

Evaluation and Selection of Tire Retread Service Providers using the AHP method

Paulo Mantelatto Pecorari, Maria Célia Oliveira, Carlos Roberto Camello Lima

Production Engineering Graduate Program
Methodist University of Piracicaba - UNIMEP
Santa Bárbara d'Oeste, SP, Brazil
crclima@unimep.br

Abstract — The retreading of truck and bus tires has economic importance, decreasing haulier operating costs, and environmental importance, reducing use of natural resources such as oil. In Brazil, mainly because it is an economic advantage, most of haulier companies have the practice of retreading their tires. The Brazilian providers of this type of service have an international standard quality level, proven by the ISO standard and are regulated in terms of safety by National Institute of Metrology, Quality and Technology (INMETRO). This paper aims to analyze criteria that involve the relationship between haulier companies and tire retread service providers. In order to respond to this objective, a survey with 157 haulier companies located in the São Paulo state. The study results show that haulier companies prioritize the commitment, the retread price and guarantee service, to choose the company that will provide tire retreading service.

Keywords—haulier companies; retreader companies; tires; decision making; AHP

I. INTRODUCTION

Historically, the relationship between haulier companies and tire retread service providers has already had a long history, more than 60 years. Service providers and the tire retreading process have followed the development of new tires over time, which has in turn met the diverse needs imposed by the automotive industry in the commercial segment and its customers. Tire is formed by carcass (structure) and treads (drawing). The retreading of tires consists of replacing the worn tread of the tire. It is a worldwide practice that had its origin as a way to avoid waste and provide economy. The commercial tire casings are designed to withstand survivors and pickups only employ 20% of the material used to produce a new tire [1, 2].

The vast majority of haulier companies in Brazil use retreaded tires. Its use is linked to monetary importance and environmental appeal. The retreaded tire has similar mileage to the new tire, costing about 70% less to the consumer. In addition, the retreading postpones the final destination of the carcass and has

its solid waste recycled by other activities, providing a significant reduction in environmental impact [3]. In this context, Brazil has the second largest market in the world, behind the United States of America. The best providers of this service in Brazil have an international standard of quality, proven by the ISO (International Organization for Standardization) standard and are regulated in terms of safety by INMETRO (National Institute of Metrology, Quality and Technology), with low rates of problems with quality [4].

The relationship between hauliers and retreaders involves technical and commercial criteria. Currently, there are 1,257 companies that provide retread services in Brazil and, despite working with distance limitations, which affects the collection and delivery time of the hauliers' retreaded tires, the competition between retreaders is considerably fierce [4].

Considering the large number of companies that provide retread services in Brazil, this paper investigates the following research question: What are the main factors that haulier companies consider from retread companies to the customer-supplier relationship? To answer this question, this study developed a Survey-type survey with 157 haulier companies, located in the São Paulo state, Brazil.

II. LITERATURE REVIEW

The history of the tire retreading industry is intrinsic to the history of the tire. However, it was in the late 1950s, about 60 years ago, that tire retreading underwent a major evolutionary change in its manufacturing process, especially in the vulcanization part, which lasts to this day. This change was boldly realized with the birth of an innovative company called Bandag, located in Muscatine, Iowa, USA [5].

Bandag's vision was to increase the quality of retreaded tires by means of a more organized retreading process that would use pre-molded bands (cold process). This process would also use a longer vulcanization time, with lower pressure and temperature, similar to the working condition, which would result in a lower exposure of the tire casing in relation to the risk variables. In this sense, more than 100 patents were registered in 25 countries around the world, modifying the way in which the haulier companies saw and would use the tire retread [5]. Dabic and Miljus [6] highlighted in their work the importance of retreaded tires for commercial vehicles

and haulier companies. In this work, they concluded that, as an alternative to premature tire discarding, which increases logistical cost and environmental impact, haulier companies must invest to improve the performance of the total tire life, especially in the conscious use of tire retreading. Because the retread for commercial tires has a double effect: it helps the fleets to become economically more competitive, while helping to preserve the environment, with less waste and less oil.

