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ECONOMIC ANALYSIS OF THE OPERATING REPAIR COSTS OF SELECTED VEHICLES OF POPULAR SEGMENTS

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Abstract – The article presents a detailed analysis of operational repair costs for vehicles with mileage of 30,000, 60,000, 90,000, and 120,000 kilometers. The study focused on selected automotive groups that offer at least three vehicle models within the same market segment, with the condition that these vehicles were equipped with identical powertrains-both spark ignition and compression ignition engines. The analysis was conducted in the context of repairs carried out at both authorized service stations and independent repair workshops. The aim of the study was to assess whether the operational repair costs for premium segment vehicles differ significantly from those of mass-market vehicles within the same automotive group. Furthermore, the study examined whether there is a relationship between the duration of individual brands' participation in the automotive group structure and the reduction of differences in operational repair costs. The research employed a numerical experimentation method using the AUDATEX system, which enabled the precise determination of repair costs. The differences in service costs for cars considered more prestigious compared to popular cars ranged from -20% to nearly 120%. This was most often to the detriment of cars considered prestigious, which is interesting given that they used the same engines. Service availability and market presence are important considerations, as younger brands tended to show greater differences.

Key words – automotive groups, automotive market, vehicle segments, vehicle operational repairs, vertical agreements

JEL Classification – D41, D51, D57

INTRODUCTION

In 1765, the French engineer Nicolas Joseph Cugnot constructed a self-propelled, steam-powered wheeled vehicle, which then underwent numerous modifications over the centuries, and the development of motoring continues to the present day. Over the years, vehicles have changed in terms of visual appearance, comfort, safety or type of propulsion. Power units have been modified, starting with steam (1765), electricity (1881), spark-ignition (1885), compression-ignition (1897) [1], autonomous (1921) [2] and hydrogen (1999) [3]. All systems have been modified to a greater or lesser extent. Over the years, vehicle manufacturing companies have sprung up in various countries around the world and existing companies have been transformed into the automotive industry. An interesting example is the Toyota brand, which in 1918 was involved in the textile industry and in 1933 set up an automobile division in its weaving workshops [4]. Today, it is the largest automotive company, since it has produced almost 10 million cars by October 2024. The current automotive industry encompasses the production, design, development, marketing, and sale of motor vehicles. It is one of the most important industries in the world, with a huge impact on the global economy. There is a wide range of car models available on the automotive market, which vary in size, drive used and performance. Such a diverse offer is due to the different directions in which automotive companies are developing. Vehicle manufacturers have high-profile and more mainstream vehicles in their ranges. When choosing a vehicle, an

important aspect is the use to which it will be put, the purpose for which it will be used. The purchase of a car is still the second largest investment of an average household, after their own home [5]. Interestingly, the past few years have shown that the number of vehicles continues to increase, and these are both new and aftermarket vehicles [6]. The most common dilemma before buying a vehicle is the value of the vehicle, which has a significant impact on society's decisions [7]. Buying a used car can involve unexpected faults, defects, unexpected expenses. Buying a new car is an investment with long-term economic consequences, thus the potential user should familiarise himself with the costs connected with its exploitation [8].

On this basis, the following hypotheses can be formulated:

1. The exploitation repair costs of brands considered to be prestigious are higher than those of popular vehicles.
2. There is a perceived difference in the cost of operating repairs among companies with different levels of market experience.

1. LITERATURE REVIEW

The current automotive industry is one of the most important industries [9], encompassing a broad spectrum of companies and organisations involved in the design, production, marketing, and sale of automobiles. In many countries, the automotive industry plays a key role as an important driver of economic growth and progress. As a major vehicle manufacturer, it also has a positive impact on the development of other economic sectors, employment and technological innovation. It creates millions of job places in vehicle production, sales and service. In turn, vehicle production and sales make a significant contribution to the country's GDP and generate tax revenues [10].

The sales success reported by a particular concern attracts many investors and shareholders who are ready to take and invest money. The fierce competition in the market, the required legal standards and the constantly changing technological environment enforce the need to constantly chase the customer. Vehicle manufacturers compete against each other by offering increasingly advanced solutions. As a large number of vehicles on our roads have a negative impact on the environment, this is already generated at the production and operation stage [11]. Nowadays, in order to reduce the environmental impact of the transport sector, governments and institutions implement more and more detailed regulations and restrictions on pollutant emissions [12]. Companies adapt vehicles to increasingly stringent standards, such as CO_2 emissions through continuous development. In order to meet the requirements of emission standards, and also these of reducing fuel consumption while maintaining the required durability of the power unit, vehicle manufacturers must develop increasingly sophisticated propulsion systems and energy conversion systems [13]. Increasingly, manufacturers make every effort to make vehicle designs lighter [14].

During such dynamic changes, individual vehicle manufacturers need to find themselves, and in order to reduce the amount of money spent on research, individual vehicle brands merge and combine to form concerns. Consolidation in the context of the automotive economy refers to the process of merging or acquiring companies. It is aimed at increasing operational scale, gaining advantages and strengthening competitive positions in the market by integrating different units, organisations or structures into a single, more coherent whole, by increasing operational efficiency, reducing costs or achieving strategic advantages. According to M. R. Carrell and N. F. Hattie (1995), consolidation refers to the process of combining resources, competencies and organisational structures in order to achieve synergies. In the context of corporate finance, by J. Ross consolidation is defined as the process of combining assets, liabilities, revenues and expenses for the purpose of achieving a common view of the financial situation of a corporate group. Similarly, R. Anthony, in his work, describes consolidation as a key mechanism for reducing financial risk by increasing the scale of operations and integrating operational processes. By consolidating a strategic company, one's performance can be checked, resulting in lower costs. Increased competition in the market affects service quality[15]. In this way, it is simply easier and safer. Brands exchange their technologies and do not have to develop a solution from scratch, since they can "borrow" it from their colleagues and this is their main objective. During such alliances, projects or research carried out are jointly used, for example, the floor pan used for five vehicle models (Nissan Qashqai, Nissan X-Trail, Mitsubishi Outlander, Renault Austral and the emerging 7-seater SUV) [16]. The fundamental purpose of such mergers is to provide guidance for dealing with and improving the organisational culture in international partnerships so that, as the economy becomes globalised, such partnerships, whether they are acquisitions, mergers or joint ventures, remain profitable as a strategy option for achieving the goals of growth, diversification, economics or global presence [17]. In addition, it is also about security, both financially and in terms of image.

