\ part\ maintenance\ cost = 0{,}0007167\ x\ spare\ part\ cost$$

$$Spare\ part\ maintenance\ cost = 0{,}0007167\ x\ Rp\ 250.000$$

$$Spare\ part\ maintenance\ cost = Rp\ 150.507$$

5. Mechanic Cost

Mechanic service per 1000 km per vehicle:

$$Mechanic\ service = 0{,}00362\ x\ S + 0{,}36267$$

$$Mechanic\ service = 0{,}00362\ x\ 25 + 0{,}36267$$

$$Mechanic\ service = 0{,}45317$$

Mechanic service cost per 1000 km per vehicle:

$$Mechanic\ service\ cost = 0{,}45317\ x\ mechanic\ cost$$

$$Mechanic\ service\ cost = 0{,}45317\ x\ Rp\ 10.000$$

$$Mechanic\ service\ cost = Rp\ 4.532$$

6. Depreciation Cost

Depreciation per 1000 km per vehicle:

$$Depreciation = \frac{1}{(2{,}5\ x\ S + 125)}$$

$$Depreciation = \frac{1}{(2{,}5\ x\ 25 + 125)}$$

$$Depreciation = 0{,}0054$$

Depreciation cost per 1000 km per vehicle:

$$Depreciation\ cost = 0{,}0054\ x\ vehicle\ price$$

$$Depreciation\ cost = 0{,}0054\ x\ Rp\ 210.000.000$$

$$Depreciation\ cost = Rp\ 560.000$$

7. Insurance Cost

Insurance per 1000 km per vehicle:

$$Insurance = \frac{38}{(500\ x\ S\ )}$$

$$Insurance = \frac{38}{(500\ x\ 25\ )}$$

$$Insurance = 0{,}00304$$

Insurance cost per 1000 km per vehicle:

$$Insurance\ cost = 0{,}00304\ x\ vehicle\ price$$

$$Insurance\ cost = 0{,}00304\ x\ Rp\ 210.000.000$$

$$Insurance\ cost = Rp\ 638.400$$

8. Capital Interest

Capital interest per 1000 km per vehicle:

$$Capital\ interest = \frac{150}{(500\ x\ S\ )}$$

$$Capital\ interest = \frac{150}{(500\ x\ 25)}$$

$$Capital\ interest = 0{,}01$$

Capital interest cost per 1000 km per vehicle:

$$Capital\ interest\ cost = 0{,}012\ x\ vehicle\ prive$$

$$Capital\ interest\ cost = 0{,}012\ x\ Rp\ 210.000.000$$

$$Capital\ interest = Rp\ 2.520.000$$

The formula is applied to both the existing condition as well as the condition after the implementation of digital parking system, in accordance with respective travel speed. The results of VOC calculation for each condition is shown in table 5.3. The result shows the VOC of each vehicle for every 1000 km.

Table 5. 3 Vehicle Operating Cost

Description	Existing Condition				After Digital Parking System			
	Y	S (km/h)	Cost		Y	S (km/h)	Cost	
Fuel Consumption	144,11867	25	Rp	1.441.187	114,0174	35	Rp	1.140.174
Lubricant consumption	1,41778	25	Rp	1.134.224	1,23278	35	Rp	73.967
Tire consumption	0,017587	25	Rp	1.055	0,026435	35	Rp	21.148
Spare part	0,0007167	25	Rp	150.507	0,000781	35	Rp	163.947
Mechanic cost	0,45317	25	Rp	4.532	0,48937	35	Rp	4.894
Depreciation cost	0,005333333	25	Rp	560.000	0,004706	35	Rp	494.118
Insurance cost	0,00304	25	Rp	638.400	0,002171	35	Rp	456.000
Capital interest	0,012	25	Rp	2.520.000	0,008571	35	Rp	1.800.000
Total VOC			Rp	6.449.905			Rp	4.154.247

The result of VOC calculation above shows vehicle operational cost for 1 vehicle per 1000 km. The formula to calculate total VOC of Gajah Mada street in one year is as follow:

$$Total\ VOC\ per\ year = Total\ VOC\ x\ 365\ x \left(\frac{Distance}{1000}\right) x\ no.of\ vehicle\ daily$$

Total VOC per year of existing condition is calculated as shown in the calculation below:

$$Total\ VOC\ per\ year = Rp\ 6.449.905\ x\ 365\ x \left(\frac{1}{1000}\right) x\ 561$$

$$Total\ VOC\ per\ year = Rp\ 1.320.714.720$$

Total VOC per year of condition after implementation of digital parking system is calculated as shown below:

$$Total\ VOC\ per\ year = Rp\ 4.154.247\ x\ 365\ x \left(\frac{0{,}5}{1000}\right) x\ 561$$

$$Total\ VOC\ per\ year = Rp\ 425.322.178$$

The calculation of VOC is then applied to the 15 years lifetime of the parking system, in both the existing condition as well as condition after the application of the digital parking system, following the increase in daily potential usage of parking spaces.