About the economic part that involves the relationship between haulier companies and retread service providers, Pecorari and Lima [7] analyzing the tire cost in a haulier company, found that the retreaded tires obtained a similar, if not superior, performance to the new tire, with a 67% lower cost. However, as commented by Ponisciakova and Sukalova [8], the tire cost in haulier companies is a cost dependent on their own performance. The tire cost is directly related to the care with its use, and consequently, its wear, which increases as the vehicle rolls. This also means that this cost depends indirectly of the vehicle's performance and the driver's driving. In this sense, Schmidt et al. [9] point out that the cost and performance of the tire in a fleet also depends on a number of technical characteristics of the tire, which must be evaluated before its purchase, such as: measurement, model, load capacity and speed limit.

These characteristics become even more important, as they have a direct impact on the fuel efficiency of the vehicle. However, for the retreading and everything else that involves the tire cost to obtain positive results, control and management is necessary. Cohn [10] points out that the control of the tire cost occurs through a technical work, which consists in the careful analysis of the data for decision making, resulting in a higher productivity with the reduction of unemployed vehicles, a greater durability with the increase in the useful life of the tires, and consequently, lower costs for the haulier companies. Technical works with retreaded tires and new tires, oriented to the proper use of the product and the reduction of its cost can be observed in several works [3, 7, 11-13].

These works also involve safety, analyzing the causes of more critical failures, leading to emphasize the importance of adequate preventive measures. The preventive measures aim to define the time of removal before the failure, avoiding accidents and potential damages. About the environmental part that involves the relationship between the haulier companies and the retread service providers, when a tire is retreaded the tire casing is being reused, contributing to a new tire not being manufactured. Because, as call attention, Lagarinhos and Tenório [14] used tires are becoming a world problem. The tire discarding grows, year after year, all over the world and little importance has been given to its disposal, in many countries. In addition to contributing to a lower amount of solid waste to be treated, tire retreading also contributes environmentally to less use of a non-renewable natural

resource, petroleum. The industry estimates that to produce a retreaded tire, seven gallons of oil is needed, while a new commercial tire requires 22 gallons [15]. Thus, in view of the economic and environmental issues involved in the commented relationship between company and service provider, there are criteria considered extremely relevant by both sides. However, up to where it was researched, these criteria are analyzed only to measure customer satisfaction rather than their priorities [16].

III. RESEARCH METHOD

According to Forza [17], in the construction of a survey, there is a long process for its validation. This process includes some related sub-processes, which were developed in this research: the theoretical domain for empirical domain; the construction and testing of a pilot; the data collection for the theoretical test; analysis of data; and the interpretation of the data and report writing of the research. Initially, a theoretical study was carried out to construct a pilot questionnaire, consisting of questions presented on the Likert scale, which was applied to ten maintenance managers of haulier companies that used tire retread services.

The five-point Likert scale used had the following meaning: number five indicated that the hauliers agreed fully with the assertion of each criteria; number four indicated the hauliers who agreed in part; the number three who did not agree or disagree, that is, they did not wish to answer their question; in number two they disagreed partially; and the number one indicated that the hauliers disagreed completely.

After the analysis of the answers of the pilot test and the suggestions made by the respondents, the questionnaire was re-adapted to be applied in 300 haulier companies. However, only 157 of these companies were interviewed and answered the survey questionnaire (52.3%). All of them were located in São Paulo state (Brazil) and use tire retread services. The interviews were carried out with visits scheduled *in loco*, in the headquarters of the haulier companies, from July to September of 2016. The interviews were made, in the majority, with those responsible for the decision of tire retread company's selection, that is, people who decided by the haulier.