It is always good to have the backing of a giant concern [18]. In previous years, the process of smaller companies' acquisitions by larger ones took place in various industries. As a rule, larger companies have opted for acquisitions in order to gain a competitive advantage, expand their offer, increase their market share or acquire new technologies.

In the automotive sector there are many concerns, which can be divided on the basis of the extent of their activities. Accordingly, on the market we have American, Chinese, Japanese, German, British and the other concerns. Among companies offering both internal combustion and electric vehicles include concerns such as:

- Bayerische Motoren Werke AG (BMW) offers brands such as BMW, Rolls-Royce and MINI,
- Mercedes-Benz Group offers brands such as Mercedes-Benz, Maybach and Smart,
- Ford Motor Company offers brands such as Ford and Lincoln,
- Geely Automobile offers brands such as Geely Auto, Lynk & Co, Proton Cars and Geometry,
- General Motors Company (GMC) offers brands such as Cadillac Pontiac and Rapid Motor Vehicle,
- Honda Motor Company offers the Honda brand,
- Hyundai Motor Group offers brands such as Hyundai, Daewoo and Kia,
- Mazda Motor Company offers brands such as Mazda,
- Renault-Nissan-Mitsubishi Alliance offers brands such as Renault, Nissan, Mitsubishi and Infinity,
- Stellantis offers brands such as Fiat Chrysler Abarth, Alfa Romeo, Citroën, DS, Jeep, Maserati, Peugeot, Vauxhall, Chrysler, Lancia, Opel, Dodge and Ram and SRT,
- Subaru Corporation offers the Subaru brand,
- Suzuki Motor Corporation offers the Suzuki brand,
- Tata Group offers the brands, Jaguar, Land Rover and TATA,
- Tesla Inc offers the Tesla brand,
- Toyota Motor Corporation offers brands such as Toyota, Lexus, Daihatsu, and Hino,
- VAG offers brands such as Volkswagen, Skoda, Seat and Cupra, Audi, Lamborghini, Bentley, Ducati, and Porsche,
- Ferrari N. V. offers the Ferrari brand,
- BAIC Group offers brands such as Senova and Wevan. BJEV,
- BYD offers the BYD brand,
- McLaren Group offers the McLaren brand,
- SAIC Motor Corporation offers brands such as Roewe, IM, Maxus, Morris Garages, Baojun, Wuling.

This article will therefore continue with research undertaken on the three concerns, hence their brief characteristics are given below:

1. **The Renault-Nissan-Mitsubishi Alliance** initially concerned only Renault, founded in 1899. In 1990, the company entered into a partnership with Volvo, which lasted until 1999. Following this collaboration, Renault reached an agreement with Nissan, forming an alliance that Mitsubishi later joined. Thanks to these strategic partnerships, the concern has become one of the largest manufacturers of light vehicles in the world [19]. In the study, the prestige of a vehicle was determined by the value of the new vehicle and in the study, the most prestigious was considered to be: Infinity Q30, the less luxurious Nissan Pulsar and the popular vehicle Renault Megane.

2. **Stellantis** compared to other automotive concerns on the market, is a fairly recent entity, having been created in 2021 as a result of the merger of Fiat Chrysler Automobiles and Groupe PSA. It currently offers brands such as Abarth, Alfa Romeo, Citroën, DS. Automobiles, Fiat, Jeep, Maserati, Peugeot, Vauxhall, Chrysler, Lancia, Opel or Dodge, as well as Ram and SRT [20]. In the survey, vehicle prestige was determined by the value of a new vehicle and in the survey the most prestigious was considered to be: Opel Astra, the less luxurious Citroën C4 and the mainstream vehicle Peugeot 308.

3. **Volkswagen AG** began in 1934 with the presentation of the Volkswagen Garbus model, described as a 'car for the people'. In 1937, Volkswagen GmbH was founded. In 1976, the company acquired the Seat and Skoda brands, and in 1998 it expanded its portfolio to include Bentley, Bugatti and Lamborghini. Today, Volkswagen offers vehicles under 10 core brands, which are divided into three categories: Core Group (Volkswagen, Skoda, Seat and Cupra), Progressive Group (Audi, Lamborghini, Bentley and Ducati) and Sport Luxury Group (Porsche) [21]. In the study, vehicle prestige was determined by the value of the new vehicle and in the study the most prestigious was considered to be: AUDI A3, the less luxurious Volkswagen Golf and the popular vehicle Škoda Octavia.

Referring to the topic of the article 'Running Costs Analysis', it should be emphasised that during the use of a new car, its components are subject to exploitation and therefore there are subject to periodic replacement, the validity of which is directly derived from vehicle repair technology. During maintenance, the replacement, adjustment or inspection of the components listed below is a guarantee of the safe mobility for the vehicle purchaser [22]:

- The valve train, comprising the timing belt or chain, belt or timing chain tensioner, gears (timing wheels), camshaft, valves, gaskets, valve springs, valve pads, valve cover gasket,
- The brake system, comprising the brake fluid, brake pads and discs, brake lines, brake calipers, springs and pistons, etc.,
- Exhaust system, comprising muffler, catalytic converter, diesel particulate filter (DPF), connecting pipes, gaskets and exhaust pipes, the noise emission value of the vehicle is defined by standards [23],
- Cooling system, comprising coolant, coolant radiator, thermostat, cooling hoses, water pump, cooling fan, radiator temperature control valve, coolant expansion tank and gaskets,
- Suspension system, comprising shock absorbers, suspension springs, suspension pins and arms, wheel bearings, stabilisers, suspension cushions, tie rods, covers and bushings, and tyres,
- Steering system, comprising steering wheel, steering gear, power steering fluid, tie rods and rod ends, king pins, steering knuckles, steering column, steering column bearings.

