Spare parts logistics of automobile enterprises in conditions of module production

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Received July 6.2012; accepted July 25.2012

Abstract. The peculiarities of module production of automobile companies are lighted. Research on the role of innovations in automotive development has been carried out. An algorithm of decision making for optimizing logistics costs is presented. The hierarchy of needs in the area of spare parts maintenance is presented. The benefits of partnership relations in the automotive industry are outlined.

Key words: module production, logistics, spare parts, automotive industry, relationship management, cooperation.

INTRODUCTION

Automotive industry in the post-crisis period is usually characterized by a significant change in the policy of market “key players”, mainly concentrated on improving the efficiency of production and economic, financial, marketing, logistics of enterprise. Any changes that take place in the existing system should be aimed at improving or correcting errors of functioning. While describing the changes that have taken place in the automotive industry after the global economic crisis of 2008-2009 it is not possible to distinguish the single decisive one, but the fact has to be admitted that the industry has undergone a qualitative change, and moving further in the selected direction we can analyze the key changes [1, 2].

Basically, the structure has undergone significant changes in the market. Part of the enterprises announced bankruptcy, others entered the warehouse more resilient enterprises, created a number of associations. The role and influence of agents of the first and second level was increased, carrying out production of some spare parts and complete units for car assembly enterprises. Competition in the market and aftermarket services has escalated. The increasing role of outsourcing, Internet trading, short product life cycle, increasing the speed and flow of information, formation of joint departments on innovation, the management of certain manufacturing or logistics processes with intermediaries and competitors, increasing consumer awareness and, consequently, increased demands for quality, functionality and service are part of the trends that currently accompany the development after the crisis on the automotive industry.

PROSPECTS FOR THE AUTOMOTIVE INDUSTRY

Activity on any market depends to the presence of certain features and certain barriers. Identifying them enables to identify prospects and set the right ways of doing business. In general, existing barriers, trends and opportunities for business of automobile industry should be considered, taking into account the following factors: political, economic, social, technological, legal and natural [3]. The political include:

– Tax deductions for fuel and road duty,
– Infrastructure development of region, heavily dependent on government policy.

Economic:

– Globalization promotes trade without borders, and thus logistic flows as complex products and certain spare parts for them, their intensity, saturation, structure and nature of the service creates a new paradigm in development,
– The choice of a partner is usually carried out on the basis of cost and quality of its services,
– Enhancing the role of services in packing and sorting that can generate added value and avoid the feeling of mass goods,
– Significant logistic chains pose obstacles to effective, efficient and quality management, and thus reduce their resistance,
– Mergers provide an opportunity to increase market share, access to the new technologies, to achieve economies of scale, reduce the development and release of a new products, etc.,
The desire of companies to focus on their core competencies promotes outsourcing, which, in its turn, changes the structure of the industry.

Social:
- With the development of consumer awareness, increase of demands for goods and for related services: targeting supply (predefined user), efficiency response to the request, manufacturing and delivery of environmental friendly goods and production, enhancing the role of reverse logistics (increase of the number of goods returns).

Technological:
- Transparency and the ability to control any of the processes that take place in the logistics chain, both on consumers side and directly on the side of logistic chain elements,
- Internet-tailored logistic system,
- New methods of production, assembly and distribution of spare parts [4, 5],
- Using of advanced production materials,

The legal:
- Legislative regulation: the length of the workweek, transportation, level of environment’s impact, the level of innovation activity, etc.

Natural:
- Increase of the volume of CO2 emissions into the atmosphere,
- Growth of the part of reverse logistics under increasing role of utilization,
- The use of finite natural resources, the search for alternative energy sources.

The authors believe that the key “generators” of the development of any industry (including automotive) can be innovations that are designed to solve certain technological, natural, social and other factors and challenges. Figure 1 shows the chronology of the development of innovative technologies used in motor vehicles.

In general, innovation can be divided into two groups - technical (technological) and administrative (non-technological). The technical innovations in logistics today include: radio frequency identification, or so-called RFID technology; integrated information systems between organizations in the supply chain, automatic information systems that builds the optimal route of vehicles (the ability to change the route after the departure from the party); digital administration, which is intended to reduce the time of booking process; integrated systems for processing and transmitting information; modern vehicles with low CO2 emissions into the atmosphere, as well as cars with hybrid and fully electric engines; the use of new models of vehicles for car transportation that are able to increase the number of floors as needed (maximum of 3) and so on. Administrative innovations in enterprises logistics of automobile industry can be summarized as follows: the emergence of logistics operators class 3PL and 4PL, enabling complete on-line control of moving goods from producer to consumer, while providing services for the temporary storage of goods, increasing manufacturers attention to the environmental logistics, implementation of which should be done in terms of administrative innovations, increasing the role of automated warehouses, packing centers, departments for personalization or localization of orders, etc., further development of logistics, based on the principle of “just-in-time» (JIT). Overall, as studies have shown, the number of innovations that were developed as an administrative and technical nature are considerably less than the number of actual implementations (see Figure 2). Therefore, scientific and technical departments are critical to recognize perspectives of this or that development.