The evaluated hauliers were distributed approximately in one hundred cities in the São Paulo state. These companies operate in urban, rural or road transport of various activities and products, such as: collective transport of people, transportation of food, beverages, fuels, chemicals, construction products, industrial products, household appliances, electronics and fractional load ordering. After carrying out the research with the hauliers, a hierarchical model was constructed to structure the research problem, as suggested by the AHP method. Figure 1 presents the overall goal, identified as: "Selection of tire retread service providers by hauliers". In addition to the overall goal, technical and commercial criteria of greater relevance for retread service were defined.

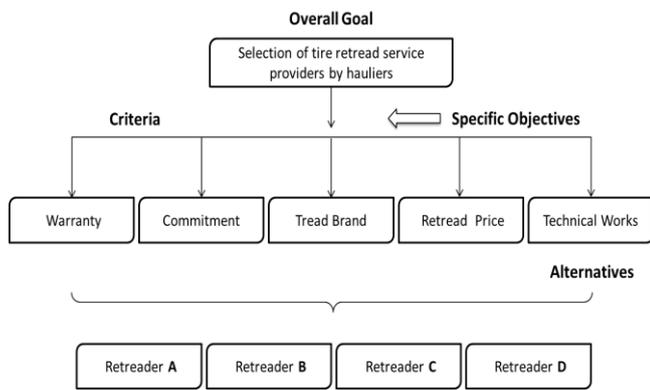


Fig. 1. Hierarchical model of problem structuring

When reading the questionnaire, the haulier was faced with the following assertions, for five-point Likert-scale weightings: (i) The granting of guarantees has a strong influence on our choice of service provider; (ii) The retreader commitment, with which it was negotiated, has a strong influence on our choice; (iii) For us, the tread brand is more important than the service provided by the retreader; (iv) The retread price has a strong influence on our choice of service provider, and; (v) Technical works that reduces tire costs has a strong influence on our choice of retread service provider.

Frame 1 presents the details of the model's criteria defined in Figure 1, with the main characteristics, explanations, arguments and theoretical foundations, about the relation of each of them with the haulier companies and the retread service providers.

Criteria	Main characteristics
<i>Commitment</i>	The Commitment criterion mainly involves the situations agreed and negotiated during the hiring of the service provider by the haulier company. Among these situations, the ones that are usually more charged by the haulier to the retreader are related to the collect of the tires for retreading, like presence and time. The presence of retreader on the haulier for casings collect must have the frequency and time of delivery agreed.
<i>Technical Works</i>	The criterion Technical Works deals with activities that the service provider can carry out in the haulier company with the objective of reducing the tire cost. These activities are linked to the analysis of waste tires (scrap tires), analysis of tires running (fleet inspection) and training for employees (drivers, tire man, etc.). The analysis of waste tires can identify failures that can be corrected with the awareness of those involved, through training and capacity building. The analysis of rolling tires can identify irregular tire wear caused mainly by inadequate pressures and deviations of vehicle geometry, thus contributing to proper maintenance.
<i>Tread Brand</i>	The Tread Brand criterion identifies exclusively the strength that the brand has in the decision making of the haulier when selecting the retread service provider. In this sense, new tire manufacturers also manufacture treads and work on the concept of total product life cycle, offering the same tread of each original model. Thus, new tire manufacturers can influence the haulier companies in their decision making. However, in this context, there are also independent tread manufacturers of new tire manufacturers in Brazil.
<i>Retread Price</i>	The criterion Tread Price simply involves the force of the price in the choice. The price may be related to the cheaper or more expensive tread brand, as well as the

installed capacity and retreader strategy, which may have a strong influence on this composition (tread + service) and formation of the retread service price, when offered for the haulier.

Warranty This criterion is linked to two important situations among the relationship addressed: (i) the quality of the service provided, where it can be measured from the percentage of technical failures that may occur during the service life in relation to the service amount of retreaded tires, and; (ii) the commercial ability of the service provider to deal with customer satisfaction when it is identified in a warranty case that the fault is not technical but relative to other situations, such as improper conditions of use.