Modern vehicles, despite their advanced technology and high production quality, require regular servicing, and in relation to this, their components must undergo service replacements in order to remain fully operational in the long term. Daily use and a variety of road conditions mean that certain parts are subject to wear and tear regardless of the age of the vehicle. Even brand-new cars need attention, as components such as filters or operating fluids have a finite lifespan. The vehicle manufacturer specifies a maintenance schedule, during which detailed checks are carried out and worn-out components are replaced [24].

The standard maintenance activities that apply to all vehicles, regardless of the type of drive, should not be forgotten either. Manufacturers often release new features, bug fixes or optimisations that can affect vehicle performance, range or even driving safety. Some of these updates can be carried out remotely, but some require a service visit. Keeping the vehicle in good working order is also important in terms of protecting the warranty, which is provided by the manufacturers for, among other things, batteries/batteries and other key components [25]. Regular servicing is a way of preventing major breakdowns, which can generate high costs. Operating a vehicle requires regularity, the right approach and adherence to the manufacturer's recommendations. Regular repairs are not only a matter of aesthetics, but above all of road safety [25].

Vehicle manufacturers have divided vehicles into so-called classes. In the European classification there are 10 classes, six of which are based on criteria relating to overall length and wheelbase, while the others are based on functionality and body type. Each category is identified by a further letter of the alphabet. This division is regularly updated in order to better correspond to the dynamically changing automotive market. The range of dimensions, in particular vehicle length, between categories is indicative and subject to gradual changes that are the result of evolving consumer preferences and technological advances in vehicle design. New models that enter the market are often slightly larger than their predecessors, forcing periodic adjustments of the boundaries between segments [26]. For more than twenty years in Poland, the problem of vehicle segmentation has been dealt with by the Automotive Market Research Institute SAMAR [27], according to whose guidelines the vehicle classes and their representatives are presented below:

- Class A: mini-cars (e.g. Citroen C1, Toyota Aygo, Fiat Seicento, Panda);
- Class B: small cars (e.g. Fiat Punto, Opel Corsa, Renault Clio, Skoda Fabia, Dacia Sandero);
- Class C: medium-sized cars (e.g. Opel Astra, Fiat Bravo, Ford Focus, Skoda Octavia);
- Class D: large cars (e.g. Peugeot 508, Opel Insignia, Ford Mondeo, Vw Passat, Toyota Avensis and Volvo S60);
- Class E: prestige cars (e.g. Honda Legend, Alfa Romeo, Audi A6, Lexus GS and BMW 5-series);
- Class F: luxury cars (e.g. Lexus LS, Audi A8, Jaguar XJ and BMW 7-series);
- Class G (S): sports cars (e.g. Chevrolet Corvette, Porsche 911, Porsche 911, Porsche 911). Chevrolet Corvette, Porsche 911, Maserati GranTourismo and Lamborghini Aventhador);
- Class H: convertibles - modified versions of B-, C- and G-segment vehicles, distinguished by their characteristic folding roof (e.g. Fiat 124 Spider, Mini Convertible, BMW 2 Series Convertible and Porshe 718 Boxster);
- Class I (J): off-road sports cars (e.g. Range Rover, Jeep Cherokee and KIA Sorento);
- Class K (M): multi-purpose cars (e.g. Renault Espace, Chrysler Voyager, Toyota Sienna and Opel Zafira).

The wide range of vehicle models, in addition to the division into segments or classes, also divides them into commercial vehicles (e.g. Škoda, Volkswagen, Peugeot, Opel, Renault, Hyundai…), and those considered prestigious, or so-called high-end. Representatives of the premium brands are: Acura, Alfa Romeo, Aston Martin, Audi, Bentley, BMW, Bugatti, Cadillac, Ferrari, Genesis, Infiniti, Jaguar, Lamborghini, Land Rover, Lexus, Lincoln, Lotus, Maserati, McLaren, Mercedes-Benz, Porsche, Rolls-Royce, Tesla and Volvo. The higher prestige of the car comes from a combination of elements such as branding, interior materials and finishes, innovative technology, unique design, high price and additional services and personalisation. Such vehicles are usually less available and some are exceptional models. Importantly, prestige does not depend solely on the brand itself, but also on the manufacturer's ability to incorporate elements into its cars that set them apart from the competition. As a rule of thumb, repair costs for prestige vehicles are also higher, and this is influenced by:

– The cost of spare parts, as concerns use more expensive components that are brand specific. Parts prices are higher than those produced for vehicles of popular brands.
– Labour costs, at ASOs of prestige brands, are generally higher than those of popular brands, due in part to less common technologies that require specialised service and diagnostics.

Building a prestige brand of premium vehicle can be more profitable in the long term, but comes with higher initial cost. Premium vehicles are sold at higher prices than cars from popular brands, and because they are bought in smaller quantities, there is a higher profit margin per unit. Admittedly, higher prices also often mean more demanding customers, but loyal premium car customers are often prepared to buy again from the same brand, and this provides manufacturers with revenue stability in the long term. Producing premium vehicles involves higher costs related to the quality of materials, advanced technology, a complex production process and a more specialised workforce. In addition, premium brands invest in technology development, such as innovative systems, autonomous functions or electric drives, which generates additional costs. Manufacturers of premium brands invest heavily in marketing and image-building to emphasise the prestige, quality and uniqueness of their products. Creating an image requires investment in advertising campaigns, events and sponsorship of high-performance sports, which increases costs. In recent years, there has been a growing interest in electric cars, with premium manufacturers investing heavily in the development of such technologies. The literature indicates that brand luxury has received relatively little empirical attention, thus quoting J.N. Kapferer 'luxury objects provide additional pleasure and flatter all the senses simultaneously'.

