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COMPARATIVE EFFICIENCY ANALYSIS OF HIGHWAY CONCESSIONS IN BRAZIL

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ABSTRACT

This study presents a comparative analysis of efficiency in Brazilian highway concessions, focusing on the relationship between operational costs, management scale, and infrastructure quality. The research adopts an exploratory and descriptive design with a quantitative-comparative approach, combining observed data, estimated variables, and structured qualitative indicators. A Composite Efficiency Index (ICE) was developed based on normalized indicators of operational cost, management quality, and network scale. The methodology incorporates explicit thresholds, standardized classification criteria, and data harmonization procedures to enhance transparency and reproducibility. The results indicate that large concessionaire groups tend to exhibit higher infrastructure quality and investment capacity, while mid-sized operators achieve more balanced efficiency levels due to lower relative costs. The findings also reveal that operational scale alone is not sufficient to explain efficiency differences, highlighting the importance of managerial performance and contractual conditions. The study contributes to the literature by proposing a structured and replicable framework for comparative efficiency assessment in infrastructure concessions. However, the results should be interpreted with caution due to the use of partially estimated variables and the absence of direct causal inference.

Keywords: Highway concessions; transport infrastructure; economic efficiency; logistics; road management.

1. Introduction

Transport infrastructure is one of the fundamental pillars for economic development, territorial integration, and a country's logistics competitiveness. In Brazil, the road system plays a central role in the movement of goods and passengers, accounting for more than 60% of freight transport and a significant share of intermunicipal and interstate mobility.

Despite its strategic importance, the expansion and maintenance of the Brazilian road network have historically faced limitations related to the scarcity of public resources, low governmental investment capacity, and increasing demand for high-quality infrastructure. In this context, since the 1990s, Brazil has adopted institutional models aimed at increasing private sector participation in infrastructure management, particularly through concession contracts and public–private partnerships.

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Pages: 1-22

Highway concessions consist of delegating the management of road segments to private entities for a defined period, through contracts that establish obligations related to investment, maintenance, operation, and service provision to users. In return, concessionaires generate revenue primarily through toll collection.

Since the implementation of the Highway Concession Program, private sector participation in the management of Brazil's road infrastructure has expanded significantly. Currently, approximately 30,000 kilometers of highways are under concession, covering key logistics corridors and economically strategic regions.

Although the concession model has been widely promoted as an alternative to expand investments and improve infrastructure quality, debates persist regarding its economic efficiency and its ability to generate benefits proportional to operational costs and tolls paid by users.

In this context, it becomes essential to empirically evaluate the performance of highway concessionaires, considering aspects related to operational efficiency, management scale, and infrastructure quality.

Based on these considerations, this study seeks to answer the following research question:

What is the relationship between the operational costs of highway concessions and the quality of infrastructure provided by different private operators in Brazil?

The general objective of this research is to analyze the economic efficiency of Brazilian highway concessions by comparing different concessionaire groups, considering indicators such as operational scale, investment levels, and estimated costs per kilometer managed.

2. Theoretical Framework

2.1 Transport Infrastructure Concessions and Public–Private Partnerships

Studies by Kleber Zanchim et al. (2013), Gabriel Fajardo and Guilherme Theo Sampaio (2024), Kal Machado (2002), and Maurício Portugal Ribeiro

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Vol: 13.06
DOI: 10.66104/9txv7s09
Pages: 1-22

(2011) provide complementary perspectives on the highway concession model in Brazil, addressing its legal, economic, institutional, and operational dimensions.

Zanchim et al. (2013) offer a structural overview of the concession model, highlighting the legal and regulatory framework as well as the economic foundations that support the delegation of public services to the private sector. In this regard, the authors argue that “adequate risk allocation and legal certainty are central elements for the sustainability of concession contracts” (ZANCHIM et al., 2013, p. 45). Furthermore, they emphasize that “the efficient performance of regulatory agencies directly contributes to the economic and financial balance of contracts” (ZANCHIM et al., 2013, p. 62).

Ribeiro (2011), in turn, deepens the discussion on bidding processes and concession and public–private partnership (PPP) contracts, proposing best practices related to contract design, governance, and risk mitigation. According to the author, “the proper structuring of bidding documents is crucial to attract investment and ensure competitive procurement processes” (RIBEIRO, 2011, p. 89). Additionally, he highlights that “economic and financial rebalancing mechanisms are essential to maintain contract viability over time” (RIBEIRO, 2011, p. 134).

