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Application of the PrOPPAGA Method in the evaluation of returnable stretches in the context of the processes of early extension of railway concessions

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Abstract

According to data from the National Association of Railway Carriers - ANTF, the Brazilian rail network is composed of 30,557 km, being distributed in 15 networks granted to the private initiative. Of this total, about 39% (8,335.9 km) are without traffic or with low demand and sometimes completely deteriorated. Given the proximity of the end of the current railway concession contracts, studies for their Early Extension were initiated. In this context, the evaluation of stretches that are without traffic is a strategic decision, both for companies and for the Union. Thus, the article seeks, through the multi-criteria analysis method PrOPPAGA, to evaluate the economic viability of 5 railway stretches that have little or no traffic based on criteria such as demand and operating costs of the stretches. The methodology is also used to carry out the ordering of the stretches from the most viable to the least economically viable. As a result, it was recommended the return 4 of the 5 excerpts, demonstrating the viability of the method as a tool to aid decision-making in this sector. It should be noted that parameters such as strategic interest and desired profit indicators, which can be evaluated in future research, were not incorporated into the research.

Keywords: Railways, Return of sections, PrOPPAGO Method, Early Extension.

1. Introduction

When it comes to large volumes of cargo and long distances, the rail modal stands out as being one of the fastest and cheapest [1].This modal is attractive, mainly due to the amount of wagons that a composition can carry, as well as the amount of cargo that can be accommodated in each wagon [2, 3] By traveling on exclusive routes, rail transport contributes to the reduction of the deterioration of the highways, mainly due to the action of truckloads. It also contributes to the reduction of greenhouse gas emissions. The volume of cargo transported

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along the Brazilian railways has had a significant increase in recent years, which is related to the investments made by railway concessionaires, aiming at increasing productivity and modernizing the sector, factors that culminated in the diversification of customers and, consequently, in the increase in the daily flow of trains [4]. Despite the investments undertaken by the sector, in September 2022, the movement of cargo in the country by railways represented only 14.95% of the total, while highways transported 64.86%, cabotage approximately 10%, and the other modes (waterway, air, and pipeline) less than 10% of the loads transported in the período.Com this discrepancy observed between the main modes of transport, highways, and railways, the definition of the stretches that are economically viable on a railroad is vital for any company in the field [5, 6].

In this scenario, the only way to support the problematic resolution of this complexity in a reasonable time is using multi-criteria models, enabling the implementation of mathematical models for decision-making in complex problems that have been used in several recent problems, such as [7–16].

In the case of a strategic decision of essential importance for a company, the use of Multi-criteria Decision Support (MDA) methods helps the decision maker to choose the alternative that best meets the criteria defined as relevant to the decision [17].

Still, it is extremely important to select a method that best meets the particularities of each decision problem.

2. Problem Description

The Brazilian rail network is 30,557 km long, distributed in 15 networks, which connect with the Railway Quadrangle in the south of Minas Gerais, as well as the main mining and steel centers of the country [18].

In addition, the federal rail network connects the largest industrial centers and agricultural areas in the country, especially in the Midwest Region, to the most important Brazilian ports, including Santos, in the state of São Paulo, Itaqui, in Maranhão, Vitória, in Espírito Santo, and Rio de Janeiro.

As pointed out by Jardim [19], such a process of abandonment observed in Brazilian railways is a result of the way the railway modal adapts to market fluctuations, that is, if there are economic interests, there is a massive investment in the creation of new stretches and extensions, however, on the other hand, when the revenues generated do not exceed the costs for maintenance of the existing stretches, these are neglected and completely abandoned[20].

With the process of early extension of railway concessions, authorized by Law No. 13,448 of June 5, 2017, many of these stretches are being disconnected from the provision of the service and returned to the Union. In this sense, the correct definition of the stretches that do not have economic viability in the process of early extension is essential both for companies and for the State [21].

In such a way that for the company, they represent a stretch with loss when the costs do not exceed the revenues, and for the union, that may give another destination to the asset, such as the implantation of tourist lines [22].

To structure the problem under study, Chart 1 presents the CATWOE analysis, a tool that allows the visualization of the various aspects that permeate the problem under study. This is a mnemonic of the six main parameters in the structuring of a parameter [23]:

C – Client – that is, either beneficiaries or victims of the process;

A – Actors – the agents involved in the process;

T – Transformation – the process itself;

W – Worldview – a worldview that makes the process meaningful;

O – Owners – those who have a determining role in the process, and can paralyze it;

E – Environmental constraints – contextualization of events outside the main process, but that may interfere with it.

With this, the present study evaluates five railway sections that present low or no demand as to their feasibility of reactivation and maintenance in the provision of rail cargo transport, the following hypotheses will be evaluated: the return of the stretches and maintenance of the stretches.