Among the available passenger car segments, the most popular segment remains the compact models segment C [28]. The same results are recorded in the cyclical studies conducted by AUTO ŚWIAT, the most frequently purchased and most frequently used class of vehicles is class C and such vehicles will be subject to further analyses.

2. RESEARCH METHODOLOGY

In the 1990s, digitalization spread to the automotive industry through the creation of applications that allowed for the cost estimation of vehicle repairs [29]. The solution to this problem was the creation of IT systems that collect, store, and then process technical data about vehicles [30]. Repair cost estimation was standardized and thus improved with the help of specialized computer programs [31]. Currently, there are three computer applications available on the market for estimating repair costs [29], i.e.: AUDATEX [32], EUROTAX [33] and D.A.T. [34].

In each of the systems, data is updated within a 30-day period. The technology, labor intensity of the repair - replacement of individual elements is based primarily on the vehicle manufacturer [35]. The cost of spare parts is determined by the prices of parts set by car manufacturers or distributors of parts (for cars manufactured in Poland) and the prices of parts set by general importers and representatives of manufacturers (for imported cars). This data is the basis for the aforementioned specialist calculation programs [35]. The three main components of the final repair value are: the price of parts, the cost of paint materials and the time required for the work. When preparing a repair cost estimate, it is prepared based on the time standards of repair operations specified in specialist expert programs, the rate for one man-hour established by the entity performing the repair divided into time units (JC), taking into account the list of parts or assemblies qualified for operational replacement at individual stages of operation [36].

The AUDATEX system has a significant market share in estimating repair costs in the workshop industry, therefore this system will be used to estimate the costs of operational repairs.

Using the above system, the costs of operational repairs were estimated with the scope of parts and repair activities resulting from the repair technology. The following values of the working hour (hereinafter RBG) were adopted as:

– Authorized service station (hereinafter ASO) – PLN 280.00 net,
– Craft workshop – PLN 160.00 net.

The indicated RBG values (for ASO and independent workshop) were the dominant prices in most workshops during the period of the study.

During operational repairs, the differences in the estimated repair costs were the values of spare parts and the hourly rate. When estimating the repair costs in authorized service stations, only the highest quality original parts were taken into account. Repairs in craft workshops included the cheapest spare parts to be replaced. The legal status allowing the use of such parts has been permissible since the automotive market was opened. At that time, it was possible to carry out repairs using different types of spare parts. This opening took place after the introduction in Poland on 28 January 2003 of the Regulation of the Council of Ministers on the exclusion of certain vertical agreements (i.e. agreements concluded between two or more entrepreneurs operating at different levels of trade, the purpose of which is the purchase, sale or resale of new motor vehicles, spare parts for motor vehicles or the provision of service services concerning motor vehicles, including repair services) in the motor vehicle sector from the prohibition of agreements restricting competition [37]. This regulation was preceded in 2002 by the Commission's Motor Vehicle Regulation 1400/2002 (known as the old GVO), which was subsequently replaced by Commission Regulation (EU) No 461/2010 of 27 May 2010 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of vertical agreements and concerted practices in the motor vehicle sector – Gruppenfreistellungsverordnung (hereinafter referred to as the GVO) or Block Exemption Regulation (hereinafter referred to as the BER). Thanks to this directive, it is permissible to fit parts from manufacturers supplying original components, but sold under their own logo without losing the manufacturer's warranty.

In order to present the differences in repair costs in the performance of repairs of individual vehicles, a series of cost estimates were made for each vehicle, where the variables were the RBG value and the type and quality of parts. The subject of the research was not the analysis of technical parameters supported by strength tests of spare parts. During the research for individual vehicles, within the scope of a specific concern, vehicles with the same engine parameter were taken into account. The research was carried out for both spark-ignition (PI) and compression-ignition (CI) engines. Costs were determined for the following mileages: 30,000 km, 60,000 km, 90,000 km, and 120,000 km.

In accordance with the technology of repair of vehicle brands, the following activities were taken into account during operational repairs, which are presented in Table 1.

3. RESULTS OF RESEARCH PRESENTING DIFFERENCES IN OPERATING REPAIR COSTS BY ENTITY PERFORMING THE REPAIR AND BY THE CATEGORY OF SPARE PARTS USED

The study covered 3 concerns, namely:

1. VAG,
2. Stellantis,
3. Renault, Mitsubishi, Nissan Alliance.

Among the presented concerns, these three representatives had at least 3 models of medium-class vehicles in segment C. During the selection of a vehicle within a given concern, the parameters of engine capacity and power were taken into account as criteria. The repair cost presented in Table 2 shows the costs for a spark-ignition vehicle performed at an authorized service station and a craft workshop, similarly Table 3 shows the costs of repairs performed in the same entities, for compression-ignition vehicles. The above calculations of operating repair costs are based on the technology of repairing vehicle brands, which enabled a comparison of how the value of the repair performed changes during periodic inspections. The main dependencies influencing the final value were the amount of working hours and the availability and occurrence of spare parts other than the original ones

Table 1. Scope of activities subject to operational repairs

Activities	Repair at mileage [km]			
	30 000	**60 000**	**90 000**	**120 000**
Replacement at every repair	Pollen filter, Engine oil, Brake fluid,			
Replacement - additionally		Fuel filter (ZS) Spark plugs (ZI)	Air filter element Timing system, Water pump.	Alternator, fuel filter (ZS), spark plugs (ZI).
Check at every repair	Engine tightness, Front and rear brake pad condition, Brake system tightness, Exhaust system tightness, Floor condition, Coolant level and condition, Battery fluid level, Battery condition, Tire pressure, Headlight settings, Tire profile, External and internal lighting, Windscreen washer fluid level, Steering rod ends.			
Additional activities	Service sticker - embed Service indicators reset			