From a more critical perspective, Machado (2002) seeks to demystify common assumptions about highway concessions. The author argues that “the expectation of immediate cost reduction for users does not always materialize under concession models” (MACHADO, 2002, p. 57), and also points out that “significant challenges remain regarding regulation and tariff control” (MACHADO, 2002, p. 103).

More recently, Fajardo and Sampaio (2024) analyze the introduction of the *free flow* model, characterized by the elimination of physical toll plazas and the adoption of automated toll collection systems. The authors highlight that “the free flow system represents a significant advancement in terms of operational efficiency and traffic flow” (FAJARDO; SAMPAIO, 2024, p. 41), but caution that “its implementation requires regulatory and technological improvements,

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particularly regarding enforcement and payment compliance" (FAJARDO; SAMPAIO, 2024, p. 78).

Private sector participation in the provision of public infrastructure has been widely discussed in economic and institutional literature. According to the World Bank, "public–private partnerships can increase efficiency in service delivery and expand access to infrastructure investment" (WORLD BANK, 2017, p. 12). Complementarily, the OECD emphasizes that "PPPs contribute to a more efficient allocation of public resources, provided they are supported by adequate governance frameworks" (OECD, 2015, p. 23). In this sense, the efficiency of public–private partnerships is directly conditioned by the quality of institutional arrangements and the regulatory and oversight mechanisms adopted.

In Brazil, the Highway Concession Program began in the 1990s, within a broader context of institutional reforms aimed at modernizing national infrastructure. Ministerial Ordinance No. 10/1993 established the initial foundations of the program, while Law No. 9,277/1996, known as the Delegation Law, enabled the transfer of federal highway segments to states and municipalities.

Subsequently, the creation of the Agência Nacional de Transportes Terrestres (ANTT), through Law No. 10,233/2001, represented a significant regulatory milestone for the sector. As highlighted in the literature, "the institutionalization of an independent regulatory agency was fundamental to strengthening the concession model in Brazil" (RIBEIRO, 2011, p. 52).

Highway concession contracts (Figure 1) typically have durations ranging from 25 to 30 years and include obligations related to maintenance, capacity expansion, and service provision to users. In return, concessionaires are authorized to charge tolls, which constitute the primary source of revenue for covering operational costs. As summarized by Zanchim et al. (2013), "the concession model seeks to reconcile economic efficiency with the adequate provision of public services" (ZANCHIM et al., 2013, p. 28).

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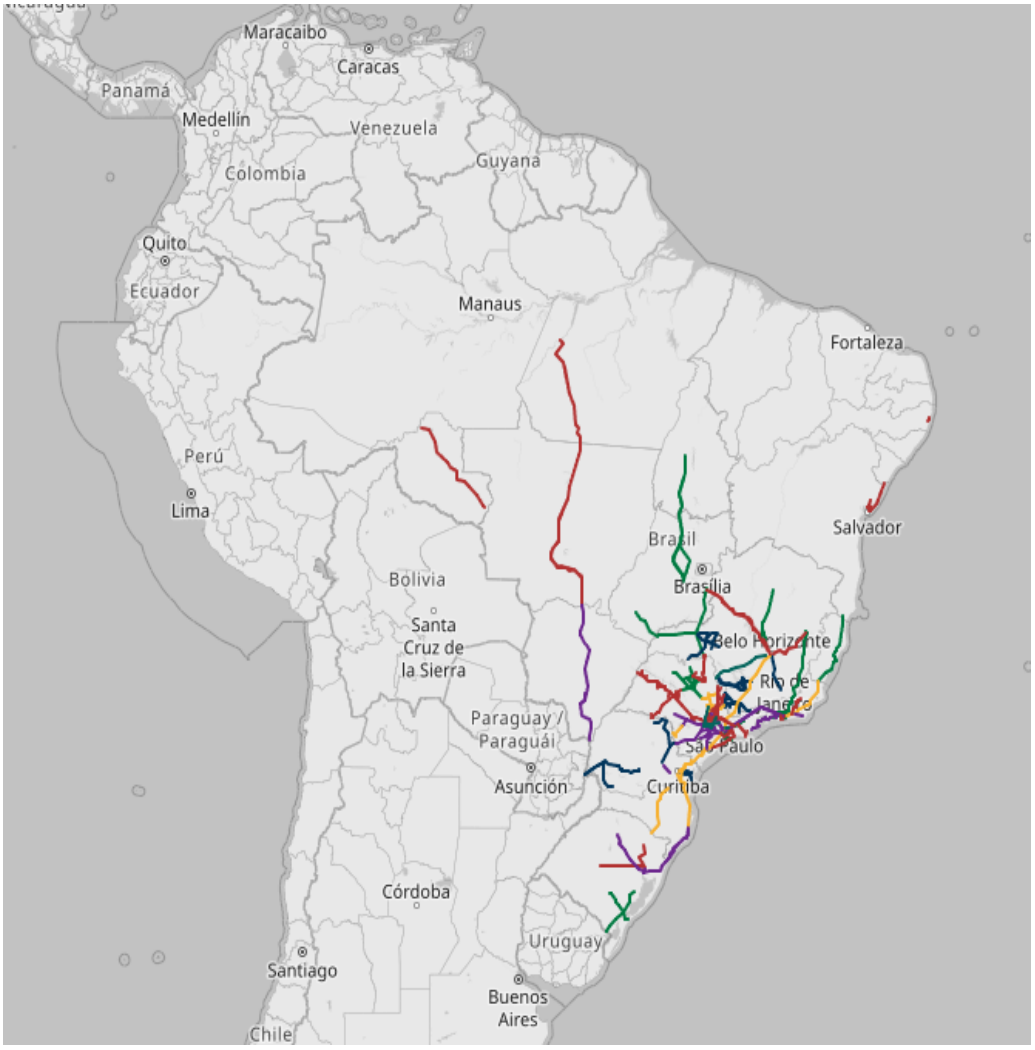
Figure 1 – Map of Highway Concessions in Brazil (2025)



