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Evaluation of Economic Feasibility by Using ETLE in Increasing Road User Compliance to Reduce Traffic Accident Rates

Original Article

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Abstract

This study aims to evaluate the effectiveness, efficiency, and economic benefits of implementing the Electronic Traffic Law Enforcement (ETLE) system in Indonesia, particularly within the context of digital transformation in traffic law enforcement. Using a quantitative approach based on survey instruments, the research model was developed through the integration of Benefit-Cost. Four key variables were examined: the quality of ETLE camera installation, operational efficiency, road user compliance, and supporting implementation factors. The survey instrument was comprehensively constructed and validated through expert judgment, involving both academics and ETLE practitioners. Data were collected from 115 respondents through both online and offline distribution methods, targeting road users and ETLE system administrators. The results of the analysis indicate that all variables significantly influence traffic law compliance. Operational efficiency was found to be a key mediating factor between installation quality and user compliance. Furthermore, the Benefit-Cost Analysis revealed a BCR value of 3.01, indicating that every Rp1 invested in the ETLE system yields a social and economic return of 3.01. This study asserts that the ETLE system not only enhances the accountability and efficiency of law enforcement but also significantly reduces potential state losses resulting from traffic violations and accidents. The practical implications of these findings provide a strong foundation for formulating sustainable digital transportation policies.

Keywords: ETLE, Benefit-Cost Theory, Operational Efficiency, Traffic Compliance.

1. Introduction

The rapid development of science and technology has brought significant impacts in various aspects of life, including the transportation sector (Raihan et al., 2024; Sahu et al., 2022; Saida et al., 2024). In Indonesia, the growth in the number of motorized vehicles each year has created various traffic problems (Soehodho, 2017), such as congestion (Lee, 2015), rule violations (Susilo et al., 2015), and accidents (Steg & van Brussel, 2009). Data from the Korlantas POLRI (2024a), the number of traffic violations recorded through the Electronic Traffic Law Enforcement (ETLE) system reached 460,246 cases, while non-ETLE enforcement was 1,683,987 cases. This number shows how high the level of violations on the road, which is a big challenge in efforts to create a more orderly and safe transportation system. To overcome this problem, the Indonesian National Police (POLRI) implemented the ETLE system, a technological innovation in traffic law enforcement (Suriadi et al., 2022). ETLE utilizes electronic technology, such as surveillance cameras (CCTV), road sensors, and Automatic Number Plate Recognition (ANPR), to detect, record, and act on traffic violations automatically without direct interaction between officers and violators. This system is expected to increase transparency, accountability, and efficiency of law enforcement, while reducing the potential for illegal activities that often occur in the manual ticketing process.

Since its national implementation in March 2021, ETLE has shown a positive impact. Data from the Korlantas Polri noted that in the period January to May 2023, the number of traffic violations recorded through ETLE reached 512,924 cases. In addition, the implementation of ETLE contributed to a decrease in the number of traffic accidents. In 2023, the number of traffic accidents decreased by 3% compared to the previous year, from 137,851 events to 133,796 events. This decrease indicates that ETLE is effective in increasing road user compliance with trafic regulations. However, the effectiveness of ETLE is inseparable from the quality of the surveillance camera installation used. ETLE cameras that are not properly installed or experience technical problems can reduce the system's ability to accurately detect violations, thus impacting operational efficiency. Research by Yuliantoro and Sulchan (2021) shows that the level of readiness of an environment in adopting ETLE technology, including the quality of camera installations, greatly affects the success of this system. Aminah also emphasized the importance of technological infrastructure support and operator training as determinants of ETLE effectiveness

Based on previous studies, ETLE procurement has great potential to overcome traffic problems in Indonesia where by using ETLE, law enforcement can be carried out automatically and consistently without having to rely on the presence of field officers. However, challenges related to installation quality and infrastructure limitations still need to be overcome to ensure the success of this system. Therefore, further research is needed that focuses on the operational and economic side of ETLE to ensure that ETLE camera installation is an investment that provides optimal results in creating traffic order that provides transparency and fairness in prosecuting violations. This research will make an important contribution to the development of a more effective and sustainable ETLE implementation strategy in the future.