Table 5. 4 Existing Condition VOC

EXISTING CONDITION			
Year	**Cars**	**VOC**	
2020	561	Rp	1.320.714.720
2021	574	Rp	1.334.840.011
2022	588	Rp	1.348.965.302
2023	602	Rp	1.363.090.593
2024	616	Rp	1.377.215.884
2025	631	Rp	1.391.341.175
2026	646	Rp	1.405.466.466

Table 5. 5 Cont. Existing Condition VOC

EXISTING CONDITION			
Year	**Cars**	**VOC**	
2027	661	Rp	1.419.591.757
2028	677	Rp	1.436.071.264
2029	693	Rp	1.452.550.770
2030	709	Rp	1.469.030.276
2031	726	Rp	1.485.509.783
2032	743	Rp	1.501.989.289
2033	761	Rp	1.518.468.795
2034	779	Rp	1.534.948.301
2035	797	Rp	1.551.427.808

Table 5. 6 After Digital Parking System VOC

AFTER DIGITAL PARKING SYSTEM		
Year	**Cars**	**VOC**
2020	561	Rp 425.322.178
2021	567	Rp 429.871.078
2022	573	Rp 434.419.978
2023	579	Rp 438.968.879
2024	585	Rp 443.517.779
2025	591	Rp 448.066.679
2026	597	Rp 452.615.580
2027	603	Rp 457.164.480
2028	610	Rp 462.471.530
2029	617	Rp 467.778.581
2030	624	Rp 473.085.631
2031	631	Rp 478.392.681
2032	638	Rp 483.699.732
2033	645	Rp 489.006.782
2034	652	Rp 494.313.832
2035	659	Rp 499.620.883

The existing and after project Vehicle Operational Cost is then used to calculate the savings gained by applying the digital parking system. The VOC savings is calculated by the following formula:

$$VOC\ Savings = VOC\ Existing - VOC\ After\ Digital\ Parking\ System$$

The result of annual VOC savings during the lifetime of the parking system is shown in table 5.6.

Table 5. 7 Vehicle Operational Cost Savings

Year	Cars	VOC EXISTING	VOC AFTER	VOC SAVINGS
2020	561	Rp 1.320.714.720	Rp 425.322.178	Rp 895.392.542
2021	567	Rp 1.334.840.011	Rp 429.871.078	Rp 904.968.933
2022	573	Rp 1.348.965.302	Rp 434.419.978	Rp 914.545.323
2023	579	Rp 1.363.090.593	Rp 438.968.879	Rp 924.121.714
2024	585	Rp 1.377.215.884	Rp 443.517.779	Rp 933.698.105
2025	591	Rp 1.391.341.175	Rp 448.066.679	Rp 943.274.496
2026	597	Rp 1.405.466.466	Rp 452.615.580	Rp 952.850.887
2027	603	Rp 1.419.591.757	Rp 457.164.480	Rp 962.427.277
2028	610	Rp 1.436.071.264	Rp 462.471.530	Rp 973.599.733
2029	617	Rp 1.452.550.770	Rp 467.778.581	Rp 984.772.189
2030	624	Rp 1.469.030.276	Rp 473.085.631	Rp 995.944.645
2031	631	Rp 1.485.509.783	Rp 478.392.681	Rp 1.007.117.101
2032	638	Rp 1.501.989.289	Rp 483.699.732	Rp 1.018.289.557
2033	645	Rp 1.518.468.795	Rp 489.006.782	Rp 1.029.462.013
2034	652	Rp 1.534.948.301	Rp 494.313.832	Rp 1.040.634.469
2035	659	Rp 1.551.427.808	Rp 499.620.883	Rp 1.051.806.925

5.3 Time Value

Time value refers to the amount of money spent by a user to save time. The reference used to calculate time value in this research is PT. Jasa Marga method. In the calculation of time value, only vehicles class 1A or passenger cars are considered, as motorcycles are not significantly affected in terms of travel time. To analyze the time value savings, the travel time of vehicles should be calculated based on the speed and travel distance, summarized in table 5.7.

Table 5. 8 Travel Time

Year	EXISTING CONDITION		AFTER DIGITAL PARKING SYSTEM	
	Travel Distance (Km)	Travel Time (Hour)	Travel Distance (Km)	Travel Time (Hour)
2020	1	0,04	0,5	0,01429
2021	1	0,04	0,5	0,01429
2022	1	0,04	0,5	0,01429
2023	1	0,04	0,5	0,01429
2024	1	0,04	0,5	0,01429
2025	1	0,04	0,5	0,01429
2026	1	0,04	0,5	0,01429
2027	1	0,04	0,5	0,01429
2028	1	0,04	0,5	0,01429
2029	1	0,04	0,5	0,01429
2030	1	0,04	0,5	0,01429
2031	1	0,04	0,5	0,01429
2032	1	0,04	0,5	0,01429
2033	1	0,04	0,5	0,01429
2034	1	0,04	0,5	0,01429
2035	1	0,04	0,5	0,01429

A calibration score based on the difference of monetary value from the PT Jasa Marga reference with current value is needed to calculate the time value. This is done by comparing dollar exchange rate of year 1996 with exchange rate of the current year:

$$Calibration\ Score = \frac{Dollar\ Exchange\ Rate\ in\ 2020}{Dollar\ Exchange\ Rate\ in\ 1996}$$

$$Calibration\ Score = \frac{Rp\ 14.433}{Rp\ 2.306}$$

$$Calibration\ Score = 6{,}259$$

The calibration score is further used to process basic time value as well as minimum time value, as shown below:

Basic Time Value:

Basic time value in year 1996 = Rp 12.287/hour/vehicle x K-value Jawa Timur

Basic time value in year 1996 = Rp 12.287/hour/vehicle x 0,25

Basic time value in year 1996 = Rp 3.071

Basic time value in year 2020 = Basic time value in year 1996 x calibration score

Basic time value in year 2020 = Rp 3.071 x 6,259

Basic time value in year 2020 = Rp 19.226

Minimum Time Value:

Minimum time value in year 1996 = Rp 6.000/hour/vehicle

Minimum time value in year 2020 = Minimum time value in year 1996 x calibration score

Minimum time value in year 2020 = Rp 6.000 x 6,259

Minimum time value in year 2020 = Rp 37.553

Time value used for further analysis is the value with the larger amount between the basic time value and minimum time value. Basic time value in year 2020 is Rp 19.226 while minimum time value in year 2020 is Rp 37.553. Therefore, minimum time value is determined to be the time value per hour per vehicle.

Each year, the time value increases according to inflation. To adjust the minimum time value in accordance to the digital parking system lifetime, a formula shown below is used:

$$i = (1 + inflation\ rate)^{year-n}$$

$$Minimum\ time\ value = minimum\ time\ value\ year\ 2020\ x\ i$$

The inflation rate used is by calculating the average inflation rate of the past year as sourced from Bank Indonesia. The average inflation rate used in the calculation is determined to be 2,94%, based on BI inflation rate from May 2019 to June 2020.

Table 5. 9 Inflation Rate

BANK INDONESIA INFLATION RATE	
Year	**Inflation Rate**
Jun-20	1,96%
May-20	2,19%
Apr-20	2,67%
Mar-20	2,96%
Feb-20	2,98%
Jan-20	2,68%
Dec-19	2,72%
Nov-19	3%
Oct-19	3,13%
Sep-19	3,39%
Aug-19	3,49%
Jul-19	3,32%
Jun-19	3,28%
May-19	3,32%
Average	**2,94%**

The result of minimum time value with inflation rate in consideration is summarized in table 5.9.

Table 5. 10 Minimum Time Value

Year-n	Year	i	Minimum Time Value
0	2020	1	Rp 37.553
1	2021	1,0294	Rp 38.657
2	2022	1,05966436	Rp 39.794
3	2023	1,090818492	Rp 40.964
4	2024	1,122888556	Rp 42.168
5	2025	1,155901479	Rp 43.408
6	2026	1,189884983	Rp 44.684
7	2027	1,224867601	Rp 45.998
8	2028	1,260878709	Rp 47.350
9	2029	1,297948543	Rp 48.742
10	2030	1,33610823	Rp 50.175

Table 5. 11 Cont. Minimum Time Value

Year-n	Year	i	Minimum Time Value
11	2031	1,375389812	Rp 51.650
12	2032	1,415826273	Rp 53.169
13	2033	1,457451565	Rp 54.732
14	2034	1,500300641	Rp 56.341
15	2035	1,54440948	Rp 57.998

Minimum time value shown in table 5.9 is the time value per vehicle per hour. The calculation to find the annual time value for Gajah Mada Street is as shown in the formula below with an example of existing condition in 2020:

$$Time\ Value = minimum\ time\ value\ x\ travel\ time\ x\ number\ of\ vehicle\ x\ 365$$

$$Time\ Value = Rp\ 37.553\ x\ 0{,}04\ x\ 561\ x\ 365$$

$$Time\ Value = Rp\ 307.584.379$$

The formula is then applied to both the existing condition as well as after digital parking system for 15 years of its lifetime. To calculate the savings in time value, the following formula is used:

$$Time\ Value\ saving = TV\ existing\ condition - TV\ digital\ parking\ system$$

The result of time value and savings calculation is as shown in table 5.10.

Table 5. 12 Time Value Savings

Time Value			
Year	Existing Condition	After Digital Parking System	Savings
2020	Rp 307.584.379	Rp 109.851.564	Rp 197.732.815
2021	Rp 320.013.749	Rp 114.290.625	Rp 205.723.124
2022	Rp 332.908.102	Rp 118.895.751	Rp 214.012.351

Table 5. 13 Cont. Time Value Savings

Time Value			
Year	**Existing**	**After Digital Parking System**	**Savings**
2023	Rp 346.284.036	Rp 123.672.870	Rp 222.611.166
2024	Rp 360.158.722	Rp 128.628.115	Rp 231.530.607
2025	Rp 374.549.926	Rp 133.767.831	Rp 240.782.095
2026	Rp 389.476.025	Rp 139.098.581	Rp 250.377.445
2027	Rp 404.956.034	Rp 144.627.155	Rp 260.328.879
2028	Rp 421.700.932	Rp 150.607.476	Rp 271.093.456
2029	Rp 439.080.403	Rp 156.814.430	Rp 282.265.973
2030	Rp 457.117.285	Rp 163.256.173	Rp 293.861.112
2031	Rp 475.835.212	Rp 169.941.147	Rp 305.894.065
2032	Rp 495.258.640	Rp 176.878.086	Rp 318.380.554
2033	Rp 515.412.872	Rp 184.076.026	Rp 331.336.846
2034	Rp 536.324.091	Rp 191.544.318	Rp 344.779.773
2035	Rp 558.019.388	Rp 199.292.638	Rp 358.726.749

5.4 Capital and Operational Cost

Capital cost consists of the expenses needed to prepare for the application of the digital parking system, while operational cost are expenses spent to operate the parking system. This subchapter will describe more thoroughly about the two types of costs of the parking system.

