Ecological - economic factors of spare parts supply to car service centres, Republic of Cyprus

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Abstract. The article considers environmental and economic factors in the models of supplying spare parts to car service centres in the Republic of Cyprus. The features of the formation of economic and environmental factors are revealed, country specifics are clarified. Based on the results of a survey of representatives of 21 car service centres with various business organization formats, it is shown that car service companies in the Republic of Cyprus use a predominantly intuitive approach to organizing the supply of spare parts. The assessment of the formed carbon footprint is carried out extremely rarely and only selectively. Using the Hamel-Prahalad core competencies matrix, key supply models are grouped, considering the possibilities of digitalization and distributed management. The upper quadrants define advanced management models - dealership (upper left quadrant) and digitalization and decentralization model (upper right quadrant), referring to the ideal situation. Based on regression modelling, the relationship between the aspects of organizing the supply of spare parts to the formed carbon footprint is shown. While based on correlation analysis, the presence of a close relationship between environmental (specific carbon footprint) and economic (service coefficient) factors was confirmed. Taking into account the results obtained, the main organizational and managerial changes are proposed that will allow car service enterprises of the Republic of Cyprus to optimize the supply of spare parts while taking into account environmental and economic criteria, including the introduction of a competent approach to managing the supply of spare parts; modernization and digitalization of the inventory management system; implementation of quality, environmental responsibility, risk, cost and performance management systems, as well as the development and implementation of innovation management systems.

1 Introduction

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2 Materials and methods

To build a matrix for choosing strategic models for the supply of spare parts to car service enterprises of the Republic of Cyprus, focused on the integrated consideration of environmental and economic factors, a competency-based approach was applied, mediated by the Hamel-Prahalad matrix of key competencies [1]. One of the main advantages of the approach that led to its choice is the availability of opportunities for the development of market competencies and innovations to produce systemic improvements.
3 Results and discussion

The supply of spare parts is necessary for car service enterprises, both to ensure the continuity and quality of work performed, and for direct sales to consumers. Direct sales of spare parts to car enthusiasts, in turn, form one of the highest margin segments of the auto service business, due to which many business indicators are levelled off and often ensure positive profitability. Numerous studies have confirmed the dependence of timely and complete provision of auto service enterprises with spare parts on seasonality factors, placement of distribution warehouses, competent formation of applications and insurance stocks in auto service centers [2, 3, 4, 5]. It is also shown [6, 7, 8, etc.] that the optimization of inventory management in the subject area is facilitated using applications for automating planning, analysis, monitoring, and control. Appropriate information technologies have been used in European countries since the 1970s, and since the mid-2010s they have been gradually replaced by more high-precision and productive digital tools designed to process significant arrays of heterogeneous socio-economic information and to comprehensively facilitate rational decision-making in conditions of uncertainty [9].

The digitalization of the management of the supply of spare parts for car service enterprises, in fact, came to the rescue in attempts to help solve the previously insoluble problem of combining economic and environmental interests in the management of the car.
A wide awareness of the importance of the environmental problem took place at the end of the 20th century [10], however, in the auto service business, until recently, the possibilities of greening were either minimal or came into sharp confrontation with economic considerations. It is also important to understand that in almost all countries of the world, the auto service business is an area of intense competition, which combines numerous approaches to business organization, including dealer network companies, individual service, small and family businesses [11]. In the Republic of Cyprus, the experience of which is considered in this publication, according to statistical estimates, about 7.5 thousand car service enterprises operate today, which is approximately one car service centre per hundred registered cars [12].

The supply and final cost of spare parts in the car service business of the Republic is influenced by a number of factors that are not typical for the average state of the European Union, including, first of all, the insular (isolated) position of the state, the lack of its own authorized production of branded spare parts, a high level of motorization of the population, combined with extremely a fleet of predominantly right-hand drive cars that is heterogeneous in terms of brands and age. Cyprus, together with Malta and Ireland, is one of the three EU countries with left-hand traffic.

Intense competition creates the need to balance economic and environmental factors in the operation and management of car service centres in the Republic of Cyprus, especially since the importance of environmental problems today is increasingly recognized by society and supported by the state. In the next decade [13], large-scale transformations in the environmental legislation of Cyprus and the European Union are announced, aimed primarily at supporting the low-carbon transition. Businesses that generate a high climate load will be subject to significant taxation and administrative pressure. In fact, the car service centres of the Republic of Cyprus have one or more years to adapt to the new conditions.