This research basis is benefit-cost analysis theory in building research models, which was comprehensively introduced by Dupuit (1844) and refined by Marshall (1890), emphasizing that the successful implementation of technology such as ETLE does not only depend on technical aspects alone, but must also consider the balance between the benefits obtained and the costs incurred in the long run. In the context of ETLE implementation, the expected benefits include a decrease in the number of traffic violations, increased road user safety, and higher operational efficiency. Conversely, costs include initial investments such as procurement and installation of surveillance cameras, system operations, and periodic maintenance to ensure optimal performance of ETLE.

Although various previous studies have shown the effectiveness of the ETLE system in improving traffic compliance (Yuliantoro & Sulchan, 2021; Susanto et al., 2022; Aprianto et al., 2025), some limitations still need to be studied further. Previous research has focused more on aspects of ETLE implementation in general or its effect on the level of traffic violations. However, there is still a void in studies that specifically evaluate the effectiveness of ETLE camera installations on overall system operational efficiency. In addition, the role of factors such as the quality of installation, coverage of the surveillance area, and the level of socialization to the community has not been widely explored in depth. This study aims to fill this gap by analyzing the relationship between the quality of ETLE camera installations and operational efficiency, while providing strategic recommendations for system optimization.

2. Literature Review

2.1. Traffic Attitude and Traffic Accident

Traffic attitude is one of the psychological factors that play a role in driver behavior on the road. Traffic attitude includes an individual's tendency to judge, respond, and behave towards traffic rules. This attitude comes from personal beliefs, social norms, and perceptions of one's ability to control traffic behavior. According to research by Susilo et al. (2015), a driver's attitude towards traffic regulations greatly influences the driver's tendency to obey or violate the applicable rules. An indifferent attitude towards the rules certainly tends to increase the risk of violations. The types of violations that often occur include driving at high speed, using the opposite lane, and overtaking other vehicles from the wrong side or lane. These types of violations are part of the repetitive behaviors often found in big cities in Indonesia and contribute to the high number of traffic accidents in the region.

Another research state that there are several types of violations that occur frequently, which can generally be categorized into two types. First are common violations such as deliberately driving faster than the speed limit, following another vehicle too closely, or crossing an intersection just as the traffic light is about to turn red. The second is aggressive violations characterized by hostility, such as honking or flashing lights out of anger at another driver, or aggressively following the vehicle in front out of impatience. It is this intentional violation behavior that is the strongest predictor of a driver's involvement in a traffic accident (Parker et al., 1995).

2.2. Benefit-Cost Theory

Benefit-Cost theory was first introduced by Dupuit (1844) and widely developed by Marshall (1890) in an economic context. This theory is used to evaluate the feasibility of a project or policy based on the balance between the benefits obtained and the costs incurred. In the context of research on ETLE, cost-benefit theory is used to evaluate whether the benefits of implementing this technology in increasing road user compliance are greater than the investment and operational costs required. The costs in implementing ETLE include the procurement of high-resolution surveillance cameras, the cost of camera installation, the cost of routine maintenance and calibration of technology devices, and operational costs that include data communication network stability, electronic data management and processing. Another important cost component is the implementation of socialization to the community, increasing the capacity of human resources in managing ETLE technology, as well as providing supporting infrastructure such as servers, database integration systems, and software for violation data analysis.

Some previous studies show that when the benefits of ETLE implementation are able to exceed its operational costs, the level of road user compliance increases significantly. These findings support the basic assumptions of Benefit-Cost Theory, where the decision to implement new technology in the transportation sector should provide benefits that outweigh the costs incurred, so that overall, it can improve social welfare and public safety. Thus, Benefit-Cost Theory is the right framework to evaluate the effectiveness and feasibility of implementing ETLE technology in supporting traffic law enforcement policies in Indonesia (Vernadi & Pambudi, 2024).

In the proposed scheme, this research will analyze the extent to which the quality of camera installation (which includes position accuracy, image resolution, identification speed, network stability, and ANPR technology accuracy) and system operational efficiency (which includes the number of violations detected, reduction in officer workload, and speed of ticket processing) are proportional to the benefits in the form of increasing the level of road user

compliance. Implementation support factors such as regulation, socialization, and community participation also play a role in determining whether ETLE implementation can run efficiently so that optimal benefits can be achieved.