Source: Data resulting from vehicle repair technology

The above repair cost calculations made it possible to compare how the value of vehicle operational repairs changes with two variables, i.e. the entity where the repair will be performed and the availability of spare parts. Table 4 and Figure 1 shows the indicated percentage differences, where the sums of the operational costs of repairs were compared, comparing the most prestigious vehicle to the most popular vehicle in a given group of the study. The obtained results allow us to indicate that the operating costs for the VAG group with a spark-ignition engine, for AUDI A3 will be 3% lower for repairs in ASO and 10.6% higher for repairs by a craftsman compared to the costs of repairing Škoda Octavia, similarly for Volkswagen Golf they will be almost 2.5% lower for repairs in ASO, and 7.8% higher for repairs in a craftsman's workshop compared to repairing Skoda Octavia. These results indicate a wide access to spare parts in them than those available in ASO. The Stellantis Group also shows differences, but this time the Opel Astra will be 1.9% more expensive to repair in an authorized service center and 13.7% cheaper to repair in a craft workshop, compared to the Peugeot 308, while the Citroën C4 will be 6.4% cheaper to repair than the aforementioned Citroen in authorized service centers, and 33.5% cheaper to repair in a craft workshop. This study shows that a significant number of spare parts are available for the Citroën C4. The next examined concern shows much greater differences, namely the repair costs for the Infinity Q30 vehicle will be 30% higher for repairs at an Authorised Service Centre and 27.2% higher for repairs in a craft workshop, compared to the Renault Megane, while periodic repairs of the Nissan Pulsar are 32.7% more expensive for repairs at an Authorised Service Centre and 33.4% more expensive for repairs in craft workshops compared to the Renault Megane.

Table 2. Summary of repair costs for spark-ignition vehicles [Pb], performed at authorized service centers and craft workshops

	Company	Brand	Model	Spark ignition	Mileage for which the repair is being performed				sum	Mileage for which the repair is being performed				sum
					30 000	**60 000**	**90 000**	**120 000**		**30 000**	**60 000**	**90 000**	**120 000**	
					ASO RBG 280 zł net					Craft workshop RBG 160 zł net				
1	**VAG**	Audi	A3	1.5 dm^3 110 KM	1324,49	2018,78	5709,65	5852,38	14905,30	764,06	1089,72	4253,63	1456,20	7563,61
		Volkswagen	Golf 8		1359,81	1914,09	6057,79	5663,70	14995,39	754,67	1035,41	4231,52	1353,88	7375,48
		Škoda	Octavia		1238,22	1972,10	6496,20	5665,71	15372,23	499,19	878,94	4296,03	1165,41	6839,57
2	**Stellantis**	Peugeot	308	1.2 dm^3 96 KM	1437,53	1594,07	5376,77	4509,75	12918,12	856,47	940,94	4231,52	1110,71	7139,64
		Citroën	C4		1142,51	1337,06	4942,01	4666,42	12088,00	635,75	728,27	2438,12	946,04	4748,18
		Opel	Astra		1046,93	1345,44	6120,64	4652,29	13165,30	676,93	825,40	3493,14	1163,21	6158,68
3	**Renault-Nissan-Mitsubishi Alliance**	Infiniti	Q30	1.6 dm^3 86 KM	2031,74	2723,09	6941,06	6124,02	17819,91	1329,46	2102,29	4949,55	2156,30	10537,60
		Nissan	Pulsar		1358,54	1854,47	9932,41	5044,02	18189,44	862,12	998,11	7120,79	2070,09	11051,11
		Renault	Megane		1199,80	1777,28	6038,10	4690,21	13705,39	765,05	2186,05	4138,75	1195,94	8285,79

Source: Author's calculations, based on repair costs

Table 3. Comparison of the costs of repairing compression-ignition vehicles carried out at an authorized service station and a craft workshop

	Company	Brand	Model	Compression ignition	Mileage for which the repair is being performed				sum	Mileage for which the repair is being performed				sum
					30 000	**60 000**	**90 000**	**120 000**		**30 000**	**60 000**	**90 000**	**120 000**	
					ASO RBG 280 zł netto					Craft workshop RBG 160 zł netto				
1	**VAG**	Audi	A3	2.0dm^3 150 KM	1393,52	2020,88	5033,79	5938,49	14386,68	825,17	920,71	3149,25	1325,73	6220,86
		Volkswagen	Golf 8		1474,17	1651,94	4196,45	5569,55	12892,11	872,19	869,31	2292,48	1274,43	5308,41
		Škoda	Octavia		1346,59	2001,96	4031,10	5723,56	13103,21	540,39	651,93	2043,55	944,95	4180,82
2	**Stellantis**	Opel	Astra	1.5 dm^3 96 KM	1089,61	1554,76	5536,20	5405,15	13585,72	739,79	915,14	3056,61	1221,57	5933,11
		Citroën	C4		904,70	1355,85	4330,94	5171,64	11763,13	581,18	748,53	2082,52	1044,71	4456,94
		Peugeot	308		1511,16	1594,07	4748,80	4826,89	12680,92	959,68	942,45	2362,77	1278,94	5543,84
3	**Renault-Nissan-Mitsubishi Alliance**	Infiniti	Q30	1.5 dm^3 81 KM	1732,32	1844,32	6412,22	5752,28	15741,14	1189,49	1628,32	3739,33	4957,45	11514,59
		Nissan	Pulsar		1313,35	1864,86	3951,99	5112,78	12242,98	880,61	1073,48	2927,35	1400,93	6282,37
		Renault	Megane		1333,13	1903,37	4114,22	4738,82	12089,54	820,47	1033,80	2133,06	1280,34	5267,67

Source: Author's calculations, based on repair costs

Table 4. Differences in the costs of repairing operational spark-ignition vehicles performed at an authorized service station and a craft workshop, in the indicated concerns, in relation to a car considered to be the least prestigious