There are also a number of innovations that include features of both groups. These include the so-called modular production in cooperation of several companies. For businesses of automotive industry, modular production in the conditions of a continuous search of opportunities to

![Fig. 1. Characteristics of innovation in automotive industry [6]](image-url)
optimize costs, trying to meet the growing demands of consumers to the product, is one of the most promising ways of developing in the coming years [7]. The successful implementation of the considered innovation allows for:

- Reduction of the cost of developing new models,
- Speeding up the output of new products on the market (over 30%),
- Reduction of the cost of training staff that performs repair and servicing of motor vehicles,
- Unification of many spare parts in modules that apply to different car models, thus reducing the cost of spare parts to the end user,
- Using a single platform with multiple-choice modules - producing a range,
- Reducing dependence on a single supplier,
- Reducing risks related to natural disasters,
- Effectively management of the disposal.

In addition to the positive aspects of modular production a number of drawbacks are inherent:

- Difficulty of establishing close partnerships,
- Inability of radical differentiation of developed platform to meet individual customer orders,
- Increasing complexity of designs of some replacement parts,
- Availability of additional costs for testing object models.

The nature of the modularity conditions on every automotive company is specific, but they are united by the presence of a number of modules, certain systems or car parts, the layout of which makes it possible to unify the car.

For example, the company Nissan in the modular production (program “Common modular family Nissan») used four different modules: engine compartment, cabin, front and rear underbody. Combining different variations of these modules allows for the creation of a broad range of cars, including models from the wagon to the hatchback. Options of modules and their combination results are shown graphically in Figure 3.

As seen from Figure 3, the use of multiple versions of a module part allows more dynamic individualization of production process.
Considered technology with certain modifications of production (including the needs of consumers in product differentiation of automotive companies) also used such enterprises as: Ford, General Motors, Volkswagen, Mercedes, Renault Nissan alliance and others [9].

As already noted, this production technology is much better with contracts of cooperation between different institutional units that are present both within the supply chain of a particular company and outside it. One of the main goals of parties cooperation is to improve the competitiveness of all parties of cooperation, by increasing production, stimulating savings of scale and division of costs between the parties aimed at the processes of development and introduction of new products or innovative technologies.

In addition to the above advantages, cooperation enables:
- Reducing the cost of spare parts through standardization,
- Gaining access to advanced technologies,
- Improvement of the level of cooperation between all parties of cooperation,
- Transparency of information flows,
- Optimization of logistic processes,
- Creation of interchangeable parts for different automakers etc.

However, before innovation process in a company it should be noted that all the above benefits can be achieved in greater or lesser value, and are accompanied by other effects [10]. Thus, according to the research conducted, innovations usually increase product quality, and thus increase the cost of the goods, reduce the number of spare parts that are used in the preparation of the product, but the structural complexity tends to increase.

Any merger involves compromises and cooperation in the field of automotive branch under conditions of involving a large number of diverse businesses also puts the problem of optimal operating conditions in a rather broader area. One of such areas are logistics and information exchange within the logistics processes. Tasks such as: production with minimal inventory volumes; implementation of any order within 48 hours; rapid response of all companies involved in the production process to the predicted changes by marketing department in the size and structure of demand for goods; providing information about availability, costs, delivery time, the possibilities of additional production, allocation of necessary spare parts – for all companies, engaged in the supply of raw materials, as well as those engaged in direct sales, repairs processes or servicing of vehicles, shipping products to any destinations, providing an appropriate level of product safety; providing the required level of consumer service (availability of appropriate spare parts), even after removal of goods from production, can be realized thanks to modern systems optimization and rapid development of information technologies, which can be flexibly and comprehensively implemented by companies in various sectors and activities.

LOGISTIC SYSTEM IN THE IMPLEMENTATION OF MODULE PRODUCTION

To build a harmonious spatial logistics system, which facilitates the development of relationships between au-

![Diagram](image-url)  

Fig. 4. The hierarchical structure of logistics system tasks realization [11]
tomotive assembly companies, suppliers of first, second levels, suppliers of raw materials, research institutes, enterprises, partners, dealers, 3PL-4PL-and logistics operators, repair companies and service stations, it is necessary to clearly define the tasks of appropriate logistics system and determine those places where there is a conflict of goals. Figure 4 shows the hierarchical structure of tasks in the logistics system.