2.3. Electronic Traffic Law Enforcement (ETLE)

ETLE is a technology-based traffic law enforcement system that serves to improve road user compliance through automatic monitoring. This system uses surveillance camera (CCTV) technology, road sensors, and Automatic Number Plate Recognition (ANPR) to detect and record traffic violations without direct interaction between officers and violators. With this technology-based approach, ETLE plays an important role in reducing the potential for corruption in the traffic law enforcement system and increasing transparency in sanctions. The implementation of ETLE in various countries shows mixed results depending on the legal system, technology and supporting infrastructure. In Singapore, ETLE has been integrated with a big data analytics-based traffic management system. This integration allows for more accurate prediction of traffic patterns as well as automatic detection of certain violations, thus helping authorities enforce the law more efficiently. South Korea developed an ETLE system equipped with artificial intelligence (AI) capable of identifying high-risk driving behaviors, such as cellphone use while driving and speed limit violations. The AI in the system enables more sophisticated detection and automated learning to improve the accuracy of offense identification.

ETLE in Indonesia was first implemented in stages since 2018 and expanded nationwide in 2021 with Jakarta as the main pilot project. ETLE implementation aims to reduce the number of traffic violations, improve road user compliance, and automate the ticketing system to reduce direct contact between officers and violators. Several studies have confirmed the effectiveness of ETLE in improving traffic compliance. A study conducted in Jakarta showed that the implementation of mobile ETLE succeeded in reducing the number of violations by 27%. However, there are several challenges that must still be overcome, including limited public understanding of the ETLE mechanism, uneven camera coverage, and the need for clearer regulations to support this system.

Table 1. Comparison of ETLE Implementation in Various Countries

No	Countries	Advantages	Challenges
1	Singapore	More accurate traffic pattern prediction	Limited supervision coverage in some areas
2	South Korea	High accuracy in violation identification	Requires highly sophisticated technology infrastructure
3	Indonesia	Reduces direct interaction between officers and offenders	Low public understanding and limited camera coverage

Source: Govinsider.asia

The success of ETLE in improving traffic compliance is highly dependent on several factors such as the quality of camera installations, the effectiveness of surveillance, and the level of awareness and socialization to the community. The quality of the camera installation determines the extent to which this system can accurately detect violations. If the camera is installed in a strategic location with good lighting, the accuracy of the ETLE system in capturing violations will be higher. However, if the camera infrastructure is inadequate, such as low resolution or non-strategic positions, this system will not run optimally.

2.4. Previous Research

Based on the results of previous research, ETLE is generally proven to increase traffic compliance, reduce the level of violations, and eliminate the practice of illegal levies in law enforcement. However, there are several challenges that are still faced, such as limited camera coverage, technical constraints in system integration, and lack of public understanding of the ETLE system. This research is expected to fill the research gap by exploring more deeply the effectiveness of the quality of ETLE camera installations on operational efficiency and how technology can be used to increase public acceptance of this system.

Table 2. Previous Research

No.	Title	Author	Problems	Advantages	Analysis Method	Discussion	Analysis Gap
1	*Efektivitas ETLE dalam Penindakan Pelanggaran Lalu Lintas*	(Venardi & Pambudi, 2024)	Evaluation of the effectiveness of ETLE in reducing the number of traffic violations	ETLE increases transparency and accountability of traffic law enforcement	Descriptive Analysis based on the number of violations before and after ETLE	ETLE has reduced traffic violations and increased legal compliance	There are still technical obstacles such as expired BRIVA codes and limited supervision coverage.
2	The Effectiveness Against Traffic Violations with ETLE	(Yuliantoro & Sulchan, 2021)	Implementation of ETLE in reducing corruption levels and increasing efficiency in traffic law enforcement	Reduce direct interaction between officers and violators, thereby reducing the potential for illegal levies	Qualitative Analysis based on interviews with officers and police data	ETLE improves driving discipline and speeds up the process of giving electronic tickets	Technology infrastructure is still a major obstacle in the implementation of ETLE
3	*Evaluasi Implementasi ETLE di Kota Medan*	(Saibi & Sihombing, 2024)	Evaluating the impact of ETLE on road user compliance in Medan	ETLE implementation can significantly reduce the number of traffic violations	Comparative Analysis of the number of violations before and after ETLE	There was a decrease in the number of violations after ETLE was implemented, but the lack of surveillance cameras is still an obstacle	Expansion of supervision coverage and improvement of supporting technology
4	*Regulasi dan Kebijakan ETLE di Indonesia*	(Abdullah & Windiyastuti, 2022)	How ETLE regulations support system effectiveness in enforcing traffic laws	Strong legal basis for ETLE	Normative Juridical Approach	Regulations are in place, but implementation still faces technical and social barriers	Low public awareness of the ETLE mechanism
5	*Implementasi Tilang Elektronik di Yogyakarta*	(Pardede et al., 2022)	How the effectiveness of electronic ticketing in reducing the number of violations in Yogyakarta	ETLE is able to provide a deterrent effect for traffic violators	Observational Methods and Interviews with violators and officers	Most people feel that ETLE is more efficient than manual tickets	Lack of socialization is still a major challenge