In cases where there is no anticipated demand that covers the costs of operation, maintenance, and other charges arising from the maintenance of a stretch for the provision of rail freight transport, as well as confer profit to the company, the disconnection and return of the stretch are considered [24].

In the case of stretches, which, although they currently have a low demand, which is expected future demand that justifies their permanence in the granted network, such a solution will be proposed [25]. Emphasizing that in case of maintenance of the stretch, it must be recovered so that it offers the necessary conditions for the maintenance/resumption of the service [26].

3. Methodology

According to Drumond [27], the methodology Priority Observed from the Presumption of Gaussian Attitude of Alternatives - PrOPPAGA was designed and developed to be of the simple and effective application when compared to the other methods of multi-criteria analysis most used, especially in problems involving more than 30 possibilities, occasions in which, depending on the methodology employed, parity comparisons are needed, which increase the possibility of inconsistencies and the need for rework.

As the main assumption, the method considers that all alternatives present Gaussian behavior, a premise that is fundamental in the standardization of the attributes of the alternatives since such attributes are compared to a Gaussian variable that presents the same mean and standard deviation values of the set of attributes of the alternatives in a given criterion. [28].

Initially, to define the most relevant aspects to be treated in this article, bibliographic research was carried out about railroad scenarios in Brazil, the economic viability of railway stretches, and multi-criteria methods. Given the wide range of academic materials, as well as their reliability and quality, the academic references extracted from the Scopus database, dated between 2017 and 2022, were selected [29].

Additionally, a survey was conducted with professionals in the area to substantiate the adequacy of the most relevant criteria for the present study [30]. Being selected Five railway sections that have low or no traffic because they are sensitive data these sections will be identified by [31]:

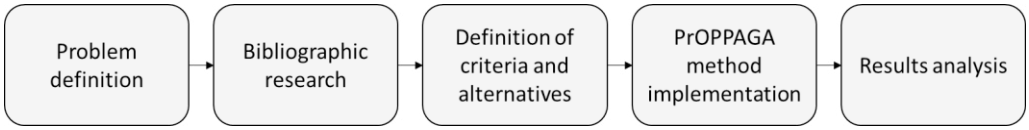
- SECTION 1;
- SECTION 2;
- SECTION 3;
- SECTION 4; and
- SECTION 5.

Data collection for each criterion was performed through research in statistical reports of the National Land Transport Agency – ANTT, which is responsible for the management of cargo transportation in the country [32].

Considering that the criteria to be evaluated for each stretch are quantitative, we chose to apply the PrOPPAGA method since this methodology allows the comparison of multiple criteria, allowing the feasibility analysis of each stretch in a simplified way.[33].

The steps followed in the present study are summarized in Figure 1.

Figure 1 – Research methodology



4. Case Study

In possession of the analysis criteria and their respective values, the ordering matrices of the criteria and alternatives are configured for each excerpt, as presented in Tables 1 to 5 for the application of the PrOPPAGA Method.

Table 1 – Criteria for evaluation of Section 1.

	C1	C2	C3	C4	C5	C6
	Snippet recovery (R$)	Demand carried over in the remainder of the contract (t)	Net revenues from the remainder of the contract (R$)	Operating costs (R$)	Demand forecast 2030 (t)	Depreciation (R$)
Maintain	190 411 691.05	0	0	16 994 000	1 400 000	21 221 000
Return	181 295 907.36	0	0	0	0	0

Table 2 – Criteria for evaluation of Section 2.

	C1	C2	C3	C4	C5	C6
	Snippet recovery (R$)	Demand carried over in the remainder of the contract (t)	Net revenues from the remainder of the contract (R$)	Operating costs (R$)	Demand forecast 2030 (t)	Depreciation (R$)
Maintain	134 795 547.51	0	0	12 380 000	64.000	15 023 000
Return	153 180 583.15	0	0	0	0	0

Table 3 – Criteria for evaluation of Section 3.

	C1	C2	C3	C4	C5	C6
	Snippet recovery (R$)	Demand carried over in the remainder of the contract (t)	Net revenues from the remainder of the contract (R$)	Operating costs (R$)	Demand forecast 2030 (t)	Depreciation (R$)
Maintain	133 696 266.16	8 287 000	217 504 000	93 942 000	1 900 000	45 692 000
Return	98 233 373.36	0	0	0	0	0

Table 4 – Criteria for evaluation of Section 4.

	C1	C2	C3	C4	C5	C6
	Snippet recovery (R$)	Demand carried over in the remainder of the contract (t)	Net revenues from the remainder of the contract (R$)	Operating costs (R$)	Demand forecast 2030 (t)	Depreciation (R$)
Maintain	140 319 521.20	2 363 000	113 501 000	41 806 000	446 000	63 055 000
Return	139 016 010.71	0	0	0	0	0

Table 5 – Criteria for evaluation of Section 5.