Source: Agência Nacional de Transportes Terrestres (ANTT), 2026.

Table 1 presents the ranking of concessionaire groups operating highways in Brazil in 2025, based on the total length of road segments under management. In this study, the data were aggregated by controlling economic group, whereas the Agência Nacional de Transportes Terrestres (ANTT) provides information at the individual concessionaire level (Special Purpose Entities – SPEs), which required data processing and consolidation.

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Pages: 1-22

Table 1 – Ranking of highway concessionaire groups in Brazil in 2025 (by managed road length)

Rank	Group/Platform	Managed Road Length (km)	Market Share (%)
1	EcoRodovias	4,789	16,4%
2	Motiva Rodovias	4,475	15,3%
3	Pátria	3,245.8	11,1%
4	Arteris	3,200	10,9%
5	EPR	3,008	10,3%
6	Way Brasil/Kínea	2,091	7,1%
7	Via Appia	1,842	6,3%
8	VINCI Highways	1,198	4,1%
9	CSInfra	1,168	4,0%
10	Conasa Infraestrutura	1,031	3,5%
11	4UM/Opportunity	990	3,4%
12	Grupo Zopone	650	2,2%
13	Monte Rodovias	394	1,3%
14	CSG	271	0,9%
15	Sacyr (RS)	204	0,7%
	Total (estimated) ≈	30,000 km	**100,0%**

Source: Prepared by the authors based on data from the Agência Nacional de Transportes Terrestres (ANTT), 2026.

Table 1 shows a high concentration of highway concessions in Brazil, with the five largest groups accounting for more than 60% of the total managed network. EcoRodovias and Motiva Rodovias lead the ranking, each controlling over 4,000 km of highways. This distribution indicates a significant degree of market concentration, which may influence competition, investment capacity, and operational efficiency within the sector.

However, the literature also highlights critical perspectives regarding concession models, including issues related to contract renegotiation, regulatory capture, tariff affordability, and information asymmetry between public authorities and private operators. These factors may affect both the efficiency and the social legitimacy of concession arrangements, indicating that economic performance does not necessarily translate into broader public welfare gains.

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Pages: 1-22

2.2 Economic Efficiency in Road Management

The evaluation of economic efficiency in road concessions involves analyzing the relationship between the resources employed and the results achieved in infrastructure management. The main indicators highlighted in the literature include:

- operational cost per kilometer managed;
- road level of service;
- volume of investments made;
- pavement quality;
- road safety indicators.

International studies indicate that private management of infrastructure can generate efficiency gains when accompanied by appropriate regulatory mechanisms and well-structured contracts. A clear definition of responsibilities, the a balanced allocation of risks and the use of performance indicators are essential elements to ensure the sustainability of contracts.

In this context, Brandão (2022) highlights the importance of contractual innovations in the road concession sector, such as the implementation of balanced risk matrices, dynamic mechanisms for economic and financial rebalancing, and the adoption of electronic toll collection technologies, such as the free-flow system.

