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DAMAGE-BASED COST RECOVERY AND EQUITABLE TOLLING: A SHAPLEY VALUE MODEL LINKING ESAL FACTORS TO HIGHWAY FEE STRUCTURES IN NIGERIA

Summary. *Nigeria's reintroduction of toll gates on federal highways through public-private partnerships (PPPs) aims to address chronic funding gaps for road rehabilitation and maintenance. However, the current flat-rate tolling policy is inequitable because vehicle types impose widely varying degrees of pavement damage, largely driven by axle load configuration [1]. This study develops and applies a differentiated tolling framework for the Abuja–Lokoja highway using cooperative game theory, specifically the Shapley value method [2, 3], to allocate maintenance costs proportionally across vehicle categories based on their marginal damage contributions. Traffic volume data, axle configurations, and Equivalent Single Axle Load (ESAL) factors for five vehicle categories (2A, 3A, 4A, 5A, 6A) were obtained from Federal agencies, namely: Federal Roads maintenance Agency (FERMA), Federal Roads Safety Corps (FRSC), and Federal Ministry of Works (FMW) [4–6]. The Shapley value model was applied to compute equitable toll rates ranging from ₦9,932 (≈$6.62) for two-axle vehicles to ₦72,629 (≈$48.42) for six-axle trucks, reflecting a 7.3:1 damage ratio. Coalition analysis revealed that six-axle vehicles alone contribute 52.10 % of the total pavement damage, while representing only 39.8 % of the traffic volume. In contrast, the government's announced flat-rate structure (₦500–₦1,600) significantly underprices heavy vehicles and fails to recover maintenance costs. The proposed framework demonstrates that damage-based tolling enhances equity, ensures sustainable cost recovery, and creates proper economic incentives for the preservation of infrastructure. Implementation requires electronic toll collection (ETC) and weigh-in-motion (WIM) technologies, supported by transparent governance mechanisms to prevent revenue misappropriation. These findings provide an actuarially efficient and scientifically*

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defensible foundation for an equitable PPP toll policy in Nigeria and similar developing country contexts.

Key words: *Equivalent Single Axle Load (ESAL), Shapley value, equitable tolling, cost recovery, highway maintenance.*

1. INTRODUCTION

A nation's road network is critical for economic growth and development, as it facilitates the seamless transportation of goods and services. However, road networks in Nigeria are costly to maintain, requiring routine upkeep and substantial capital for new construction. The Federal Government has a significant funding gap, with the amount required for optimal road maintenance being far higher than the annual allocation. This gap has led to a reactive, rather than preventive, maintenance approach. To address these costs, the government is exploring partnerships with the private sector through PPPs to fund, rehabilitate, and maintain its roads [7]. In this arrangement, the private sector raises capital, often through loans, to fund road projects and recovers the investment by charging road users a toll gate fee. Comparative studies show that PPP toll models have been successfully applied in emerging economies, such as India [8], South Africa [9], and China [10]. These provide useful lessons for Nigeria, where axle overloading remains a persistent issue. The history of tolling in Nigeria is a complex one. Toll gates were first abolished in 2003 by former President Olusegun Obasanjo, who argued that the ₦63 million generated daily was insufficient and that the toll gates were a “cesspool of corruption” and an inconvenience to motorists [11]. At the time, road maintenance was to be funded through increased fuel prices, a form of petrol tax. However, this policy proved unsustainable. Despite the federal abolition, some states, like Lagos, have continued to operate toll gates. The current administration is now reviving the tolling system to repay loans and generate sustainable revenue for road maintenance [12]. A recent example is the Abuja – Akwanga – Lafia – Makurdi road, where toll operations were launched to repay a $460.8 million loan from China Exim Bank. The government hopes this new model will ensure transparency and accountability, avoiding past mistakes.

2. STATEMENT OF THE PROBLEM AND RELEVANCE OF THE STUDY

The reintroduction of road tolling in Nigeria via PPPs aims to address chronic funding deficits for road maintenance. However, the proposed flat-rate toll structure is inherently inequitable as it ignores the well-established principle that vehicle axle load is the primary driver of pavement damage. Heavy vehicles, particularly those operating with axle overload, impose costs that are exponentially higher than those imposed by lighter vehicles [1]. This failure to allocate maintenance costs proportionally to the damage caused (high Equivalent Single Axle Load (ESAL)) results in two major problems: first, it leads to the financial unsustainability of the road infrastructure as costs are under-recovered; and second, it removes the economic incentive for fleet operators to comply with legal axle load limits. This study seeks to solve this equity and financial sustainability problem by developing a scientifically defensible, damage-based cost allocation framework, using the Abuja – Lokoja highway as a case study.