5.4.1 Capital Cost

Capital cost in developing the digital parking system consists of two kinds of capital, fixed and operational preparation cost. Fixed capital consists of the cost of hardware, land and building, software, contingency, administration and insurance, as well as environment and social. Meanwhile, operational preparation cost consists of preparation and training cost. The details for each cost is further shown in table 5.11. The cost considers that the number of officers in Gajah Mada street are 19 officers, each going through 2 training periods.

Table 5. 14 Capital Cost

CAPITAL COST			
DESCRIPTION	**Number of Officers**	**Cost per Unit**	**Cost**
FIXED CAPITAL			
HARDWARE			
Data Centre			Rp 650.000.000
QR Code Scanner	19	Rp1.000.000	Rp 19.000.000
Hardware Total			Rp 669.000.000
LAND AND BUILDING			
Building and completeness (45% of hardware)			Rp 301.050.000
SOFTWARE			
Mobile Apps			Rp 100.000.000
Software Total			Rp 100.000.000
EPC (Hardware+Land and Building + Software)			Rp 1.070.050.000
Contigency (5% of EPC)			Rp 53.502.500
Administration and Insurance (2% of EPC)			Rp 21.401.000
Environment and Social (5% EPC)			Rp 53.502.500
FIXED CAPITAL			Rp 1.198.456.000
OPERATIONAL PREPARATION COST			
PREPARATION COST			
10% of Fixed Capital			Rp 119.845.600
TRAINING COST			
Parking Officer Training (2 times)	19	Rp 500.000	Rp 19.000.000
OPERATIONAL PREPARATION COST			Rp 138.845.600
TOTAL CAPITAL COST			Rp 1.337.301.600

5.4.2 Operational Cost

Operational cost refers to the cost to operate the digital parking system throughout its lifetime. The operational cost consists of variable cost and fixed cost, where variable cost is labor, supervision, maintenance, and electricity cost while fixed cost is overhead payroll, system development, depreciation, and insurance cost. Other general expenses include administration and finance cost.

Table 5. 15 Operational Cost

OPERATIONAL COST			
VARIABLE COST	**Number of Officers**	**Cost per Unit**	**Cost**
Labor Cost (12 months)	19	Rp 51.600.000	Rp 980.400.000
Supervision Cost (5% of labor cost)			Rp 49.020.000
Maintenance (6% fixed capital)			Rp 719.073.600
Electricity (1% of capital cost)			Rp 133.730.160
TOTAL			Rp 1.029.420.000
FIXED COST	**Number of Officers**	**Cost per Unit**	**Cost**
Overhead Payroll (15% of labor cost)			Rp 147.060.000
System Development (10% of labor cost)			Rp 98.040.000
Depreciation			Rp 239.691.200
Insurance (1% FC)			Rp 133.730.160
TOTAL			Rp 245.100.000
VARIABLE + FIXED COST			Rp 1.274.520.000
Finance			Rp 15.931.500
Administration (2% variable + fixed cost)			Rp 25.490.400
TOTAL OPERATIONAL COST			**Rp 1.315.941.900**

5.4.3 Total Cost

Total cost of digital parking system in 15 years of its lifetime is then calculated by considering inflation and replacement cost due to depreciation every 5 years. The replacement cost is adjusted according to the average inflation rate. The formula used to calculate the replacement cost is as follow:

$$Replacement\ Cost = Capital\ Cost\ x\ Inflation\ Rate^{n-1}$$

The calculation of total cost consisting of capital cost, replacement cost, and operational cost is shown in table 5.13. Year 2020 is considered year-0 as it is the development year, therefore the first year of the implementation of digital parking system is in year 2021. The operational cost is spent starting from year-1,

Table 5. 16 Total Cost

Year	Capital Cost	Replacement Cost	Operational Cost	Total Cost
2020	Rp 1.337.301.600	-	-	Rp 1.337.301.600
2021	-	-	Rp1.354.630.592	Rp1.354.630.592
2022	-	-	Rp 1.394.456.731	Rp 1.394.456.731
2023	-	-	Rp 1.435.453.759	Rp 1.435.453.759
2024	-	-	Rp 1.477.656.100	Rp 1.477.656.100
2025	-	-	Rp 1.521.099.189	Rp 1.521.099.189
2026	-	Rp 1.545.788.898	Rp 1.565.819.505	Rp 3.111.608.403
2027	-	-	Rp 1.611.854.599	Rp 1.611.854.599
2028	-	-	Rp 1.659.243.124	Rp 1.659.243.124
2029	-	-	Rp 1.708.024.872	Rp 1.708.024.872
2030	-	-	Rp 1.758.240.803	Rp 1.758.240.803
2031	-	Rp 1.786.779.674	Rp 1.809.933.082	Rp 3.596.712.756
2032	-	-	Rp 1.863.145.115	Rp 1.863.145.115
2033	-	-	Rp 1.917.921.581	Rp 1.917.921.581
2034	-	-	Rp 1.974.308.476	Rp 1.974.308.476
2035	-	-	Rp 2.032.353.145	Rp 2.032.353.145

5.5 Benefit Cost Ratio Analysis

Economic feasibility analysis of digital parking system in Gajah Mada Street is determined by its Benefit Cost Ratio. The value is analyzed by comparing the benefits of the digital parking system with the cost of developing and operating the parking system. Benefits from the system includes the income from parking retribution, vehicle operational cost savings, and time value savings while the cost consists of capital and operational cost.