These instruments contribute to increasing operational efficiency, reducing administrative costs, and aligning economic incentives between the granting authority and the concessionaire.

2.3 Logistics Infrastructure and Regional Development

The improvement of road infrastructure has a direct impact on economic competitiveness, the reduction of logistics costs, and regional integration. Roads in better condition reduce travel time, decrease fuel consumption, and enhance the safety of freight transportation.

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Pages: 1-22

In this context, the performance of concessionaires becomes a strategic element for economic and territorial development.

3 Methodology

This study is exploratory and descriptive in nature, adopting a quantitative-comparative approach with the use of estimated variables and structured qualitative categorization. Part of the indicators used is based on observable data, while others are constructed from proxies grounded in contractual references, international benchmarks, and technical criteria explicitly defined in the methodology.

3.1 Data Sources

To ensure the traceability and reproducibility of the results, the data were structured according to three analytical categories:

Observed variables: directly obtained from public sources (e.g., length of roads under management, data from ANTT, concessionaire reports);

Estimated variables: derived from proxies based on concession contracts and international benchmarks;

Qualitative variables: constructed from standardized technical criteria, based on regulatory indicators and specialized literature.

All variables were harmonized considering a 2024–2025 base year, with monetary values converted into Brazilian reais (R$) from international references in US dollars (US$), using the annual average exchange rate.

3.2 Variables Analyzed

The indicator was constructed based on:

- road concession contracts available in ANTT public databases;
- concessionaires' financial reports;
- international benchmarks for operational costs (range of US$ 25,000 to US$ 60,000/km/year).

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Pages: 1-22

Monetary conversion was performed using the average exchange rate for the 2024–2025 period, resulting in estimated values between R$ 120,000 and R$ 300,000/km/year.

The allocation of ranges by operator considered:

- investment intensity (CAPEX);
- contractually required level of service;
- operational complexity (e.g., duplicated highways, high traffic volumes).

Classification for Operating Cost (R$/km/year):

- High Cost: > R$ 250,000/km/year
- Medium Cost: R$ 150,000 – R$ 250,000/km/year
- Low Cost: < R$ 150,000/km/year

Infrastructure Investment Level (CAPEX/km):

Classification based on technical criteria:

- Very High Cost: CAPEX > R$ 1,500,000/km/year
- High Cost: R$ 800,000 – R$ 1,500,000/km/year
- Medium Cost: R$ 300,000 – R$ 800,000/km/year
- Low Cost: < R$ 300,000/km/year

Pavement Quality (comparative proxy among operators): This includes real technical indicators, such as:

- International Roughness Index (IRI) for the road segments analyzed (BRAZIL, 2025);
- accident rate.

Classification:

- Excellent: IRI < 1.9 and accidents < 2 per 100 million vehicle-km
- Good: IRI between 2.5 and 3.5
- Moderate: IRI between 3.5 and 5.0
- Poor: IRI > 5.0

Management Quality:

- Excellent: ≥ 95% contractual compliance (ANTT) and IRI < 2.5

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- Very Good: 80%–95% compliance
- Good: 60%–80%
- Fair: < 60%

Public Budget (categorical variable):

- Low: self-sustaining concessions (toll-based)
- Medium: presence of PPPs or public contributions
- High: significant public sector investment

Qualitative Classification of Management

Constructed based on:

- ANTT performance indicators;
- contractual compliance;
- pavement quality (CNT);
- market evidence (sectoral reports).

This variable should be interpreted as a structured qualitative assessment rather than a directly observable measure.

To enhance methodological robustness, all classification thresholds were defined based on technical references from regulatory documents, sectoral studies, and international benchmarks. The criteria adopted aimed to minimize subjectivity and ensure consistency across concessionaires.

The qualitative variables should be interpreted as structured assessments derived from observable indicators rather than purely subjective judgments.

International benchmarks for operational costs were based on studies from organizations such as the World Bank, OECD, and infrastructure reports from multilateral institutions, which indicate typical cost ranges for highway operation and maintenance.

3.3 Measurement of Efficiency

To operationalize the concept of economic efficiency, a Composite Efficiency Index (CEI) was developed, based on the aggregation of variables

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representative of cost, management quality, and the operational scale of concessionaires.

The construction of the index followed three methodological steps:

(i) Variable selection:

- operational cost per km (proxy for economic efficiency);
- management quality (proxy for operational performance);
- length of the network under management (proxy for scale).