3. ANALYSIS OF THE RECENT RESEARCH AND PUBLICATIONS

The challenge of sustainably funding road infrastructure has led many countries, including Nigeria, to adopt the PPP model. However, the implementation of PPP projects, particularly in the transport sector, is fraught with risks. A study on the Lekki toll road project in Nigeria found that its failure was primarily due to the poor management of stakeholder risks, including issues related to cost allocation [13]. Similarly, a study on Cameroon’s road toll system identified loopholes that lead to fraudulent activities, suggesting that the poor physical state of tolled roads is a direct result of the misappropriation of funds [14]. Evidence of corruption on highways in Nigeria, which necessitated the 2003 abolition of toll gates, has been documented in historical accounts [15]. Both studies underscore the need for transparency and effective risk management in toll collection to ensure the longevity of the project and the continuous maintenance of road networks.

A key factor in a fair toll system is the equitable allocation of costs based on the damage a vehicle inflicts on the road. It is a well-established principle that a vehicle's weight and axle configuration are the primary determinants of pavement damage. This relationship is often described by the "fourth power law", which states that pavement wear increases exponentially with axle load [16]. For instance, a doubling of the axle load can result in a 16-fold increase in pavement damage [17]. It is particularly relevant in Nigeria, where vehicle overloading beyond legally permitted limits is a common issue that significantly shortens the lifespan of road infrastructure [1, 18]. The cumulative effect of these heavy loads is often expressed using the ESAL, a metric that standardizes the damaging effect of various vehicle types to a single comparable unit [19, 20]. Studies from other African contexts, such as Kenya, confirm the high costs associated with pavement damage from axle overloading [21, 22]. The causes of general pavement deterioration, which must be addressed by maintenance, have also been investigated in the region [23, 24]. Therefore, a rational tolling policy must account for the ESAL of each vehicle to ensure that the costs of maintenance are borne proportionally.

The literature review identified key gaps in existing policy and research concerning road tolling in Nigeria and similar contexts:

1. Inequitable Cost Allocation Policy: The most critical gap is the government's proposed flat-rate toll structure. While studies acknowledge that axle load is the primary driver of pavement damage (often citing the "fourth power law") [1, 16], the current policy in Nigeria fails to apply this principle, leading to an inherently inequitable system where heavy vehicles that cause exponentially higher damage are significantly undercharged.
2. Lack of Scientifically Defensible Cost Models: Existing policy lacks a scientifically defensible, damage-based cost allocation framework. Previous studies often highlighted the problem of overloading [1, 18] and the high costs involved [21], but did not provide a rigorous, game theory-based mathematical model that links maintenance costs directly to vehicle-specific damage contributions (ESALs) to determine a fair toll rate.
3. Governance and Sustainability Focus: While corruption and governance issues in past Nigerian tolling attempts were documented [14, 15], the economic models proposed for revival often neglect to ensure financial sustainability by accurately recovering the massive maintenance costs, nor do they include the proper economic incentives (damage-based fees) to encourage fleet operators to comply with legal axle load limits.

This study makes the following significant contributions to the body of knowledge in transport economics, infrastructure management, and cooperative game theory application:

1. Novel Application of Shapley Value to Tolling: It is one of the few studies, and the first in the Nigerian context, to employ the Shapley Value method [2, 3] to solve the public good/cost-sharing problem of highway maintenance. It mathematically proves that this method is ideal for damage-based tolling because it satisfies the core fairness axioms, providing a theoretically robust solution.
2. Development of an Actuarially Correct Differentiated Tolling Model: The study translates raw engineering data (ESAL factors) and real-world financial data (maintenance costs) into an actuarially correct, damage-based fee structure. It moves the discussion beyond simply identifying overloading as a problem to providing concrete, quantifiable toll rates (e.g., ₦9,932 for a 2-axle vehicle vs. ₦72,629 for a 6-axle vehicle) necessary for sustainable cost recovery on the Abuja-Lokoja highway.
3. Foundation for Policy Reform: The findings provide a scientifically defensible foundation for the Federal Government and PPP concessionaires to reform the current flat-rate tolling policy. It demonstrates how to align the economic mechanism (toll fee) with the engineering reality (pavement damage), thereby fostering equity, financial sustainability, and infrastructure preservation through proper economic signaling.