	C1	C2	C3	C4	C5	C6
	Snippet recovery (R$)	Demand carried over in the remainder of the contract (t)	Net revenues from the remainder of the contract (R$)	Operating costs (R$)	Demand forecast 2030 (t)	Depreciation (R$)
Maintain	687 143 734.61	5 598 000	233 516 000	70 024 000	1 150 000	131 294 000
Return	614 964 831.85	0	0,00	0,00	0,00	0,00

For the application of the PrOPPAGA method, the computational tool developed for this purpose was used, whose access can be made through the electronic address: www.proppaga.com.br. Initially, the characterization of the decision to be made should be defined, as well as the criteria to be evaluated.

The criteria should also be classified as to the nature of the information, whether qualitative or quantitative, the quantitative parameters should still be discretized between criteria of gain, that is, those that favor the decision, or cost, those that reduce its attractiveness [34].

In the next step, the weights of the criteria are defined, that is, the parameters are ordered according to their relevance to the final decision [35]. The present study has six criteria for evaluating the excerpts, so the weight of the criteria was assigned between 7 (most relevant) and 1 (least relevant). Considering also that in the case under study, all the criteria are extremely important for decision making, being used the following weights, as Table 6 exposes.

Table 6 – Criteria weights

Criteria	Description	Punctuation	Weights
C1	Stretch recovery	6	0,194
C2	Demand transported in the remainder of the contract	4	0,129
C3	Net revenues from the remainder of the contract	4	0,129
C4	Operating costs	5	0,161
C5	Demand forecast 2030	7	0,226
C6	Depreciation	5	0,161

The weight of greatest relevance was attributed to C5 (Demand forecast 2030) because this is the parameter by which revenues are generated for the company, and therefore justifies or does not the maintenance of a certain stretch. The criteria related to the remaining period of the contract were assigned a degree of importance of 4, lower among the others because the remaining period of the contract (5 years) represents a small portion of the concession.

After defining the criteria, the values of each parameter evaluated are entered into the *software* for each of the alternatives. Once the calculation parameters have been inserted into the tool, the solution that best suits the parameters and weights is identified.

About Section 1, the application of the PrOPPAGA method in the analysis of the permanence of the stretch in the concession contract reflected the empirically expected since the stretch does not currently present traffic volume, and yet, the projected demand for the horizon of the contract is considered low, from the point of view of rail transport. The return of the stretch proves to be the best solution from the economic point of view for the company.

On the other hand, Section 2, which also has no traffic at the moment and has a lower demand forecast than the previous stretch, pays for the maintenance of the stretch in the rail freight transport service. A hypothesis for such a result may be the more expressive value for the return of the stretch than for its reactivation, associated with less expressive values of maintenance and depreciation when compared to the other stretches.

For Section 3, although it currently has less traffic than its installed capacity and still a forecast of future demand higher than that observed in the other sections, the high costs of restoring the road to the minimum traffic conditions, associated with maintenance and depreciation costs, also make this stretch economically unviable.

As in Stretch 3, Section 4 has a low traffic density now and a low forecast of future demand, facts that corroborate the indication of the method for its return.

Excerpt 5 presents the same characteristics of low current and future demand, the recommendation of the method for its return is quite reasonable.

When comparing all the stretches regarding the viability of permanence in the network, Section 3 appears as the most viable, this result can be explained by the fact that this segment presents the highest future demand, which is the most relevant criterion.

In the second place, as more economically viable, is Stretch 1, which presents the second highest demand for the future. The fact that Section 2 appears in third place in the feasibility comparison may be related to the recovery value of this stretch, being the second smallest.

In the fourth and fifth positions appear Sections 4 and 5, respectively, positions that can be explained according to the value of recovery of the road to the desirable conditions of traffic. It should be noted that the present study did not evaluate factors such as the company's strategy, as well as did not obtain values such as taxes and profit margin considered by the company in its evaluations.

In this context, the application of the PrOPPAGA method in the evaluation of the feasibility of permanence of railway stretches with little or no traffic in the concession contracts proved advantageous in most cases and can be used as another tool to corroborate with the strategic decisions to be taken by a railway company.

5. Conclusion

The fundamental purpose of this research was achieved since, with the application of the PrOPPAGA method, it was possible to determine, to a certain extent, which railway sections are economically viable for a company, still allowing an ordering between the sections in question from the most viable to the least viable. Demonstrating that the application of such a multi-criteria analysis method can be another tool to aid decision-making in this sector.

Future research may incorporate into the evaluation criteria that express the strategic interest of the companies, as well as indicators of desired profit so that the method becomes more efficient and consistent with the reality of the market and that even other methodologies are used, allowing corroborating, or refuting the conclusions found.

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