Until recently, in the practice of functioning of car service companies in the Republic of Cyprus, there have been several main approaches to managing the supply of spare parts: intuitive (analog); strategizing based on planning (often done manually); use of simple automation systems (ERP, CRM); centralized distribution in dealer and company centres (specific car service centres are just waiting for the satisfaction of applications that they form on their own).

The intuitive method still (in 2023) prevails, see figure 1.

![Fig. 1. Distribution of car service centres in Cyprus by approach to managing the supply of spare parts, % (according to the results of the survey)](image-url)
According to a recent survey conducted by the authors of the publication, 52.4% of companies use it. Their list includes not only micro-businesses and small enterprises, but also many larger companies, which, however, are not networked and are not included in dealer systems. A notable case is represented by luxury car service companies. Car service dealer networks in Cyprus do not specialize separately in luxury cars, serving the entire model range. Owners of used luxury cars with expired warranties prefer to turn to trusted contractors who guarantee a personalized approach. The clients of such enterprises, which inevitably belong to the multi-brand format of business organization, are also the owners of new and used cars of numerous brands from the USA and Southeast Asia, whose branded (dealer) centres and networks are not represented in Cyprus. Expensive shipments of single spare parts are carried out from abroad by air transport, at the same time generating a significant carbon footprint, sometimes a multiple of the size formed during the production of these spare parts.

Only in the last 2–3 years, including as a response to the sharp complication of business conditions during the COVID-19 pandemic, flexible forms of organizing the supply of spare parts, such as digitally controlled joint distribution warehouses, are beginning to be considered. However, the relevant ideas are still experimental in nature the launch of any such service has not been announced today, although industry representatives are aware of attempts to develop them.

In recent years, there have also been some attempts to combine the economic and environmental aspects of the organization and operation of a car service business in the Republic of Cyprus [14]. According to the interviewed business representatives, it is too early to talk about radical successes in the subject area, at least outside the dealer networks. On the one hand, car service centres, in principle, cannot influence the supply and choice of spare parts by consumers, which, in their production, including in terms of the use of structural materials, meet the most modern requirements (the use of green fuel and the rejection of plastic, the use of composite technologies and emission control, etc.). Relevant aspects are regulated by the automakers themselves, for many of them Cyprus is a specific market and is not always of particular interest. One of the dimensions of the existing problems is the high proportion of used cars in the car fleet of the Republic. Thus, according to available statistics [12], over the past five years, on average, the share of new vehicles registered in Cyprus has been about 2% annually (average value 2.01%, median 1.98%), with a minimum level in 2020 (1.85%). As a result, the bulk of the parts supplied are not produced on the front lines of major automakers, where the most sustainable approaches have been gradually adopted in recent years. The manufacture of the respective products is often outsourced, often to countries with a low level of socio-economic development and environmental responsibility and is based on obsolete technologies (often obsolete production lines are transferred to alternative manufacturers entirely). The localization of the production of auto parts in Cyprus is not economically feasible in most cases. Only a few dealerships are authorized for deep repairs or custom assembly of some parts, which sometimes does not cover even hundredths of the existing needs. The refusal of localization is explained by relatively small volumes of demand, relatively low purchasing power (Cyprus has been consistently ranked in the second ten EU countries in terms of the indicator over the past 20 years and relatively recently–in the early 2010s–experienced an acute financial and economic crisis, the echoes of which are still felt today), the multi-brand nature of the car park, as well as the rather high cost of labour. Logistical features do not allow to effectively redirect the surplus to other countries. Cyprus is a closed island on the periphery of Europe with the closest neighbours by sea, mostly non-EU countries.