3. Methods

This research begins with Problem Identification, which is the initial stage where the main research problem is formulated based on the observed phenomenon. Once the problem was identified, a literature review was conducted, where the researcher gathered information and theories from previous relevant research. This process involves exploring various sources, such as journals, books, and white papers, to build a strong theoretical base. The literature review also helps in identifying research gaps and formulating hypotheses. Then, Theory and Hypothesis Formulation was conducted. The theory that best suits the research variables is selected. In this study, the theory used is Benefit-Cost Theory (Dupuit, 1844; Marshall, 1890), which provides a conceptual framework for analyzing the effectiveness of ETLE. After the theory and hypothesis, it is followed by a review of previous research to understand the methodological approach and results of previous research. This stage provides insight into the advantages and disadvantages of the research methods that have been used, so that it becomes a reference in the design of this research. The next stage is Data Collection, which includes primary and secondary data collection (Ghozali, 2006; Saunders et al., 2009). Primary data is obtained through questionnaires, interviews, or direct observation, while secondary data comes from official reports, statistical data, or government documents related to ETLE. Respondents in this study included road users, ETLE operators, and other stakeholders. After the data is collected, Data Interpretation is carried out to identify patterns, trends, or relationships between variables.

3.1. Data Processing

Data processing in this study was carried out systematically using SmartPLS 4 software to ensure that the data collected through questionnaires could be analyzed validly and reliably. The analysis process begins with understanding the characteristics of the respondents, followed by a series of tests aimed at ensuring the quality of the data and the research model used. This study uses the Benefit-Cost Analysis (BCA) approach to evaluate the effectiveness of implementing the ETLE system. In this approach, the benefits and costs of implementing the ETLE system are compared directly to see if the investment provides greater benefits than the costs incurred. The calculation of the benefit-cost ratio (BCR) is done by comparing the total value of benefits obtained in a certain period to the total costs incurred during the same period. Benefits are calculated from the difference in the number of traffic violations before and after the implementation of ETLE, which is then multiplied by a certain economic value as a representation of the benefits obtained from increasing road user compliance.

The cost of ETLE implementation consists of three main aspects, namely the cost of initial camera installation, system operational costs such as data processing of violations and electronic enforcement, and the cost of routine maintenance of the hardware and software used. This cost is an important variable that will affect how efficiently the system runs, thus directly affecting the benefits that can be obtained. The data processing process carried out through SmartPLS 4 ensures that the research results are based on valid, reliable and bias-free data (Aguirre-Urreta & Rönkkö, 2018), so that the resulting conclusions can be used to provide credible recommendations for the development and optimization of the ETLE system.

Secondary data analysis was conducted to complement and strengthen findings from qualitative and quantitative analysis. Secondary data were obtained from official sources such as Surabaya Police, Surabaya City Transportation Agency, and other related agencies that have a role in the implementation of the ETLE system. Thus, secondary data serves as an external validation of survey results and supports a comprehensive assessment of the performance of the ETLE system from a technical and economic perspective.

4. Results and Discussion

4.1. Primary Data and Secondary Data

This study analyzes the effectiveness and economic feasibility of implementing the Electronic Traffic Law Enforcement (ETLE) system in Surabaya. The analysis was carried out using a mixed approach that combined primary data from surveys and secondary data from Surabaya Police Station for the period 2016-2024. These are the major data used for analyzing, the first one is primary data from survey.