(ii) Data normalization:

The variables were transformed into a dimensionless scale between 0 and 1 using the min–max method, as follows:

"For benefit variables":

$$X' = \frac{X\text{-}Xmim}{Xmax\text{-}Xmin}$$

"For cost variables":

$$X' = \frac{Xmax\text{-}X}{Xmax\text{-}Xmin}$$

(iii) Weighted aggregation::

$$ICE = 0{,}4Ci^{-1} + 0{,}3Qi + 0{,}3Si$$

Where:

- **ICE** = Composite Efficiency Index;
- **Ci** = normalized operational cost (inverted);
- **Qi** = normalized management quality;
- **Si** = normalized operational scale.

The weights were defined based on the infrastructure efficiency literature and reflect the greater relative importance of the cost dimension.

By analyzing the information presented in Table 1, it was possible to organize a hierarchical flowchart of concessions (Figure 2), illustrating the distribution of companies within the road concession system.

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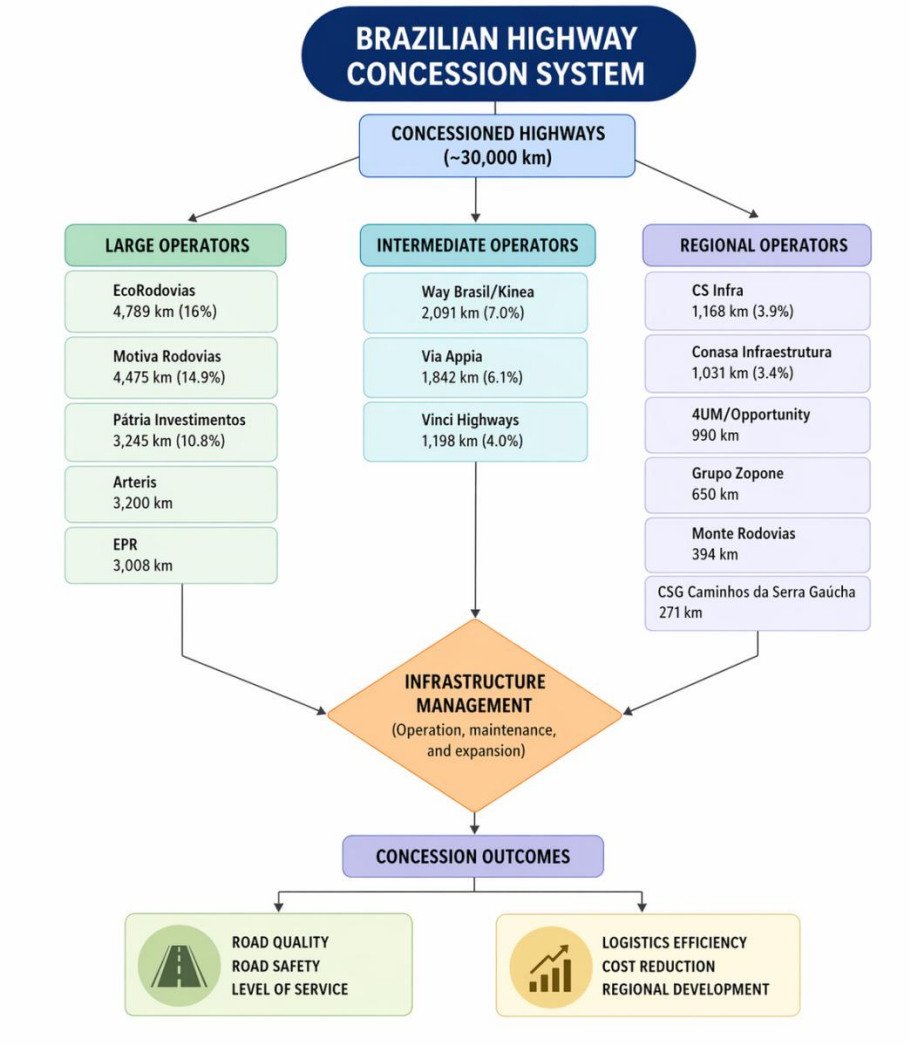
Figure 2 – Flowchart – Highway Concessionaires in Brazil (2025)



Source: Updated data (base year 2024–2025), consistent with market practices in Brazilian highway concessions (typical sources: ANTT, concessionaire reports, TCU, and IPEA/BNDES studies).

3.4 Weighting justification + limitação:

The weights assigned to the Composite Efficiency Index (CEI) were defined based on the theoretical relevance of each dimension, balancing cost efficiency, infrastructure quality, and operational scale. This approach seeks to reflect the multidimensional nature of efficiency in infrastructure concessions.