On the other hand, the logistical features of the supply, as well as the internal distribution of auto parts, also determine the significant contribution of transportation to the carbon footprint formed as part of the procurement processes of auto service centres in Cyprus.
Primary deliveries are carried out by air transport in relatively small batches, and internal distribution is carried out by road transport, operating mainly on internal combustion engines. There is no rail transport in Cyprus, the only alternative is electric motor vehicles, the level of penetration of which into the country's economy is low and amounts to 9.88% of the total number of registered vehicles (although the figure has increased by 3.2 times over the past 10 years). In rare cases, micro-mobility and velo-mobility can be used to deliver limited batches of products over extremely short distances. The territory of the Republic, controlled by the government of the Republic of Cyprus, stretched almost in a line from west to east along the coast, being limited in the centre by a mountain range. In such conditions, it is not necessary to talk about the possibility of using optimization structures for locating service centres and distribution warehouses, such as matrix, cellular ones.

Fig. 2. Distribution of car service centres in Cyprus by the number of spare parts supply units covered by the carbon footprint assessment, % (according to the results of the survey)

The highest figure obtained from the survey is 21-40% of the supply and occurs only once in the car service dealer network of one large and perhaps the most responsible European 38% 33% 24% 5% 0% More than 0%, less than 5% 5%-20% 20.1%-40% Over 40%
manufacturer, which, among other things, retains its own control over the production of auto parts for old car models. Non-chain enterprises, if they evaluate the carbon footprint, then only selectively, covering more than 0% and less than 5% of deliveries in physical terms, as a rule, in relation to the largest parts and assemblies, as part of specific preparation for the likely tightening of environmental regulation in the foreseeable future.

There are several reasons why it is difficult or impossible for car service companies in the Republic of Cyprus to organize the calculation of the ecological footprint for individual or all spare parts supply units:

– Lack of available information on the environmental performance of spare parts. Many aftermarket manufacturers do not provide detailed information about what materials were used in production, what their environmental performance is, and what their contribution to the overall environmental footprint will be.

– Limited resources. It is often difficult for Cypriot car service companies, especially small and non-chain ones, to allocate sufficient time and resources to assess the environmental footprint of each spare parts supply unit.

– Lack of environmental awareness. Many car service companies, primarily non-chain ones, may not have sufficient knowledge and experience in the field of ecological footprint assessment, which makes it difficult to organize the corresponding accounting and analytical work.

– Low demand for environmentally friendly spare parts. Given the nature of the Cypriot car market (e.g., a focus on used cars), it appears that some car service companies (and probably most of them) do not see sufficient demand for environmentally friendly spare parts to justify the cost of assessing their environmental footprint.

– No-systemic nature of regulation. Now, there is no de facto legislation in force in the Republic of Cyprus that would oblige car service companies to assess the environmental footprint of spare parts. This may mean that small companies do not see the need to organize such a calculation.

However, the existing problem can have far-reaching negative consequences, since it is the small business, including the family car service business, which is the undeniable basis of the local economy, and at the same time is extremely vulnerable (organizationally and economically) from changes in the external environment, including the tightening of environmental requirements. Without cardinal changes in the subject area, which need to be comprehensively supported now, including at the state level, one can hardly count on effective adaptation now when strict legal regulations are adopted.

The relationship between economic and environmental factors in the management of the supply of spare parts to car service companies remains a debatable issue [15, 16]. Of course, the reserves for reducing the carbon footprint in the production of new spare parts most often, at least with existing technologies, lead to a rise in the cost of production of vehicles. However, in conditions where the main carbon footprint is generated in the process of supply (carrying out logistics operations for the supply of auto service enterprises with spare parts), the situation changes dramatically and a dependence can work when the increase in environmental friendliness, expressed by the level of the ecological footprint (a key factor among observable ones) immanently entails resulting in an increase in the return on inventory costs. While in other industries similar proportions will be formed only in the future (due to increased taxes and other transaction costs associated with imperative environmental requirements), in the car service business of Cyprus, the relevant aspects are already interconnected. Rationalization of supplies in any possible way, leading to a reduction in the carbon footprint, can also lead to a reduction in transport and logistics costs, which make a significant contribution to the final cost of supplied products and profitability indicators.
competencies (knowledge, information and processing tools) with business conditions (for example, protection by a dealer model) provides advantages in the management system in the subject area, in Table 1 shows the matrix of the strategic choice of spare parts supply management models developed by the authors, which are used in practice in the Republic of Cyprus.

Table 1. Adaptation of the Hamel-Prahalad matrix [1] to develop strategic models for the supply of spare parts to car service enterprises of the Republic of Cyprus, focused on a comprehensive consideration of environmental and economic factors.