Table 3. Descriptive Statistics of ETLE Operational Efficiency Variables

No.	Statement Items	Mean	Std. Dev.
6	How many violations can be detected automatically by the ETLE system compared to conventional methods?	4.08	0.79
7	How much has the workload of traffic officers been reduced after the implementation of ETLE?	3.95	0.84
8	How quickly can the ETLE system process electronic ticketing data from detection to sanctioning?	4.02	0.76
9	How well is the ETLE system integrated with the legal system and national vehicle database?	3.90	0.87

It is known that this variable shows a fairly high average above the score of 3.90 for all items, indicating that respondents generally assess the ETLE system as having efficient performance in traffic law enforcement operations. The highest item is the system's ability to automatically detect violations (mean = 4.08), indicating that ETLE technology is seen as far superior to conventional methods in terms of massive and rapid detection of violations. The speed of processing ticket data (mean = 4.02) is also viewed favorably, indicating that the system response time from violation to issuance of sanctions is effective. However, reducing the workload of traffic officers is still at a mean of 3.95 with a relatively high standard deviation (0.84), which may indicate differences of opinion between respondents, especially between implementers and users. The fourth item, ETLE integration with the legal system and national database, received the lowest average score (3.90), which means there is still room for improvement, especially in terms of data consistency, validation of violators, and interoperability between agencies. The second data used from survey

Table 4. Descriptive Statistics of Road User Compliance Variables

No.	Statement Items	Mean	Std. Dev.
10	How much has the number of traffic violations decreased since ETLE was implemented in the operational area?	4.18	0.72
11	How has driver awareness of the law improved after the socialisation and implementation of ETLE?	4.14	0.77
12	How high is the level of road user compliance with road markings after the introduction of ETLE surveillance?	4.05	0.81
13	How much compliance with traffic signs and red lights is monitored through ETLE?	4.12	0.75

The average score on this variable was consistently high, with all items above 4.00. This reinforces the notion that ETLE contributes significantly to increasing obedient behavior on the road. The decrease in violations is the strongest indicator (mean = 4.18) which shows the direct impact of the presence of ETLE in reducing the number of violations. Followed by increased legal awareness of motorists (mean = 4.14), which is evidence of the effectiveness of socialization and public campaigns around this system. Meanwhile, obedience to road markings (mean = 4.05) and compliance with signs and red lights (mean = 4.12) also reflect a change in more disciplined behavior on the road since ETLE was implemented. These findings are important to strengthen the argument that technology-based systems are capable of providing a consistent deterrent effect.

As a form of data triangulation and an effort to strengthen the validity of external research, secondary data obtained from the Surabaya Police Headquarters were used. The use of this data provides an objective perspective on the impact of the implementation of ETLE (Electronic Traffic Law Enforcement) in the long term. The data covers various relevant aspects such as the number of traffic accidents, types of accidents, and the number of violations, both conventional and detected through the ETLE system. The analysis focuses on two time periods: before (2016–2019) and after (2020–2024) the implementation of ETLE.
Accident Data and Violation Rates Before–After ETLE.