Frame 1 – Criteria and main characteristics.

IV. RESULTS AND DISCUSSION

The results observed in the survey indicated that the evaluated hauliers have an average of more than 20 years of transport experience and an average of 200 employees. Together they own 24,776 vehicles, buy 58,664 new tires and retread 77,121 tires, per year. The majority of respondents were the responsible for decision making on the selection of retreading companies, ranging in age from 30 to 50 years, with an average of 18 years of maintenance experience. The result of the haulier companies answers about the applied questionnaire is presented in the Table 1.

TABLE I. - LIKERT SCALE SURVEY RESULTS

Criteria	5	4	3	2	1	Median	Mode	Amplitude
<i>Warranty</i>	53	47	17	29	11	4	5	42
<i>Commitment</i>	61	86	5	2	3	4	5	84
<i>Tread Brand</i>	28	21	15	42	51	2	1	36
<i>Retread Price</i>	49	78	10	13	7	4	4	71
<i>Technical Works</i>	30	34	45	30	18	3	3	27

Following the analysis of the data, the answers of the third point were discarded because they were indifferent to any statement of the research, which according to the definition refers to the respondents who omitted the opinion for that question. Thus, the percentage of companies that agreed partially or totally (4 and 5 points) with each affirmation of each criterion was evaluated, in relation to the hauliers that disagreed partially or totally with each criterion (1 and 2 points), according to Table 2 .

TABLE II. — HAULIER COMPANIES THAT AGREED VERSUS THOSE THAT DID NOT AGREE ON EACH CRITERION

Criteria	Agreed (1)	Disagreed (2)	1 x 2
<i>Warranty</i>	64%	25%	71%
<i>Commitment</i>	94%	3%	97%
<i>Tread Brand</i>	31%	59%	35%
<i>Retread Price</i>	81%	13%	86%
<i>Technical Works</i>	41%	31%	157%

With regard to the relation of hauliers that agreed, versus those that disagreed with each criterion, a new percentage comparison relation was verified, as shown in Table 3, now on the correlation of agreement

between the criteria of the research carried out. The percentage base was used to facilitate the reader's perception of established relationships. In Table 3 it is also possible to verify that, the commitment stands out as the most relevant criterion, being superior to all other criteria; and the tread brand appears as the least relevant criterion, being inferior to all other criteria.

TABLE III. – PERCENTAGE COMPARISON RELATION ON THE CORRELATION OF AGREEMENT BETWEEN THE CRITERIA

Criteria	Warranty	Commitment	Tread Brand	Retread Price	Technical Works
Warranty	100%	74%	207%	83%	125%
Commitment	135%	100%	280%	112%	169%
Tread Brand	48%	36%	100%	40%	60%
Retread Price	121%	89%	250%	100%	151%
Technical Works	80%	59%	166%	66%	100%

After the comparison in Table 3, weights were defined for the conversion of the data found by the Likert scale to the AHP method. Firstly, the paired values of the fundamental scale of absolute numbers of Saaty [18], considered intermediate, were not considered (2, 4, 6 and 8). As for the odd numbers of the scale, it was defined that: (i) for a comparison equal to 100%, the AHP scale value would be "1"; (ii) for comparisons between 101% and 120% the value of the AHP scale would be "3"; (iii) for comparisons between 121% and 150% the value of the AHP scale would be "5"; (iv) for comparisons between 151% and 200% the value of the AHP scale would be "7", and; (v) for comparisons above 200% the value of the AHP scale would be "9". The result of adapting the Likert scale to the AHP scale can be seen in Table 4.