4. PRESENTATION OF THE MAIN MATERIAL

4.1. Methodology

The study employs Cooperative Game Theory, specifically the Shapley Value method [2, 25], as the foundational mechanism for equitable cost allocation. This approach, rooted in the principles of cooperation and fair sharing [26], is chosen because it guarantees a unique and fair distribution of the total cost (C) among "players" (vehicle categories), satisfying key axiomatic properties like Symmetry, Dummy Player, and Efficiency [25]. The cost-sharing problem is framed as an *n*-person cooperative game where the vehicle categories are the players, and the shared cost is the road maintenance cost.

The problem is modelled as a transferrable utility (TU) game. Let $N=\{1,2,\ldots,n\}$ be the set of vehicle categories, and C be the total maintenance cost. The characteristic function, $v(S)$, defines the cost incurred by any coalition $S \subseteq N$. Since pavement damage is linear and proportional to the total ESALs, the cost function for this type of cooperative game is derived from the cumulative damage contribution, following established methods in carrier collaboration and cost sharing [27–29].

Let $ESALi$ be the total damage contribution (in ESALs) of vehicle category i over a given period. The cost parameter k (Naira per ESAL) is defined as:

$$k=\frac{C}{\sum_{i=1}^{n} ESAL_i}. \tag{1}$$

The characteristic function $v(S)$ for a coalition $S \subseteq N$ is the maintenance cost exclusively attributable to the vehicles in that coalition:

$$\mathrm{v(S)}=\mathrm{k}\times\sum_{i\in S} ESAL_i. \tag{2}$$

The Shapley value $\phi_i\,(N,v)$ for category i is calculated using the general formula:

$$\phi_i\,(N,v)=\sum_{S\subseteq N\setminus\{\mathrm{i}\}} \frac{|S|!(n-|S|-1)!}{n!}[v(S\cup\{i\})-v(S)]. \tag{3}$$

where: N – the set of all players (vehicle categories); n – the total number of players ($|N|$); S – a coalition of players not including player i; $|S|$ – the size of coalition S; $v\,(S)$ – the characteristic function, defining the cost incurred by coalition S; $v(S\cup\{i\})-v(S)$ – the maginal contribution of player i to coalition S.

The study focuses on the Abuja – Lokoja highway, a major artery connecting the Federal Capital Territory (FCT) to the South-West and South-East regions of Nigeria. This corridor was selected due to its high strategic and economic importance, coupled with a significant, demonstrable volume of heavy vehicle traffic that causes extensive pavement damage. The scope is limited to the allocation of the annual pavement maintenance costs.

The following secondary data were collected and used for data analysis in the study:

1. Maintenance Cost Data: The total annual recurrent expenditure required for adequate maintenance of the Abuja-Lokoja highway corridor was estimated based on historical funding data from the Federal Ministry of Works (FMW, 2005-2025) [6, 30] and FERMA reports [31].
2. Traffic Volume Data: Weekly traffic counts by vehicle category were obtained from the Federal Road Safety Corps (FRSC, 2024) [5] and Federal Roads Maintenance Agency (FERMA, 2024) [4].
3. Axle Load Factors: The Axle Load Factor (ALF), also referred to as the ESAL factor, is a standard engineering metric used to quantify the relative pavement damage. These factors were derived from AASHTO guidelines, ECOWAS regional standards, and local weigh-in-motion data from FERMA [4, 16, 19].

Given the linear characteristic function $v(S)$ from Equation (2), the Shapley value simplifies to the allocated cost:

$$\phi_i\left(N,v\right)=k\times ESALi. \tag{4}$$

The allocated cost $\phi_i\left(N,v\right)$ is then converted to a practical Toll Rate per vehicle pass by dividing by the total traffic volume of category i, which simplifies to:

$$\text{Toll Rate}_\text{i}=k\times\text{Axle Load Factor}_\text{i}. \tag{5}$$

The model is calibrated by the initial calculation of the cost parameter k (Equation 1), which anchors the relative damage contribution (ESALs) to the absolute total cost (C).

4.2. Results analysis

Table 1 presents the historical funding profile for highway construction and rehabilitation projects in Nigeria from 2005 to 2025, with specific allocations to the Abuja-Lokoja corridor.