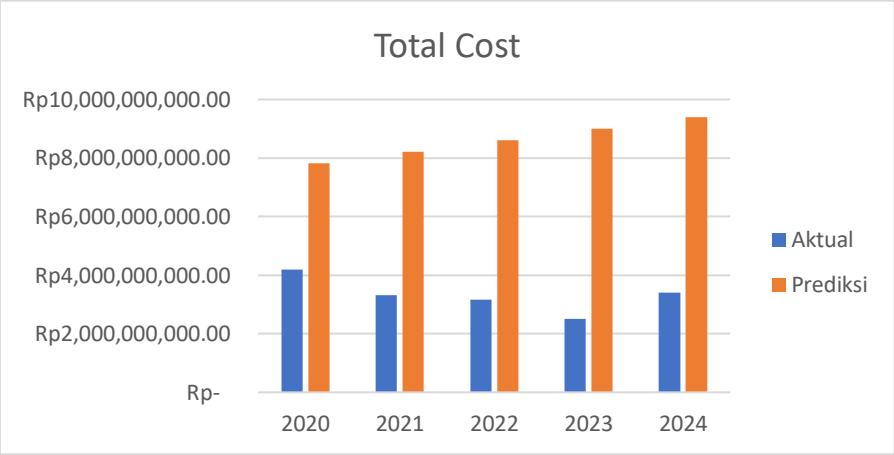

Figure 1. Total Cost 2020-2024 Period

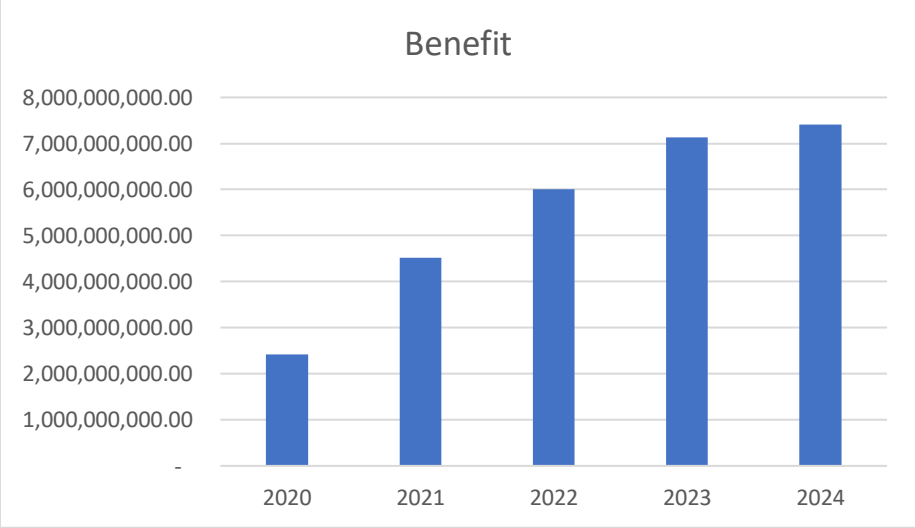

Figure 2. Benefit 2020-2024 Period

4.2. Benefit-Cost Analysis

This study aims to evaluate the feasibility of implementing the Electronic Traffic Law Enforcement (ETLE) system in the city of Surabaya, not only in terms of the effectiveness of reducing the level of violations and traffic accidents, but also from an economic perspective. One of the quantitative approaches used in assessing the efficiency of this public policy is the Benefit-Cost Analysis (BCA) method, which is an analysis technique that compares the total benefits generated by a policy with the total costs incurred in its implementation.

Table 5. Benefit Cost Ratio 2020-2024

Year	Total Benefit		Total Cost	BCR
2020	2,422,671,666.67	Rp	4,200,123,333.33	0.576809649
2021	4,514,105,368.37	Rp	3,311,313,333.33	1.363237155
2022	6,006,609,070.07	Rp	3,164,133,333.33	1.898342591
2023	7,129,332,771.77	Rp	2,509,533,333.33	2.840899811
2024	7,407,456,473.47	Rp	3,411,533,333.33	2.171298284

The total initial implementation cost of the ETLE system in Surabaya during the initial phase (including hardware, software, training, and operational costs) was recorded at Rp 20,641,310,000. This figure reflects a significant public investment, so an economic analysis is needed to assess its feasibility. With a total benefit of Rp27,480,175,350.33 and an initial cost of installing ETLE of Rp20,641,310,000, the result is 1.33. The calculation results show that the benefit-cost ratio (Benefit-Cost Ratio, BCR) > 1. This means that economically, the implementation of ETLE in Surabaya can be categorized as an economically feasible program. Not only that, if the BCR approaches or exceeds 2, this shows that every rupiah spent by the government produces twice the economic benefits, which is an indication of the efficiency of public policy.