<table>
<thead>
<tr>
<th>Key competencies</th>
<th>New</th>
<th>Limited consideration of regional features and ESG component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Digitalization and decentralization of supplies. Intelligent management, end-to-end RFID tracking, application of sharing economy tools, including networks of distributed warehouses under joint mobile digital control.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High-precision end-to-end control of the generated carbon footprint</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>Intuitive supply management methods, warehouse rental, self-delivery, and courier services. Planning from available opportunities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial informatization of supply management along with the collection and processing of historical data on the effectiveness of deliveries and satisfaction of requests with a gradual consideration of ESG components</td>
</tr>
</tbody>
</table>

Existing Technologies and Markets

The bottom two quadrants of the spare parts supply models correspond to an inertial approach, predominantly oriented towards intuitive choice and analogue planning, with the involvement of some traditional tools and methods of automating accounting and analysis (lower right quadrant). Today, these strategic choice alternatives are widespread in the non-network car service business in Cyprus (according to the results of the survey conducted by the authors, we are talking about almost every non-network and some dealer companies).

The upper quadrants represent the management of environmental and economic factors of supply with the application of the competencies of the modern era. The upper left quadrant fully covers modern dealer models for organizing a car service business. Corresponding practice is typical for Cyprus and some other remote and territorially isolated EU countries (including Malta and Ireland). The dealer model is combined with a network business organization and centralized distribution of spare parts, which are not handled by car service centres on their own. Dealer networks have a significant amount of relevant information needed to make rational decisions, as well as their own tools and means of processing it. Dealer networks of the largest European car manufacturers (and this is de facto all dealer networks operating in the Republic of Cyprus) actively apply the know-how in managing the deliveries developed in the parent companies. At the same time, as noted, the Cypriot car service market cannot be considered a priority for most of the key players. As a result, dealerships are generally not targeted for the development and testing of innovative digital solutions, which are generally still being tested even in mainland Europe. We are talking about such solutions as big data analysis based on RFID marking and end-to-end tracking of goods movement, neural network modeling of optimal stocks and shortest logistics routes, and others [17]. The specifics of the organization of transport networks and supply models in isolated conditions and the linear organization of the movement of goods flows in the Republic of Cyprus should also be reflected. Finally, due to the nature of the organization of
dealer networks, the relevant entities of the Cypriot car service market do not organize and, according to reports, do not plan to organize decentralized distribution mechanisms, such as networks of small, outsourced distribution warehouses, jointly managed by several companies through digital mobile applications. Such solutions are more suitable for other business organization models (non-dealer ones), but it is in this segment that the most significant shortage of resources and competencies is observed for the implementation of complex modernization tasks.

It is precisely from proactive innovations in the areas of digitalization and decentralization of the management of the supply of spare parts to car service enterprises that the management models of the fourth, most promising type consist, which are not implemented de facto in the car service business of the Republic of Cyprus, but are, of course, ideal goals for the future.

The results of statistical modelling of factors affecting the environmental (carbon) footprint from the supply of spare parts to car service enterprises in the Republic of Cyprus are presented in Table 2. Figure 3 shows a histogram of residuals according to the regression model.

The model is expressed by the equation

\[ \text{FTPRWT} = 1.269 + 0.022 \text{INLROUTE} + 1.11 \text{ICETRF} - 1.393 \text{AVIAOSTR} + 0.359 \text{SEAS} + 0.353 \text{SUPPLMDL} - 1.10 \text{PLANSUPF} \]

It can be stated that the indicators of the specific carbon footprint from the supply of spare parts to car service enterprises of the Republic of Cyprus are affected with significant statistical significance by the length of the supply route (direct influence, that is, the longer the path, the higher the carbon footprint, \( p = 0.002 \)), the planning method (reverse impact, with planned shipments, the carbon footprint will be lower, \( p = 0.008 \)), delivery from abroad by air (instead of sea; direct impact, \( p = 0.001 \)).