TABLE IV. – ADAPTING THE LIKERT SCALE TO THE AHP SCALE

Criteria	Warranty	Commitment	Tread Brand	Retread Price	Technical Works
Warranty	1	1/5	9	1/5	5
Commitment	5	1	9	3	7
Tread Brand	1/9	1/9	1	1/9	1/7
Retread Price	5	1/3	9	1	7
Technical Works	1/5	1/7	7	1/7	1

With the correlations between the research criteria already adapted to the fundamental scale of absolute numbers of the AHP method, a priority calculation was made to identify which criteria would be most relevant for the decision making, in the context of this study, for the selection of a service provider, as shown in Table 5.

The priority calculation, established by the AHP method and shown in Table 5, identified the most relevant criteria for decision making by a haulier in the selection of a retread service provider. The criteria, ordered by priority were: (i) Commitment of the tire retread service provider 45.6%; (ii) Retread price 29.2%; (iii) Warranty service 15.0%; (iv) Technical works 7.6%, and; (v) Tread brand 2.7%.

TABLE V. - PRIORITY CALCULATION BETWEEN THE CRITERIA.

Criteria	Warr	Com	T. Bran	R. Price	T. Work	Prior.	%
Warranty	0.088	0.112	0.257	0.045	0.248	0.150	15.0
Commitment	0.442	0.560	0.257	0.674	0.348	0.456	45.6
Tread Brand	0.010	0.062	0.029	0.025	0.007	0.027	2.7
Retread Price	0.442	0.187	0.257	0.225	0.348	0.292	29.2
Technical Works	0.018	0.080	0.200	0.032	0.050	0.076	7.6

The results presented in Table 5 highlight the importance of the commitment to the other criteria and the sensitivity to the retread price, demonstrated by the haulier companies, since the retreading alone already be related to the reduction of the operational cost, as highlighted by Dabic and Miljus [6].

V. CONCLUSION

This study concludes that it was possible to comply with its objective and to analyze the main criteria considered by haulier companies when selecting the company that provides tire retread service. For this analysis, a five-point Likert scale conversion system was used for the AHP (Analytic Hierarchy Process) method, with its fundamental scale of absolute numbers.

The Commitment was highlighted as the most relevant of all the criteria, considered by the haulier companies, in the decision making process, for the choice of the tire retread service provider, for this work. The emphasis given to the commitment, with almost half of all relevance, is due to the complexity of the operation between haulier and receiver. This complexity has to do with the other criteria already presented and a few others, for example: (i) collect of tires for retreading, (ii) delivery of tires to the haulier company, (iii) correct destination.

These additional presented criteria appear to sound simple and easy to accomplish. However, it contributes negatively to this operation, the fact that the haulier companies work with reduced inventories of new tires. In other words, when removing the tires from a vehicle to retread, normally, the hauliers do not have tires to replace and keep the vehicle suspended waiting retread tires. This is what makes the operation complex and increases the pressure on the retreader, requiring a commitment beyond the usual, for unforeseen adjustments in its administrative, commercial, logistics and productive structure. Therefore, the emphasis and relevance to commitment is understandable.

The retread price appears in the search as the second most important criterion for the hauliers. The relevance of almost 30% given this criterion demonstrates the sensitivity and fragility on the price. Often some hauliers, for various reasons, can not evaluate the cost benefit of the products and services

involved with the topic. Thus, of course, they transmit to the retreaders, the lack of such capacity, by charging for prices. However, it is normal that the retread price to be important, but the weight given to it reflects a certain lack of management, maintenance and technical work that can enhance the performance of new and retreaded tires.

Warranty service, technical work and tread brand together account for only 25% of the relevance of the haulier companies' decision-making priorities in this study. To some extent, this number reflects a regional and momentary situation, however, considerable. These three criteria involve products and services that the retreaders can present as a differential in the search for the value creation and distinction of the other competitors. Thus, it can be seen that there is a competition between the retreaders which, in a way, feeds the lack of technical interest on the hauliers part. In addition, the retreaders will have to reinvent their model of value creation, because the current one is costly and outdated.

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