The analysis of funding for federal highways reveals a critical and consistent funding gap (Table 1). The total cost (C) required for adequate annual maintenance of the Abuja-Lokoja corridor, derived from utilized funds, is estimated at ₦26,010,542,251.20 (approx. $17,340,361.50). It results in a required weekly maintenance cost for calibration of ₦500,202,735.60 (approx. $333,468.49).

Table 1

Funding profile of highway construction & rehabilitation projects (2005–2025)

Year	Amount Required (₦)	Amount Budgeted (₦)	Actual Funds Released (₦)	Funds (₦) Utilized on Abuja-Lokoja sections (Estimated)
2005	143,650,000,000	82,519,373,423	61,390,288,947	341,909,804
2006	165,560,000,000	67,854,363,765	61,074,107,804	340,148,850
2007	202,000,000,000	134,665,481,922	108,641,539,716	605,073,020
2008	258,720,896,105	142,885,032,521	127,892,820,865	712,291,961
2009	197,522,317,618	182,622,818,424	168,850,759,251	940,404,923
2010	262,213,145,782	214,876,056,048	86,624,577,055	482,450,769
2011	164,600,000,000	130,013,949,780	84,965,912,485	473,212,929
2012	167,794,147,306	133,697,103,470	92,817,759,653	516,943,356
2013	171,294,667,671	134,427,651,813	58,350,534,632	324,980,061
2014	218,897,654,879	98,669,008,704	34,879,660,947	194,260,334
2015	239,043,204,053	20,646,000,000.00	12,539,550,984.80	69,838,333
2016	445,580,952,908	251,220,169,985	169,528,000,122	944,176,778
2017	500,000,000,000	305,952,920,752	100,000,000,000	556,944,444
2020	125,000,000,000	36,600,000,000	N/A	-
2021	400,000,000,000	38,000,000,000	N/A	-
2022	850,000,000,000	76,300,000,000	15,260,000,000.00	-
2023	N/A	76,300,000,000	N/A	-
2024	700,000,000,000	77,000,000,000	64,880,000,000	-
2025	880,000,000,000	64,900,000,000	N/A	-

Source: Federal Ministry of Works (2005–2025); Federal Roads Maintenance Agency (2018, 2025) [6, 31, 32]

Table 2 shows the Vehicle Traffic, Frequency, and Axle Load Factor on Abuja-Lokoja Highway This table outlines the categories of vehicles, their weekly frequency (trips) on the highway, and their corresponding axle load factors, which quantify the damage they cause to the road.

Table 2

Vehicle traffic, frequency, axle load factor on Abuja – Lokoja highway

S/No	Vehicle Category	Weekly Frequency (Trips)	Axle Load Factor (Damage)	Total ESALs (Weekly Frequency x Axle Load factor)
1	2A	10	0.8	8
2	3A	6	3.15	18.9
3	4A	74	3.75	277.5
4	5A	15	4.45	66.75
5	6A	69	5.85	403.65
Total	N/A	174	N/A	774.8

Source: Federal Road Safety Corps (2024); Federal Roads Maintenance Agency (2024) [4, 5].
Note: Weekly Frequency refers to the average loaded trips per week for a specific highway section.

Based on the total weekly maintenance cost (C = ₦500,202,735.60) and the total weekly ESALs ($\sum ESAL_i$ =774.8), the cost parameter k (Naira per ESAL) is computed using the model calibration Equation (1):

$$k = \frac{500,202,735.60}{774.8} = NGN645,524.96 \quad (approx.\$430.35)$$

The equitable toll rate for each vehicle category is computed using Equation (5).

Table 3 shows the computed toll fees per pass using the Shapley value method. The study calculated the toll rates for each vehicle category based on their damage factor.

Table 3

Computed toll rates per pass

Vehicle Category	Axle Load Factor (Damage per pass)	Toll Rate (₦ per pass)	Toll Rate (USD per Pass)	% of 6A Per Pass
2A	0.8	9,932.15	6.62	13.67
3A	3.15	39,107.82	26.07	53.85
4A	3.75	46,556.93	31.04	64.10
5A	4.45	55,247.56	36.83	76.07
6A	5.85	72,628.81	48.42	100.00

Source: Authors' computation based on Shapley value analysis.
Note: USD values are provided at an assumed exchange rate of ₦ 1,500 per 1.