A sensitivity analysis of the weighting scheme was not performed, which is acknowledged as a limitation and an opportunity for future research.

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Pages: 1-22

4 Results and Discussion

4.1 Efficiency Analysis of Concessionaires

The data analysis shows that the Brazilian highway concession sector exhibits a significant level of market concentration. The five largest concessionaire groups are responsible for approximately half of the total length of concessioned highways in the country.

This concentration may generate advantages related to economies of scale, allowing large operators to benefit from greater investment capacity, more robust administrative structures, and easier access to long-term financing.

Table 2 – Report on Market Practices in Highway Concessions in Brazil

Concessionaire	Length of Highways Managed (km)	Estimated Operating Cost (R$/km/year)	Infrastructure Investment Level	Public Budget	Qualitative Management Classification
EcoRodovias	4,789	180,000 – 250,000	High	Low	Excellent
Motiva Rodovias	4,475	160,000 – 230,000	High	Low	Very Good
Pátria	3,245.80	170,000 – 240,000	High	Low	Very Good
Arteris	3,200	200,000 – 280,000	Very High	Low	Excellent
EPR	3,008	150,000 – 220,000	Medium–High	Low	Very Good
Way Brasil/Kínea	2,091	140,000 – 210,000	Medium	Low	Good
Via Appia	1,842	130,000 – 200,000	Medium	Low	Good
VINCI Highways	1,198	220,000 – 300,000	Very High	Low	Excellent
CSInfra	1,168	140,000 – 210,000	Medium	Low	Good
Conasa Infraestrutura	1,031	130,000 – 200,000	Medium	Low	Good
4UM/Opportunity	990	140,000 – 210,000	Medium	Low	Good
Grupo Zopone	650	120,000 – 180,000	Medium–Low	Medium	Fair
Monte Rodovias	394	150,000 – 220,000	Medium	Low	Good
CSG	271	180,000 – 260,000	High	Medium	Very Good
Sacyr (RS)	204	200,000 – 280,000	High	Low	Very Good

Source: Updated data (base year 2024–2025), consistent with market practices in Brazilian highway concessions (typical sources: ANTT, concessionaire reports, TCU, and IPEA/BNDES studies).

Table 3 summarizes the main operational indicators of the analyzed concessionaires, highlighting significant variations in average costs and in the quality levels of the services provided.

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Pages: 1-22

Table 3 – Summary of Operational and Quality Indicators of Highway Concessionaires in Brazil

Concessionaire	Length (km)	Min Cost	Max Cost	Average Cost	Quality (text)	Quality (score)
EcoRodovias	4,789	180,000	250,000	215,000	Excellent	1.0
Motiva	4,475	160,000	230,000	195,000	Very Good	0.8
Pátria	3,245.8	170,000	240,000	205,000	Very Good	0.8
Arteris	3,200	200,000	280,000	240,000	Excellent	1.0
EPR	3,008	150,000	220,000	185,000	Very Good	0.8
Way	2,091	140,000	210,000	175,000	Good	0.6
Via Appia	1,842	130,000	200,000	165,000	Good	0.6
VINCI	1,198	220,000	300,000	260,000	Excellent	1.0
CSInfra	1,168	140,000	210,000	175,000	Good	0.6
Conasa	1,031	130,000	200,000	165,000	Good	0.6
4UM	990	140,000	210,000	175,000	Good	0.6
Zopone	650	120,000	180,000	150,000	Fair	0.4
Monte	394	150,000	220,000	185,000	Good	0.6
CSG	271	180,000	260,000	220,000	Very Good	0.8
Sacyr	204	200,000	280,000	240,000	Very Good	0.8

Source: Prepared by the authors based on the normalization of operational and quality data of the concessionaires (2026).

As shown in Table 4, concessionaires such as EcoRodovias exhibit high levels of both scale (Si) and quality (Qi), while companies such as Via Appia and Way show greater penalties associated with cost (Ci).