Interest rate used in the analysis uses the average BI Interest rate of the past year as shown in the table below, from May 2019 to June 2020.

Table 5. 17 BI Interest Rate

BI INTEREST RATE	
Year	**Interest Rate**
Jun-20	4,25%
May-20	4,50%
Apr-20	4,50%
Mar-20	4,50%
Feb-20	4,75%
Jan-20	5,00%
Dec-19	5,00%
Nov-19	5%
Oct-19	5,00%
Sep-19	5,25%
Aug-19	5,50%
Jul-19	5,75%
Jun-19	6,00%
May-19	6,00%
Average	5,07%

Annual Present Worth Benefit and Present Worth Cost during the 15 years lifetime of the digital parking system is calculated to determine the value of BCR of the digital parking system. Total benefits from past calculation should be calculated before analyzing the BCR.

Table 5. 18 Total Benefits

Year	Parking Retribution	VOC savings	Time Value savings	Total Benefits
2020				Rp -
2021	Rp1.910.410.000	Rp 904.968.933	Rp 205.723.124	Rp 3.021.102.057
2022	Rp1.930.120.000	Rp 914.545.323	Rp 214.012.351	Rp 3.058.677.675
2023	Rp1.949.830.000	Rp 924.121.714	Rp 222.611.166	Rp 3.096.562.880
2024	Rp1.970.270.000	Rp 933.698.105	Rp 231.530.607	Rp 3.135.498.712
2025	Rp1.990.710.000	Rp 943.274.496	Rp 240.782.095	Rp 3.174.766.591
2026	Rp2.011.150.000	Rp 952.850.887	Rp 250.377.445	Rp 3.214.378.332

Table 5. 19 Cont. Total Benefits

Year	Parking Retribution	VOC savings	Time Value savings	Total Benefits
2027	Rp 2.031.590.000	Rp 962.427.277	Rp 260.328.879	Rp 3.254.346.156
2028	Rp 2.053.490.000	Rp 973.599.733	Rp 271.093.456	Rp 3.298.183.190
2029	Rp 2.075.390.000	Rp 984.772.189	Rp 282.265.973	Rp 3.342.428.163
2030	Rp 2.098.020.000	Rp 995.944.645	Rp 293.861.112	Rp 3.387.825.757
2031	Rp 2.120.650.000	Rp 1.007.117.101	Rp 305.894.065	Rp 3.433.661.166
2032	Rp 2.143.280.000	Rp 1.018.289.557	Rp 318.380.554	Rp 3.479.950.111
2033	Rp 2.165.910.000	Rp 1.029.462.013	Rp 331.336.846	Rp 3.526.708.859
2034	Rp 2.188.540.000	Rp 1.040.634.469	Rp 344.779.773	Rp 3.573.954.242
2035	Rp 2.211.170.000	Rp 1.051.806.925	Rp 358.726.749	Rp 3.621.703.674

Benefits from year 2020 is not included as the year 2020 is planning and development phase, whereas the implementation starts in the year 2021.

Table 5. 20 Benefit Cost Ratio Components

Year	n	Total Cost	Total Benefit	i=5,07% (P/F, i%,n)	Present Worth Cost	Present Worth Benefit
a	**b**	**c**	**d**	**e**	**f=c*e**	**g=d*e**
2020	0	Rp 1.337.301.600	Rp -	1	Rp 1.337.301.600	Rp -
2021	1	Rp 1.354.630.592	Rp 3.021.102.057	0,952	Rp 1.289.247.334	Rp 2.875.284.079
2022	2	Rp 1.394.456.731	Rp 3.058.677.675	0,906	Rp 1.263.094.282	Rp 2.770.540.092
2023	3	Rp 1.435.453.759	Rp 3.096.562.880	0,862	Rp 1.237.471.757	Rp 2.669.475.825
2024	4	Rp 1.477.656.100	Rp 3.135.498.712	0,820	Rp 1.212.368.999	Rp 2.572.575.199
2025	5	Rp 1.521.099.189	Rp 3.174.766.591	0,781	Rp 1.187.775.463	Rp 2.479.069.009
2026	6	Rp 3.111.608.403	Rp 3.214.378.332	0,743	Rp 2.312.475.357	Rp 2.388.851.590
2027	7	Rp 1.611.854.599	Rp 3.254.346.156	0,707	Rp 1.140.074.950	Rp 2.301.819.614
2028	8	Rp 1.659.243.124	Rp 3.298.183.190	0,673	Rp 1.116.947.937	Rp 2.220.228.522
2029	9	Rp 1.708.024.872	Rp 3.342.428.163	0,641	Rp 1.094.290.067	Rp 2.141.412.574
2030	10	Rp 1.758.240.803	Rp 3.387.825.757	0,610	Rp 1.072.091.824	Rp 2.065.735.415
2031	11	Rp 3.596.712.756	Rp 3.433.661.166	0,580	Rp 2.087.251.336	Rp 1.992.628.920
2032	12	Rp 1.863.145.115	Rp 3.479.950.111	0,552	Rp 1.029.037.112	Rp 1.922.017.658
2033	13	Rp 1.917.921.581	Rp 3.526.708.859	0,526	Rp 1.008.162.559	Rp 1.853.827.529
2034	14	Rp 1.974.308.476	Rp 3.573.954.242	0,500	Rp 987.711.457	Rp 1.787.985.816
2035	15	Rp 2.032.353.145	Rp 3.621.703.674	0,476	Rp 967.675.216	Rp 1.724.421.218
TOTAL					Rp 20.342.977.248	Rp 33.765.873.060