The robustness of the Shapley value model is tested by analyzing the sensitivity of the resulting toll rates to variations in the most volatile input parameter: the Total Weekly Maintenance Cost (C). The Shapley value is robust in its core axiomatic principle – the proportional share of the cost remains unchanged, but the absolute toll rates are directly sensitive to C. We analyze the effect of a ±10 % change in the estimated weekly maintenance cost (C) on the toll rate for the highest damage vehicle category (6A) (Table 4).

Table 4

Sensitivity of 6A toll rate to changes in maintenance cost

Scenario	Change in C	New Weekly Cost (₦)	New Weekly Cost (USD)	New Toll Rate for 6A (₦/pass)
High Cost	+10 %	550,222,009.16	366,814.67	79,891.69
Baseline	0 %	500,202,735.60	333,468.49	72,628.81
Low Cost	–10 %	450,182,462.04	300,122.39	65,365.93

Source: Authors, data analysis

4.3. Conclusion of Robustness Test

The Shapley allocation model demonstrates a perfect linear relationship between the total required maintenance cost and the resulting toll rates. It indicates that while the absolute toll value is highly sensitive to the accuracy of the cost estimate, the equitable proportional distribution of the cost among vehicle types is robust and mathematically consistent, as expected from the Shapley value's inherent efficiency and symmetry properties. The model's validity rests on accurately determining the required maintenance cost (C).

In contrast to the empirical model, the Nigerian government's announced tolling policy uses a flat-rate, non-differentiated structure. The government has approved a policy with simplified fees for specific vehicle categories. A recent announcement regarding the Abuja – Keffi – Akwanga – Makurdi highway (a similar route) set the following fees [26]:

– Saloon Cars: ₦500;
– SUVs/Jeeps: ₦800;
– Minibuses: ₦1,000;
– Multi-Axle Vehicles: ₦1,600.

This simplified structure does not account for the number of axles beyond a basic "multi-axle" classification. The fees are significantly lower than those calculated in this paper and do not reflect the exponential damage caused by increased axle loads, as highlighted by the article's "fourth power law" principle.

4.4. Discussion

The analysis demonstrated that a differentiated tolling system based on the ESAL of each vehicle is the most effective and fair way to impose a toll tax. This model ensures that the financial burden is distributed proportionally to the wear and tear caused, with heavier vehicles paying a significantly higher toll than lighter ones. A 6-axle truck is charged approximately 7.3 times more per pass than a 2-axle truck to account for its higher contribution to road damage. Studies, including Oyekanmi, Ibe, Ebiringa & Ejem (2020) [1], have highlighted the severe impact of vehicle overloading on Nigeria's road infrastructure, reinforcing the necessity of a damage-based tolling structure.

The seemingly high toll rates in Table 3 are actuarially correct to recover the substantial historical average weekly maintenance cost for this corridor. The cost parameter k was calculated to be ₦645,524.96 (approx. $430.35) per ESAL. The resulting toll rates are high because they accurately reflect the massive cost of repairing the damage caused by heavy transport on the highway.

The Shapley value framework [2] robustly implements the principle that cost is proportional to the individual vehicle's damage per pass. For instance, a 2-axle vehicle (2A) is charged 13.67 % of the 6A toll rate because its ALF (0.8) is approximately 13.67 % of the 6A vehicle's ALF (5.85), meaning the 2A vehicle causes proportionally less damage per trip. This proportionality justifies the computed fees, demonstrating the internal consistency of the damage-based allocation.

5. CONCLUSIONS AND PERSPECTIVES FOR FURTHER RESEARCH

A Shapley value tolling model [2, 3] offers a technically robust and equitable alternative to flat-rate fees. The rates derived in this study are scientifically defensible as they are mathematically linked to the historical cost of maintenance and the damage caused by each vehicle type through the ESAL factor. By linking charges to axle-induced damage, it supports PPP objectives and sustainable financing. This framework strengthens the policy and economic foundation for PPP tolling in Nigeria. The core conclusion is that for a sustainable and equitable tolling policy in Nigeria, the government must adopt a highly differentiated, damage-based fee structure, even if it results in significantly higher charges for heavy vehicles than currently announced.

Based on the findings, the following recommendations and suggestions are made:

1. Immediate Adoption of Differentiated Tolling: The Federal Government should adopt the proposed damage-based differentiated toll structure on the Abuja-Lokoja highway and other federal PPP roads to ensure cost recovery and equity.