Table 4 – Normalized Efficiency Indices of Highway Concessionaires (Si, Qi, and Ci)

Concessionaire	Si (Scale)	Qi (Quality)	Ci (Cost)
EcoRodovias	1.000	1.000	0.409091
Motiva	0.931516	0.666667	0.590909
Pátria	0.663424	0.666667	0.500000
Arteris	0.653435	1.000	0.181818
EPR	0.611559	0.666667	0.681818
Way	0.411559	0.333333	0.772727
Via Appia	0.357252	0.333333	0.863636
VINCI	0.216794	1.000	0.000000
CSInfra	0.210251	0.333333	0.772727
Conasa	0.180371	0.333333	0.863636
4UM	0.171429	0.333333	0.772727
Zopone	0.097274	0.000000	1.000
Monte	0.041439	0.333333	0.681818

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Pages: 1-22

CSG	0.014613	0.666667	0.363636
Sacyr	0.000000	0.666667	0.181818

Source: Prepared by the authors based on the normalization of operational and quality data of the concessionaires (2026).

In Table 5, the Composite Efficiency Index (CEI) was applied, allowing the establishment of a comparative ranking among the main concessionaire groups operating in Brazil.

Table 5 – Efficiency Index of Concessionaires

Rank	Empresa	ICE
1	Motiva	0,73
2	EcoRodovias	0,72
3	EPR	0,63
4	Pátria	0,61
5	Via Appia	0,58
6	Arteris	0,57
7	Way	0,57
8	Conasa	0,53
9	CSinfra	0,50
10	4UM	0,49
11	Zopone	0,43
12	Monte	0,41
13	VINCI	0,37
14	CSG	0,36
15	Sacyr	0,29

Source: Prepared by the authors based on the normalization of operational and quality data of the concessionaires (2026).

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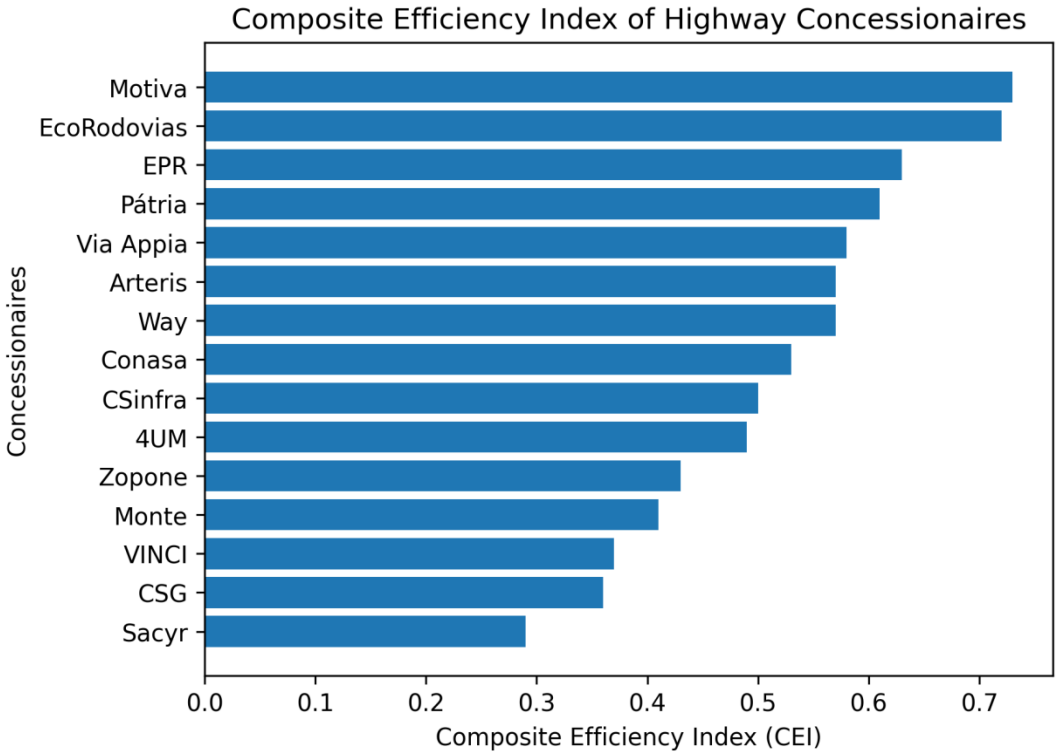
Figura 3 – Composite Efficiency Index of Highway Concessionaires (2026).



Source: Prepared by the authors based on the normalization of operational and quality data of the concessionaires (2026).

As a limitation, it is noteworthy that the index was constructed based on partially estimated and qualitative variables, which may introduce biases. Nevertheless, the adopted methodology allows for consistent and transparent comparisons among operators.

In Figure 3, the results indicate that the groups Motiva Rodovias and EcoRodovias exhibit the highest levels of relative efficiency, combining large operational scale with moderate costs and strong qualitative performance.