Based on the calculation result above, the total Present Worth Cost of the digital parking system is Rp 20.342.977.248 with a Present Worth Benefit of Rp 33.765.873.060. To calculate BCR, the following formula is used:

$$Benefit\ Cost\ Ratio = \frac{Present\ Worth\ Benefit}{Present\ Worth\ Cost}$$

$$Benefit\ Cost\ Ratio = \frac{Rp\ 33.765.873.060}{Rp\ 20.342.977.248}$$

$$Benefit\ Cost\ Ratio = 1{,}659$$

Benefit Cost Ratio value of the digital parking system based on the calculation above is 1.659. As mentioned in previous chapters, the requirement for a project to be feasible is to have a BCR value > 1. Therefore, the digital parking system implementation is stated to be economically feasible as the benefits has a greater value than the cost. This statement is based on the economic analysis that considers that the benefits of digital parking system are income from parking retributions, vehicle operating cost savings, and time value savings.

5.6 Sensitivity Analysis

Sensitivity analysis on the variables used to calculate the BCR of the digital parking system in the research is important, as there were numerous assumptions made on the data used to calculate the BCR. By analyzing the sensitivity of each variables, the effects of changes in value for each variable can be identified. This allows for determining the variable that may cause the project to be not feasible when the value of said variable is changed a certain amount. This chapter shows how changes in variables may cause changes in BCR and how sensitive each variable is.

5.6.1 Parking Users Sensitivity Analysis

Parking users indicate the number of users that utilizes the parking facilities. Number of parking users affect the overall benefits which includes the income from parking retribution, as well as amount of VOC and time value savings gained from the digital parking system. Changes in parking users may be affected by various factors, such as users who are unaware of the new parking system, negligence of parking officers, low traffic flow, and many more. The sensitivity analysis is done by calculating the BCR using various percentages out of the potential parking users.

Table 5. 21 Parking Users Sensitivity Analysis

Parking Users	BCR
100%	1,659
90%	1,49
80%	1,32
70%	1,16
60%	0,99
50%	0,83

Table 5.17 shows the BCR if there were less than 100% of parking users. BCR value of the digital parking system with up to 70% users has a value above 1, indicating that if there were only 70% of estimates parking users, the digital parking system would still be beneficial and feasible. Meanwhile, 60% and below users resulted in BCR value less than 1, showing that if the parking users were 60% or less of the estimated number, the digital parking system would not be beneficial. Figure 5.1 shows the relation between parking users and BCR.

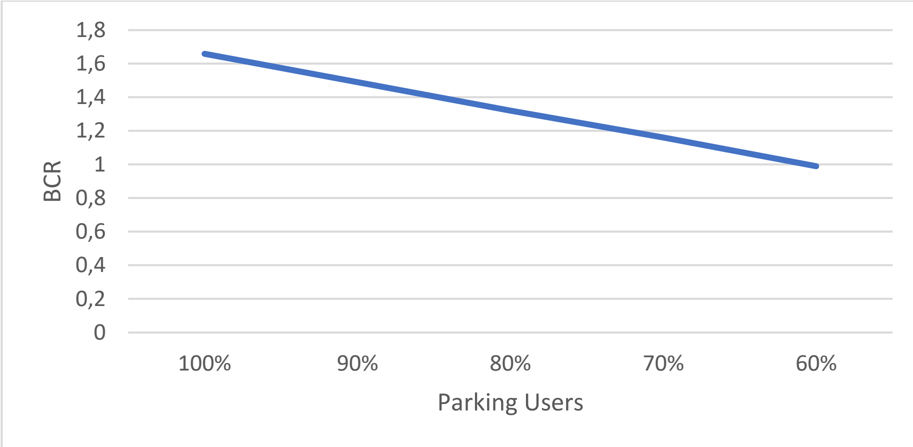

Figure 5. 1 Parking Users Sensitivity Analysis

5.6.2 Vehicle Operating Cost Savings Sensitivity Analysis

Vehicle Operating Cost savings indicate the savings saved based on travel distance and travel speed with the application of the digital parking system. The sensitivity analysis shows how changes in VOC savings affect the BCR.

Table 5. 22 VOC Savings Sensitivity Analysis

VOC Savings	BCR
100%	1,659
90%	1,601
80%	1,561
50%	1,41
20%	1,26

Based on the table above, decrease in VOC savings barely influence the BCR value of the parking system. Up to 20% of VOC savings estimation shows that the BCR, although decreasing, still results in a value above 1, therefore indicating that the digital parking system is still feasible. Figure 5.2 shows the relation between VOC savings and BCR.