	Company	Brand	Model	Percentage difference in repair costs		
				Spark ignition	in ASO	Craft workshop
1	VAG	Audi	A3	1.5 dm^3 110 KM	-3,04%	10,59%
		Volkswagen	Golf 8		-2,45%	7,84%
		Škoda	Octavia			
2	Stellantis	Opel	Astra	1.2 dm^3 96 KM	1,91%	-13,74%
		Citroën	C4		-6,43%	-33,50%
		Peugeot	308			
3	Renault-Nissan-Mitsubishi Alliance	Infiniti	Q30	1.6 dm^3 86 KM	30,02%	27,18%
		Nissan	Pulsar		32,72%	33,37%
		Renault	Megane			

Source: Author's research, based on repair costs

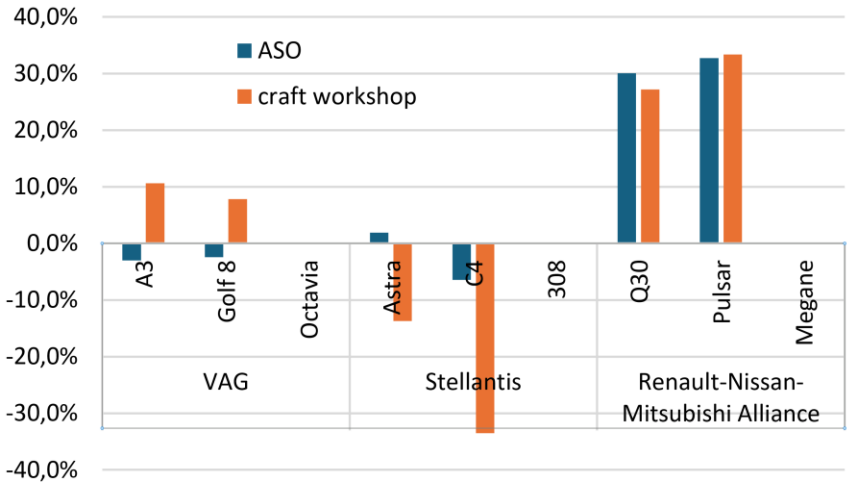

Fig. 1. Differences in the costs of repairing operational spark-ignition vehicles

Table 5 and Figure 2. shows the indicated percentage differences based on the principles of Table 4, with the difference that all values apply to compression-ignition vehicles. The results obtained allow us to indicate that the operating costs for the VAG group, for AUDI A3 will be 9.8% higher, for repairs at Authorized Service Centers and 48.8% more expensive during repairs at a craft workshop, compared to the operating costs of Škoda Octavia repairs, similarly for Volkswagen Golf they will be 1.6% lower for repairs at Authorized Service Centers and 26.9% higher during repairs at a craft workshop, compared to the operating costs of Škoda Octavia repairs. The Stellantis Group shows differences, where the costs for the Opel Astra in repairs will be slightly over 7.1% more expensive for repairs at an Authorised Service Centre and 7.0% more expensive for repairs at a craft workshop, compared to the costs of operational repairs of the Peugeot 308. The costs of operational repairs of the Citroën C4 will be 7.2% lower for repairs at an Authorised Service Centre and 19.6% cheaper for repairs at a craft workshop, compared to the costs of operational repairs of the Peugeot 308. The third group examined this time also shows greater differences, namely the costs of repairs for the Infinity Q30 vehicle will be 30.2% higher for repairs at an Authorised Service Centre and 118.6% more expensive for repairs

at a craft workshop, compared to the costs of operational repairs of the Renault Megane. The cost of operating repairs for the Nissan Pulsar will be 1.2% higher for repairs at an authorized service center and 19.3% higher for repairs at a craft workshop, compared to the cost of operating repairs for the Renault Megane.

Table 5. Differences in the costs of repairing operational compression-ignition vehicles performed at an authorized service station and a craft workshop, in the indicated concerns, in relation to a car considered to be the least prestigious

	Company	Brand	Model	Percentage difference in repair costs		
				Self-ignition	in ASO	Craft workshop
1	VAG	Audi	A3	2.0dm^3 150 KM	9,80%	48,80%
		Volkswagen	Golf 8		-1,61%	26,97%
		Škoda	Octavia			
2	Stellantis	Opel	Astra	1.5 dm^3 96 KM	7,14%	7,02%
		Citroën	C4		-7,24%	-19,61%
		Peugeot	308			
3	Renault-Nissan-Mitsubishi Alliance	Infiniti	Q30	1.5 dm^3 81 KM	30,20%	118,59%
		Nissan	Pulsar		1,27%	19,26%
		Renault	Megane			

Source: Author's research, based on own calculations

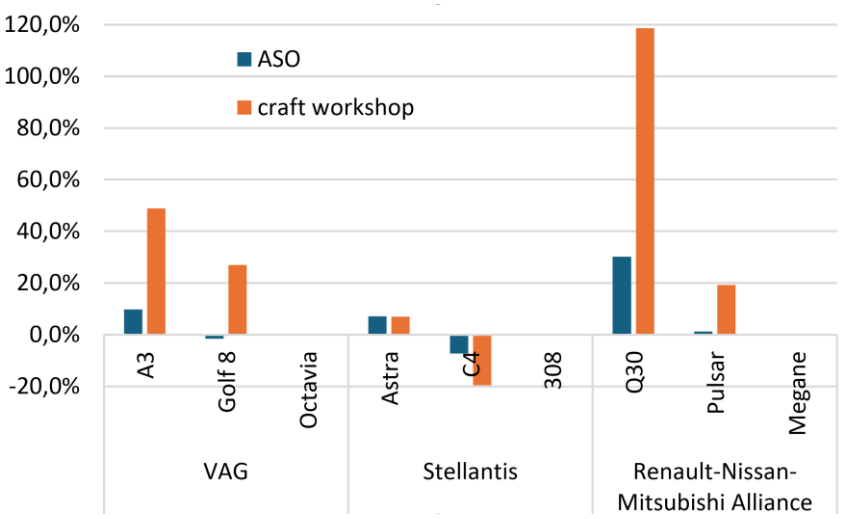

Fig. 2. Differences in the costs of repairing operational compression-ignition vehicles