Next, operators such as EPR and Pátria stand out, demonstrating a balance between cost and quality, albeit with a smaller scale.

On the other hand, concessionaires with higher operational costs, such as VINCI Highways and Sacyr, show lower relative efficiency despite high levels of infrastructure quality.

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Pages: 1-22

On the other hand, the results also indicate that mid-sized operators show relevant performance in terms of operational efficiency. These companies demonstrate the ability to maintain adequate levels of infrastructure quality with relatively lower costs per kilometer managed.

This dynamic suggests that the scale of operation, although important, is not the sole determining factor for the performance of road concessions. Aspects related to managerial efficiency, contractual structure, and the adoption of technologies also exert significant influence on the outcomes achieved.

Another relevant point concerns the regional heterogeneity of the Brazilian concession system. While federal highways located in strategic logistics corridors tend to attract large operators, state-level programs often present a greater diversity of concessionaires.

4.2 Analytical Interpretation

The results show that efficiency in the road concession sector does not depend exclusively on operational scale, but rather on the combination of cost control and management quality.

It is observed that mid-sized operators can achieve competitive levels of efficiency, indicating that performance gains are associated with managerial efficiency and not solely with the size of the managed network.

Additionally, it is found that higher costs are not necessarily offset by proportional gains in quality, which negatively impacts relative efficiency in the composite index.

From an analytical perspective, the findings suggest the presence of trade-offs between scale, operational costs, and investment intensity. While large operators benefit from economies of scale and greater access to capital, they may also face higher operational complexity and cost structures. Conversely, mid-sized concessionaires may achieve higher relative efficiency by maintaining leaner operations and focusing on cost control.

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Vol: 13.06
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Pages: 1-22

These results are consistent with the literature on infrastructure economics, which highlights that efficiency gains are not solely determined by size, but also by governance structures, regulatory incentives, and contract design.

5 Conclusion

In general, the present technical-scientific study analyzed the efficiency of road concessions in Brazil based on the relationship between operational costs, management scale, and the quality of infrastructure managed by private concessionaires.

The results indicate that the concession model has played a relevant role in the modernization of Brazilian road infrastructure, contributing to increased investment and improved traffic conditions along important logistics corridors.

It was observed that large operators have greater investment capacity and higher infrastructure quality standards, while mid-sized operators demonstrate relevant performance in terms of economic efficiency.

These results indicate that the structure of the road concession sector involves different management models, each with its own characteristics in terms of efficiency and operational capacity.

From a public policy perspective, the findings suggest the need for continuous improvement of regulatory mechanisms and performance evaluation frameworks for concessions. The incorporation of a composite efficiency index enabled progress in the quantitative measurement of concessionaire performance, going beyond purely descriptive approaches. The results indicate that economic efficiency in the sector is associated with the ability to balance operational costs, scale, and infrastructure quality.

Nevertheless, as a recommendation for further scientific research, the development of more robust quantitative models for evaluating concession efficiency is suggested, including methods such as Data Envelopment Analysis

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(DEA), multicriteria analysis, and machine learning techniques applied to the transport sector.

While the findings provide relevant insights into efficiency patterns among concessionaires, they should be interpreted as indicative rather than definitive, given the exploratory-comparative nature of the study and the limitations associated with data availability and methodological assumptions.

5.1 Study Limitations

This study presents some methodological and empirical limitations that should be considered when interpreting the results.

First, the analysis combines observed data with estimated variables and structured qualitative classifications. Although efforts were made to ensure transparency and methodological consistency, the use of proxies may introduce measurement biases.

Second, the comparison between concessionaires does not fully control for structural differences across contracts, such as traffic volume, regulatory requirements, investment obligations, and concession maturity stage. These factors may significantly influence cost structures and performance outcomes.

Third, the heterogeneity between federal and state-level concessions limits the direct comparability of operators, as different regulatory frameworks and contractual models apply.

Finally, the study does not incorporate a counterfactual analysis (e.g., public vs. private management or before-and-after comparisons), which restricts the ability to draw causal inferences regarding the superiority of the concession model.

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Appendix A – Rationale for Indicator Construction

Variable	Type	Source	Construction Method	Notes
Extension (km)	Observed	ANTT	Direct data	-
Cost/km	Estimated	ANTT+benchmarks	Currency conversion + proxy	Interval data
Investment	Qualitative	Reports	Ordinal classification	-
Management	Qualitative	ANTT + market	Qualitative scoring	Controlled subjectivity