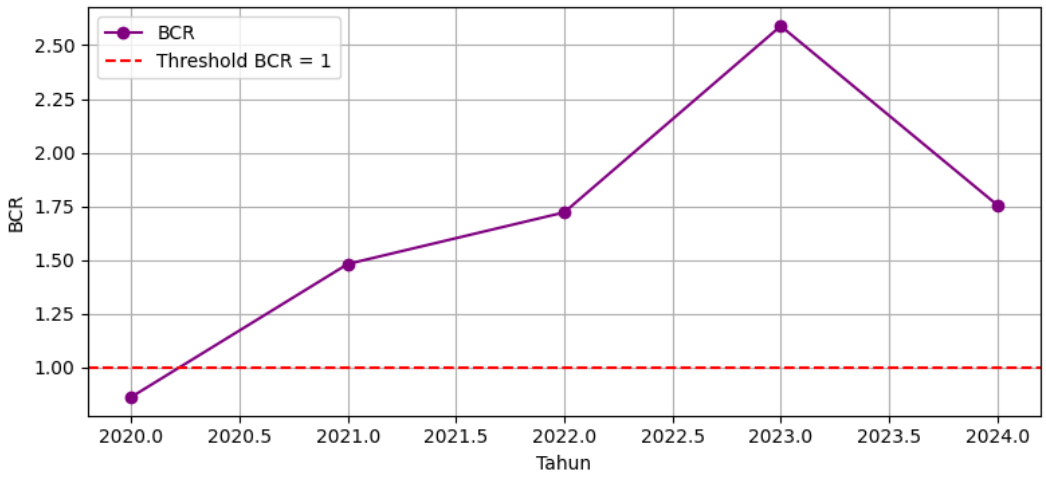

Figure 3. Benefit Cost Ratio (BCR) 2020-2024 Period

4.3. Prediction Analysis

Based on the results of secondary data processing and predictions of cost and benefit trends for five years after ETLE implementation, the prediction for annual benefit-cost ratio (BCR) between 2025-2029 was obtained as:

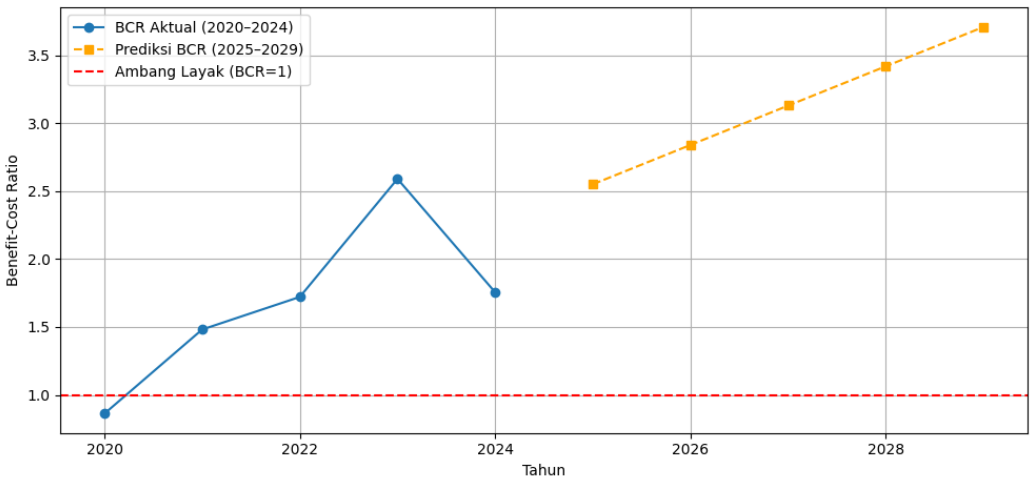

Figure 4. BCR Prediction

It can be seen that in the first year of implementation (2020), the BCR value was still below one, which was 0.58. This indicates that in the early stages, the total economic benefits obtained from the implementation of ETLE have not been able to cover the total investment and operational costs incurred. This phenomenon is understandable considering the initial costs of system installation and adaptation are quite high, while the impact on reducing violations and accidents has not been felt directly significantly in the short term. However, starting in the second year (2021), the BCR value showed a significant and consistent increase from year to year. This increase shows that the effectiveness of ETLE in reducing the number of violations and accidents is cumulative, so that its benefits become increasingly apparent in the medium to long term. The highest BCR value was recorded in 2023 with a figure of 2.84, which means that each rupiah spent by the government generates economic benefits of almost three rupiah. This figure reflects high fiscal efficiency and supports the feasibility of the program from an economic perspective.

5. Conclusion

Based on an evaluation of the economic feasibility of the Electronic Traffic Law Enforcement (ETLE) system project in Jakarta using the Benefit–Cost Analysis (BCA) approach, this study yielded a Benefit–Cost Ratio (BCR) of 1.33. This value indicates strong feasibility, as every one rupiah invested generates benefits worth Rp 1.33 for the community. These substantial benefits arise from increased efficiency in law enforcement, reduced workloads for officials, and, most importantly, enhanced compliance among road users which demonstrably leading to more orderly and safer traffic behavior.

These findings are not only relevant for Jakarta; the implementation of ETLE in areas such as Surabaya also shows feasibility supported by field data and statistical analysis. The system can be a transparent and accountable technology-based solution to urban traffic challenges. However, this technical and economic success must be matched by a long-term strategy. To ensure the sustainability of the system and expand its impact, improvements in social aspects, increased participation, and effective public communication should be prioritized. Ultimately, synergy between the government, private sector and the community is key to transforming ETLE from a law enforcement tool to an integral part of an orderly traffic culture.

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