2. Technology Implementation: Deploy ETC and WIM systems immediately to accurately measure the axle load factor of each vehicle in real-time. It includes modernizing toll gate management [32] to implement automatic payment and queue systems [33, 34], supported by automated e-tolling surveys [35].
3. Governance and Transparency: Establish an independent, multi-stakeholder regulatory body to oversee toll operations. This body must ensure complete revenue transparency and prevent misappropriation, a major concern that contributed to the failure of the previous toll system [15].

Suggestions for Further Studies are:

1. Integration of Capital Recovery Costs (CAPEX): Future research should focus on integrating CAPEX in addition to maintenance costs (OPEX) into the Shapley value model for a complete financial model of the road project.
2. Behavioral Economic Analysis: Conduct a behavioral economic analysis to model the impact of the high differentiated tolls on logistics supply chain costs, route choices (diversion), and compliance with axle load limits by fleet operators.
3. Dynamic Pricing Exploration: Explore dynamic pricing models that can account for congestion, time-of-day traffic variability, and seasonal changes in cargo volume to optimize both toll revenue and traffic flow.

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ВІДШКОДУВАННЯ ВИТРАТ НА ОСНОВІ ЗБИТКІВ ТА СТЯГНЕННЯ ПЛАТИ ЗА ПРОЇЗД: МОДЕЛЬ ВАРТОСТІ ШЕЙПЛІ, ЩО ПОВ'ЯЗУЄ ФАКТОРИ ESAL ЗІ СТРУКТУРОЮ ПЛАТИ ЗА КОРИСТУВАННЯ АВТОМАГІСТРАЛЯМИ В НІГЕРІЇ

Анотація. *Повторне введення в Нігерії платного проїзду по федеральних автомагістралях за допомогою державно-приватного партнерства (ДПП) має на меті вирішити проблему хронічного дефіциту фінансування для відновлення та утримання доріг. Однак нинішня політика фіксованої плати за проїзд несправедлива, оскільки різні типи транспортних засобів завдають шкоди різного ступеня дорожньому покриттю, що значною мірою залежить від конфігурації навантаження на вісь. Під час дослідження розроблено та застосовано диференційовану систему оплати за проїзд по автомагістралі Абуджа–Локоджа для різних категорій транспортних засобів на основі ступеня пошкодження ними доріг із використанням теорії кооперативних ігор, а саме методу Шейплі, для пропорційного розподілу витрат на утримання. Дані про інтенсивність руху, конфігурації осей та коефіцієнти еквівалентного навантаження на вісь (ESAL) для п'яти категорій транспортних засобів (2A, 3A, 4A, 5A, 6A) отримано від федеральних агентств, а саме Федерального агентства з утримання доріг (FERMA), Федерального корпусу з безпеки дорожнього руху (FRSC) та Федерального міністерства робіт (FMW). Модель Шейплі застосовано для розрахунку справедливих ставок оплат за проїзд, які змінюються від 9 932 ₦ (≈6,62 дол. США) для двовісних транспортних засобів до 72 629 ₦ (≈48,42 дол. США) для шестивісних вантажівок, що відображає співвідношення збитків 7,3:1. Аналіз результатів показав, що шестивісні транспортні засоби спричиняють 52,10 % загальних пошкоджень дорожнього покриття, хоча їх частка в загальному обсязі транспортного потоку становить лише 39,8 %. Натомість оголошена урядом фіксована структура тарифів (500–1600 ₦) істотно занижує вартість перевезень важкими транспортними засобами і не дає змоги покрити витрати на ремонт доріг. Запропонована система демонструє, що стягнення плати за пошкодження сприяє справедливості, забезпечує стале відшкодування витрат та створює належні економічні стимули для збереження інфраструктури. Для упровадження цієї системи необхідні технології електронного збирання плати за проїзд (ETC) та зважування під час руху (WIM) тощо. Ці висновки забезпечують актуальну ефективну та науково обґрунтовану основу для справедливої політики щодо плати за проїзд у межах державно-приватного партнерства в Нігерії та подібних країнах, що розвиваються.*

Ключові слова: *коефіцієнт еквівалентного навантаження на одну вісь (ESAL), значення Шейплі, справедливе стягнення плати за проїзд, відшкодування витрат, утримання автомагістралей.*