The above study is supplemented by a study of the relationship between the car brand (X-axis) and mileage (Y-axis) and the costs of operational repairs in individual mileages, shown as contour charts (fig. 3). The first three charts concern spark-ignition engines and repairs performed at an authorized service station, the next three also concern spark-ignition engines, but the repairs were performed in a craft workshop. Graphs 7-9 concern compression-ignition engines and repairs performed at an authorized service station, graphs 10-12 also concern compression-ignition engines, but the repairs were performed in a craft workshop. The darker the color, the lower the costs, the more red (burgundy), the higher the costs. The price scale on each graph is different and it is only necessary to compare the intensity of the colors.

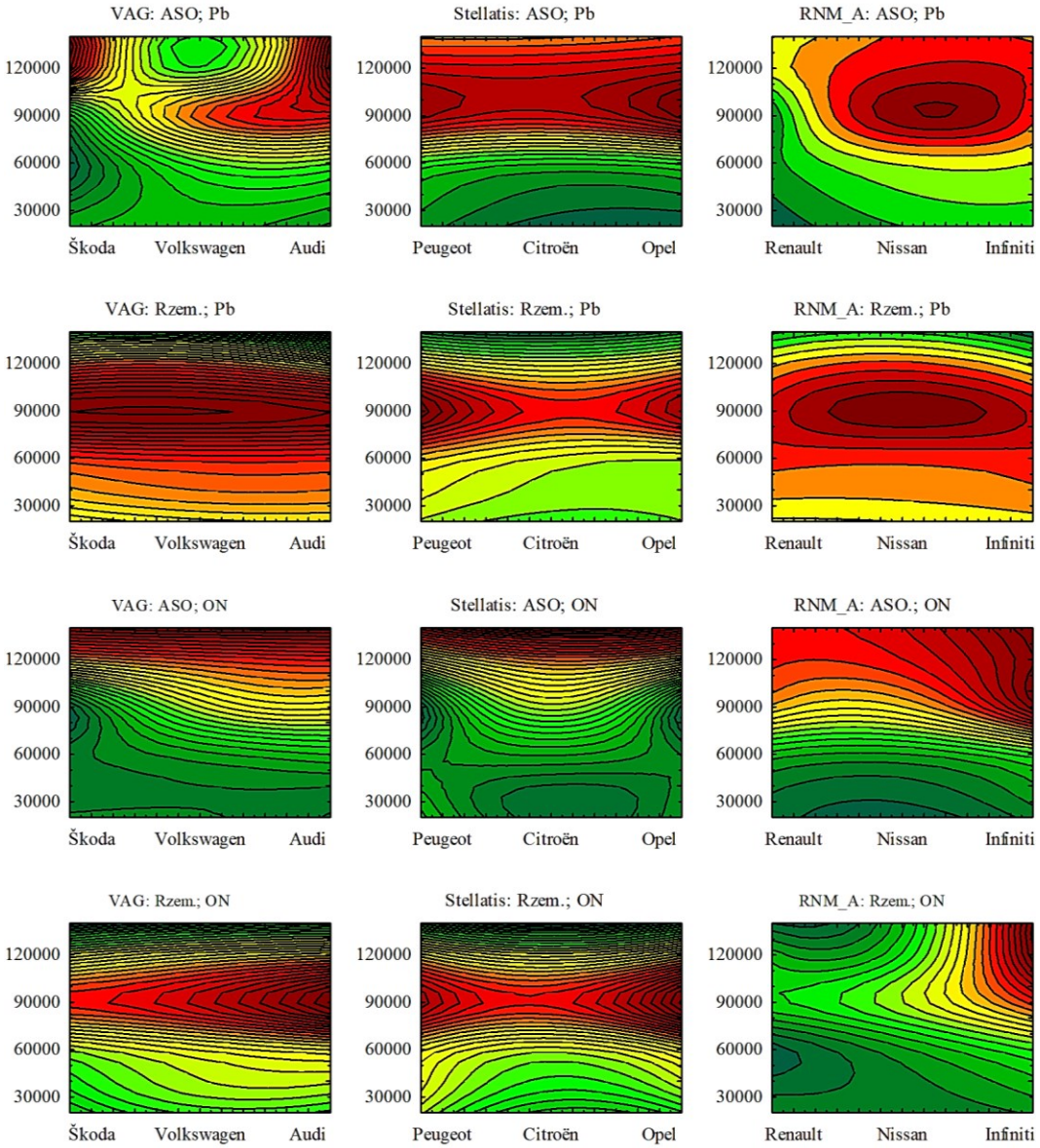

Fig. 3. The impact of brand and mileage on operating costs.
Explanations: green color - lower service prices, red color - higher service prices. Source: Own work

When observing the issue of operating repair costs, one can notice certain common elements and certain elements that differentiate individual corporations. Common elements include the relatively low cost of operating repairs of cars with a mileage of 30,000 km. What is more, at this level, in most studies, the contour lines are usually horizontal, which means that it is independent of the brand's prestige. Even at 60,000 km, one can say that this is usually the case. However, for some corporations, vertical contour lines appear already at mileages of 90,000 km and 120,000 km, which means that the costs of operating repairs of cars of different

brands of the same corporation begin to differ more or less strongly. What is more, this is independent of the place of repair (ASO or craft workshop). This is very visible, for example, for Peugeot and Opel in relation to Citroen (spark ignition engine), or Infiniti in relation to Renault and Nissan (compression ignition engine). It is also noticeable in the spark-ignition engine for Nissan in relation to Renault and Infinity when repaired after 90,000 km. However, in some concerns it is not visible, e.g. there is no spark-ignition engine for the VAG concern craft workshops or VAG compression-ignition engine serviced at ASO. Such a situation makes it difficult to draw general conclusions related to the assumption that cars of brands generally recognized as prestigious will be characterized by higher operating costs, it is more inclined to determine this is the specificity of the brand and concern unrelated to prestige.