Taking into account the revealed correlation-regression dependencies, the question of the existence of a relationship between the environmental and economic factors in the models of spare parts supply to car service centres of the Republic of Cyprus is also of considerable interest. Based on the results of statistical processing of the previously described sample of 126 products, availability was assessed, it was found that there was a statistically significant inverse correlation between the indicator of the specific carbon footprint and the service coefficient (Table 3), which illustrates the relationship between the environmental and economic components: activities that ensure growth service factor also contribute to reducing the carbon footprint generated in the supply chain, and vice versa.
Table 3. Analysis of correlations (according to Pearson) between environmental (specific carbon footprint) and economic (service factor and return on inventory) indicators in the supply of spare parts to car service centres of the Republic of Cyprus

<table>
<thead>
<tr>
<th>Indicators</th>
<th>FTPR</th>
<th>WT</th>
<th>SERVC</th>
<th>STPROF</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTPR</td>
<td>Pearson correlation</td>
<td>1</td>
<td>-0.179</td>
<td>-0.157</td>
</tr>
<tr>
<td></td>
<td>Significance (two-tailed)</td>
<td>-0.045</td>
<td>0.080</td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>126</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td>WT</td>
<td>Pearson correlation</td>
<td>-0.157</td>
<td>1</td>
<td>0.580</td>
</tr>
<tr>
<td></td>
<td>Significance (two-tailed)</td>
<td>0.080</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>126</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td>SERVC</td>
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<td>-0.179</td>
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<td>N</td>
<td>126</td>
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</tr>
</tbody>
</table>

Based on the results obtained, it seems possible to briefly outline the main organizational and managerial changes that will allow the auto service enterprises of the Republic of Cyprus to optimize the supply of spare parts while considering environmental and economic criteria.

These may include the following:

1. Implementation of a competent approach to managing the supply of spare parts to optimize the procurement process, reduce warehousing costs, and improve the quality of customer service.
2. Modernization (if necessary - development) and digitalization of the inventory management system.
3. Implementation of a quality management system that will improve the quality of supplied spare parts, reduce the number of returns, and improve the customers' satisfaction.
4. Development and implementation of an environmental responsibility management system to reduce the negative impact on the environment, improve the environmental situation and increase the level of customer confidence.

5. Implementation of a risk management system to reduce the risks associated with the supply of spare parts, improve the quality of customer service and decrease the level of unexpected losses.

6. Development and implementation of a cost management system.


8. Development and implementation of an innovation management system.

Thus, the introduction of a competent approach to managing the supply of spare parts to the car service centres of the Republic of Cyprus, considering environmental and economic criteria, will optimize the procurement process, reduce warehousing costs, and improve the quality of customer service.

The developed solutions in the field of forming organizational models for managing the supply of spare parts based on a competency-based approach (Table 1) can serve as a guideline for building strategies and roadmaps in the subject area. Because a significant number of car service centres in the Republic of Cyprus are classified as micro and small businesses, it is advisable to provide state and public support, including financial and dissemination of innovations, so that promising solutions cover the entire spectrum of industry competition and at the same time do not lead to its violations. Promoting the calculation and recording of the carbon footprint of stocks should be given priority. These processes should be digitized and carried out in an automated mode, which will form information support for managing environmental and economic factors in the subject area.

4 Conclusion

The study allows us to state that in the conditions of organizing a car service business in the Republic of Cyprus, there is a convergence of environmental and economic factors of influence in spare parts supply models. The results of statistical modelling showed that the length of the supply route, the method of planning and the method of delivery have a significant impact on the carbon footprint of the supply of spare parts to the car service enterprises of the Republic of Cyprus. An inverse correlation has also been found between carbon footprint and service factor. To optimize the supply of spare parts, considering environmental and economic criteria, it is necessary to introduce a competent approach to supply management, modernize the inventory management system, implement a quality management system, environmental responsibility, risks, costs, productivity, and innovation. State and public support is also necessary to cover the full spectrum of industry competition and account for the carbon footprint in an automated manner.

The materials of the study can be used to develop measures for assessing and managing environmental and economic factors in spare parts supply models in other countries of the European Union and the world, first, subject to adaptation to local conditions for the functioning of the auto service business. Other promising areas of research include the development of proactive competency-based models for managing the supply of spare parts to car service enterprises in the Republic of Cyprus, considering the existing business organization format. The expansion of the boundaries in the subject area of the study should be facilitated by the establishment of a system for assessing and accounting for the ecological footprint for the full range of deliveries to small non-network car service enterprises in Cyprus that are not related to dealer networks.
References