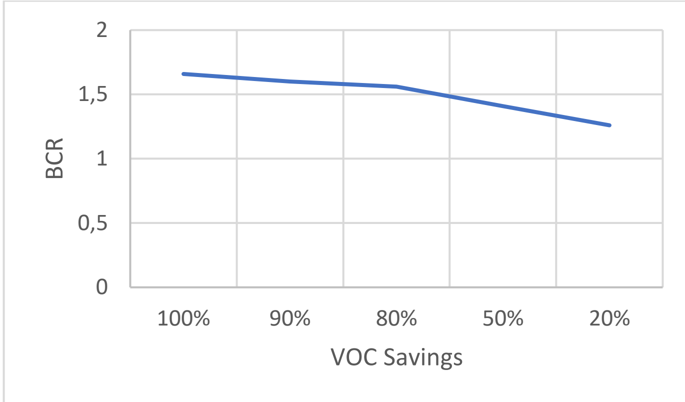

Figure 5. 2 VOC Savings Sensitivity Analysis

5.6.3 *Time Value Savings Sensitivity Analysis*

Time value savings indicate the amount of money gained by minimizing travel time with the implementation of digital parking system. The sensitivity analysis shows how changes in time value savings affect the overall BCR of the parking system.

Table 5. 23 Time Value Savings Sensitivity Analysis

Time Value Savings	BCR
100%	1,659
90%	1,64
70%	1,61
40%	1,57
20%	1,55

The table above shows that decreased time value savings does not cause the digital parking system to be nonbeneficial. Changes in time value savings has little effect in the overall BCR, therefore inaccuracy in estimates compared to actual condition has little impact to the feasibility of the digital parking system. Figure 5.3 shows the relation between time value savings and BCR.

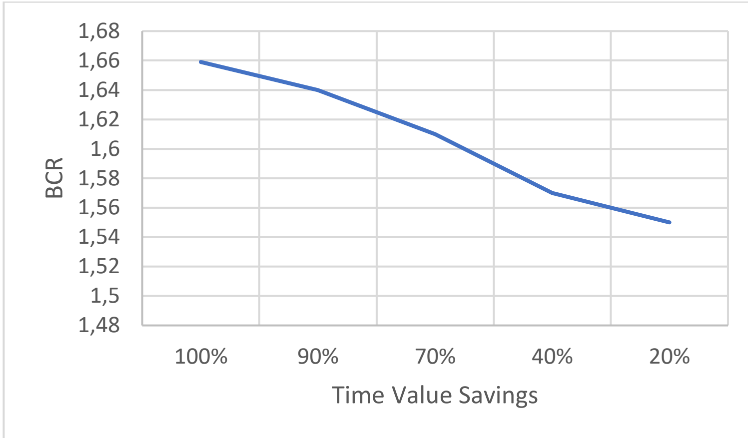

Figure 5. 3 Time Value Savings Sensitivity Analysis

5.6.4 Number of Parking Officer Sensitivity Analysis

Number of parking officers affects the total labor cost as well as training cost in the implementation of the digital parking system. Number of parking officers may differ due to unregistered parking officers. The analysis will determine whether the number of parking officers will have big impact in the feasibility of the digital parking system.

Table 5. 24 Parking Officers Sensitivity Analysis

Parking Officer	BCR
19	1,659
22	1,46
25	1,31
28	1,18
31	1,08
34	1
36	0,95

Table 5.20 shows how the number of parking officers affect the BCR value. Up to 31 officers, the BCR value is greater than 1 indicating that the system is still feasible and beneficial. Figure 5.4 shows the relation between number of parking officers and BCR.

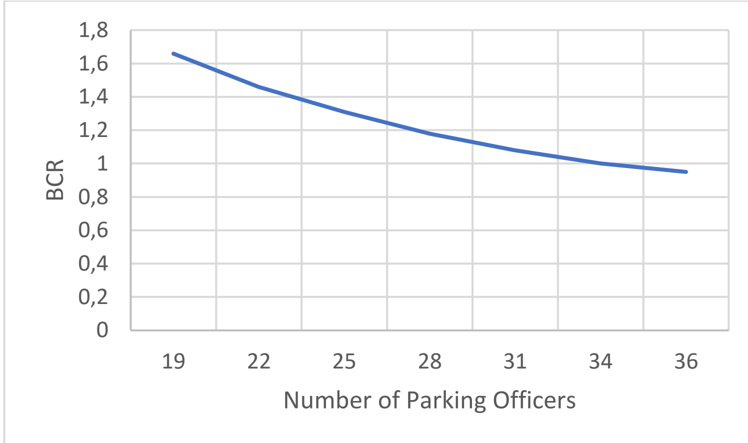

Figure 5. 4 Parking Officers Sensitivity Analysis

5.6.5 *Software Development Cost Sensitivity Analysis*

Software development cost refers to the cost to create the digital parking application. Changes in cost may occur due to request of additional feature or other factors. The analysis shows how increase in software development cost affects the BCR of the digital parking system.