CONCLUSIONS

The study found discrepant amounts of vehicle operating repair costs in the companies studied. The study included repairs under the terms of an Authorized Service Station and at an independent workshop. The study enabled the verification of the following hypotheses:

The exploitation repair costs of brands considered to be prestigious are higher than those of popular vehicles. The study concluded that:

1. There is no clear rule indicating that the costs of operational repairs for vehicles considered prestigious in a given concern are higher than for more popular vehicles. In the case of the VAG group, for spark-ignition vehicles, the situation was the opposite, the difference in repair costs was up to 3.0% when repaired at an authorized service station, and 10.6% when repaired in a craft workshop. Similarly, for compression-ignition vehicles, the difference was 9.8% when repaired at an authorized service station, and up to 49% when repaired in craft workshops. In the case of the Stellantis group, for spark-ignition vehicles, the difference in repair costs was up to 6.4% when repaired at an authorized service station, and 33.5% when the repair itself was performed in a craft workshop. Similarly, for compression ignition, this difference for repairs at Authorized Service Centers was 7.2%, while for repairs in craft workshops it was up to 19.6%.

   In the Renault-Nissan-Mitsubishi Alliance group, for spark-ignition vehicles, the difference in repair costs was up to 32.7% when repairs were made at Authorized Service Centers, and 33.4% when the repair itself was made in a craft workshop. Similarly, for compression ignition, this difference for repairs at Authorized Service Centers was 30.2%, while for repairs in craft workshops it was up to 118.6%. The popularity of the vehicle also has an impact on the cost of operational repairs, because parts of different quality are produced for frequently purchased vehicles in mass production, and their use is legally permitted.

There is a perceived difference in the cost of operating repairs among companies with different levels of market experience. Based on the conducted study, it can be stated that:

2. Of the 3 groups studied: VAG was founded in 1976, Renault-Nissan-Mitsubishi-Allias was established in 1999, while Stellantis only in 2021 in the merger of, among others, PSA-Group which had existed since 1976. The conducted study allows us to indicate that the youngest of the groups, i.e. Renault-Nissan-Mitsubishi-Allias, has the greatest differences in the costs of operational repairs of compression-ignition vehicles, while spark-ignition vehicles in the VAG group - their repair costs show the smallest difference. The conducted study of the costs of operational repairs for groups with greater seniority, also taking into account brands considered prestigious (e.g. AUDI), allows us to conclude that the cost of operational repairs is similar with popular vehicles. To a large extent, this results from the fact that some components are common to different models, which reduces their production costs. As a result, implementing common technologies confirmed the intention to merge between vehicle brands. Companies that have a short history and have not managed to implement common technologies show greater discrepancies.

   The market for modern passenger cars is constantly developing thanks to new technologies, changing consumer attitudes and economic factors. Premium vehicles are often pioneers in technological innovations, such as electric drives, advanced autonomous systems, artificial intelligence or even technologies supporting sustainable development. Premium car manufacturers introduce modern solutions to the market, which attract customers looking for the latest technologies in their vehicles.

ANALIZA EKONOMICZNA KOSZTÓW NAPRAW EKSPLOATACYJNYCH WYBRANYCH POJAZDÓW POPULARNYCH SEGMENTÓW

W artykule przeprowadzono szczegółową analizę kosztów napraw eksploatacyjnych pojazdów dla przebiegów 30 000, 60 000, 90 000 oraz 120 000 kilometrów. Badanie objęło wybrane koncerny motoryzacyjne, które dysponują co najmniej trzema modelami pojazdów w tym samym segmencie rynkowym, przy czym pojazdy te musiały być wyposażone w identyczne jednostki napędowe – zarówno o zapłonie iskrowym, jak i samoczynnym. Analizę przeprowadzono w kontekście napraw realizowanych zarówno w autoryzowanych stacjach obsługi, jak i niezależnych warsztatach rzemieślniczych. Celem badania była ocena czy koszty napraw eksploatacyjnych pojazdów segmentu premium różnią się w sposób istotny od kosztów napraw pojazdów segmentu popularnego w obrębie tego samego koncernu motoryzacyjnego. Ponadto, zbadano, czy istnieje zależność pomiędzy długością uczestnictwa poszczególnych marek w strukturze koncernu motoryzacyjnego a zmniejszeniem różnic w kosztach napraw eksploatacyjnych. W badaniu zastosowano metodę eksperymentu numerycznego, przy wykorzystaniu systemu AUDATEX, który umożliwił precyzyjne określenie wartości napraw. Różnice w kosztach serwisowania samochodów uznawanych za bardziej prestiżowe w porównaniu z samochodami popularnymi wahały się od -20% do prawie 120%. Najczęściej działo się tak na niekorzyść samochodów uznawanych za prestiżowe i co ciekawe, pomimo tych samych silników. Dostępność serwisu i obecność na rynku są istotnymi czynnikami, ponieważ młodsze marki wykazywały większe różnice w kosztach obsługi.

Słowa kluczowe: koncerny motoryzacyjne, naprawy eksploatacyjne samochodów, porozumienia wertykalne, segmenty pojazdów, rynek motoryzacyjny.

AUTHOR CONTRIBUTIONS

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- formal analysis, Ł.K. and G.P.;
- investigation, Ł.K.;
- writing - original draft preparation, Ł.K.;
- writing - review and editing, Ł.K. and G.P.;
- visualization, Ł.K. and G.P.;
- supervision, Ł.K.;
- project administration, Ł.K.

All authors have read and agreed to the published version of the manuscript.

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