Table 5. 25 Software Development Cost Sensitivity Analysis

Software Development Cost	BCR
100%	1,659
150%	1,52
200%	1,41
250%	1,32
300%	1,23

Table 5.21 shows the relation between software development cost and BCR value. Up to 300% of the estimated software development cost results in BCR value above 1, implying that if the development cost was to increase by 3 times, the digital parking system would still be feasible. Figure 5.5 shows the relation between software development cost and BCR.

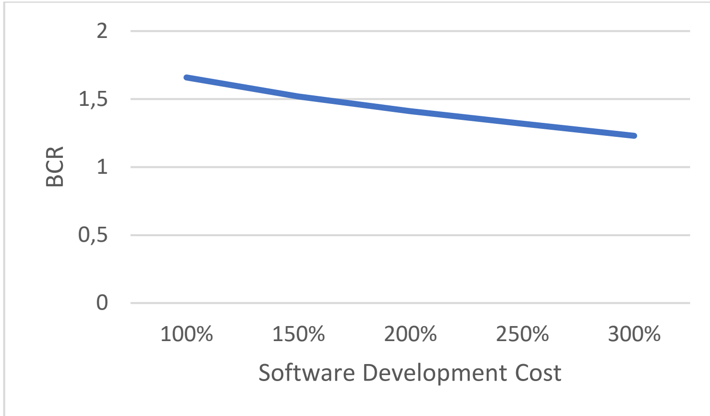

Figure 5. 5 Software Development Cost Sensitivity Analysis

5.6.6 Labor Cost Sensitivity Analysis

Labor cost is the monthly wage given to the parking officers and is included into operational cost of the parking system. The current wage of parking officers used in the economic analysis is Rp 4.300.000. A sensitivity analysis is done for future purposes where the labor cost may increase.

Table 5. 26 Labor Cost Sensitivity Analysis

Labour Cost (Million)	**BCR**
Rp 4,3	1,659
Rp 4,6	1,5
Rp 5	1,46
Rp 5,4	1,37
Rp 5,8	1,28

Table 5.22 shows how the labor cost with 19 parking officers affect the BCR value of the digital parking system. The analysis result shows that increasing labor cost up to Rp 5.800.000 million still results in BCR value above 1, meaning the digital parking system is feasible. Figure 5.6 shows the relation between labor cost and BCR.

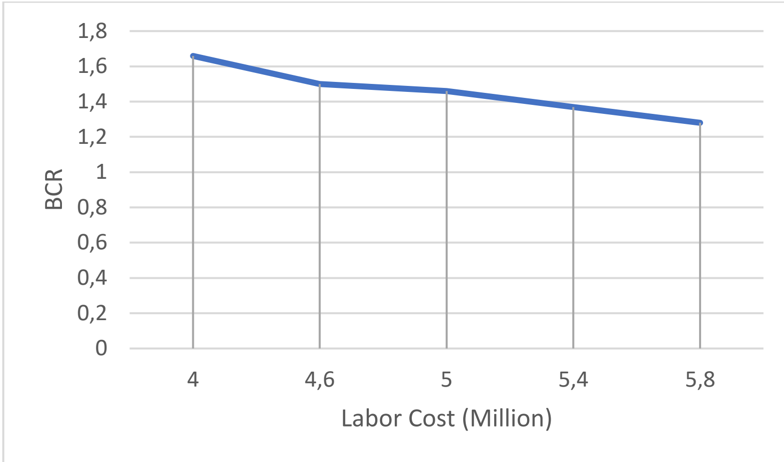

Figure 5. 6 Labor Cost Sensitivity Analysis

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CHAPTER 6
CONCLUSION AND RECOMMENDATION

5.7 Conclusion

Based on the analysis and calculation in previous chapters on the implementation of the digital parking system from development to the end of its 15 years lifetime, some conclusions are made:

1. The potential of parking retribution income from cars and motorcycle parking activity in Gajah Mada Street is Rp 1.685.935.000 per year, with potential 561 cars and 1468 motorcycles parking users, and parking fee of Rp 4.000 for cars and Rp 2.000 for motorcycles.
2. Vehicle Operational Cost savings by implementation of digital parking system is Rp 904.968.933 in its first year, and a total of Rp 14.637.513.369 in its lifetime.
3. Time Value savings by implementation of digital parking system is Rp 205.723.124 in its first year, and a total of Rp 4.131.704.196 in its lifetime.
4. The value of BCR considering the benefits and costs of the digital parking system is 1,659 (BCR > 1) which indicates that the digital parking system in Gajah Mada Street is economically feasible because the benefits gained is larger than the cost spent.
5. Sensitivity analysis shows that most variables are not sensitive to changes and will not cause loss despite some differences in estimation and actual condition.

5.8 Recommendation

Recommendation made by the writer based on the research done are as follow:

1. During the time of research, primary data were limited due to inability to conduct a direct survey and observation of study area, therefore the writer relied heavily on past researches. Future researches may collect primary

data through observation directly at the study area to get a more accurate result.

2. For future research, it is recommended to consider the dynamic characteristic of the parking activities for more accurate result and taking into account the proportion of the parking users who use conventional system and digital parking system.
3. As the result of economic analysis shows positive result, it is recommended that the digital parking system be applied in major parking areas throughout Sidoarjo.

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