Any logistics system addresses the needs of consumers in the relevant product or service quality at an appropriate price. Since spare parts as a product are heterogeneous both in matters of the cost of their production (the company) and the requirements for quality and reliability (consumer), so it seems reasonable to analyze components of costs and quality of logistics system components in the automotive industry in terms of module production (Figure 5).

As seen from Figure 5, the analysis was based on the dividing of costs, depending on the stage of production, storage or sales. In general, given dividing is arbitrary, because to make the cost separation of a given process including length and width of the supply chain in the automotive field is somewhat problematic.

So, the first step was outlined costs that cover production processes, and the processes associated with the purchase of raw materials. The second stage involves the production costs of modules, systems and small spare parts by smaller regional and world famous suppliers of automotive systems. The third stage is directly allocated car assembly enterprise and the costs that they incur in the process of developing and assembling vehicles. The fourth stage covers marketing costs, warehousing of finished products and spare parts, as well as the costs of transporting goods to the place of direct sales. At the fifth stage are the costs associated with after sales service of vehicles.

Also, one should allocate the costs associated with the organization partnerships that take place in one or other part of logistics chain. Costs associated with the cooperation may cover costs:

<table>
<thead>
<tr>
<th>Costs related to the organization and support partnerships</th>
<th>Suppliers of 1-st and 2-nd level</th>
<th>Car assembly enterprise</th>
<th>Production and assembly</th>
<th>Dealers</th>
<th>Service stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Transaction costs;</td>
<td>- The cost of transportation services;</td>
<td>- The cost of raw materials;</td>
<td>- The cost of sales activities;</td>
<td>- The cost of after-sales service</td>
<td>- The cost of after-sales service</td>
</tr>
<tr>
<td>- The cost of receiving, warehousing and technical examination of material resources;</td>
<td>- The cost of receiving, warehousing and technical examination of material resources;</td>
<td>- The cost of assembly and packaging;</td>
<td>- The cost of after-sales marketing;</td>
<td>- The cost of labor;</td>
<td>- The cost of labor;</td>
</tr>
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<td>- The cost of extraction and standardization resources.</td>
<td>- The cost of the design;</td>
<td>- The cost of the design;</td>
<td>- The cost of after-sales marketing;</td>
<td>- The cost of transportation services;</td>
<td>- The cost of transportation services;</td>
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<td>- The cost of fuel and energy;</td>
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<td>- Labor costs;</td>
<td>- Labor costs;</td>
<td>- The cost of disposal.</td>
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<td></td>
<td>- Costs associated with work equipment;</td>
<td>- Costs associated with work equipment;</td>
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<td></td>
<td>- The cost of assembly and packaging;</td>
<td>- The cost of assembly and packaging;</td>
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<td></td>
<td>- The cost of quality control;</td>
<td>- The cost of quality control;</td>
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<tr>
<td></td>
<td>- Costs associated with the management of production processes;</td>
<td>- Costs associated with the management of production processes;</td>
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<td></td>
<td>- The cost of testing;</td>
<td>- The cost of testing;</td>
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<td></td>
<td>- The cost of research and development</td>
<td>- The cost of research and development</td>
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</table>

Fig. 5. Components of logistics system costs in automobile industry [12]
Fig. 6. Pattern of decision making for optimizing logistics costs [12]

Quality function deployment

**Marketing**: an analysis of the market situation, finding analogs, prototyping, analysis of customer requirements, forecasting demand, competitors monitoring

**Constructing**
- Standardization
- Modules of surfaces parts
- Modular Connection
- Structural modules
- Modular units
- Modular Products

**Technology**
- Modular manufacturing
- Processing Modules
- Modular Operation
- Modular assembly processes
- Modes of modular assembly

**Production**
- Testing of security
- Modular equipping
- Setting up
- Organization of modular assembly
- Diagnostics
- Control
- Salaries
- Infrastructure

**Exploitation**
- Terms of Use
- Diagnostics
- Elimination of common faults
- Maintenance
- Repairs
- Lifetime
- Recycling

**Logistics**: Construction of an integrated logistics system, the implementation of "just in time" principle; warehousing, supply, marketing of products, on-line control system of orders, logistics crisis situations, reverse logistics.

- Costs of Standardization
- Costs of modular design
- The cost of software
- Production of experimental
- Finalization of technology
- The cost of a virtual checking
- The cost of a modular design
- The cost of software
- Production of experimental
- Finalization of technology
- The cost of a virtual checking
- The cost of production
- The cost of equipment, installation
- Accessories
- labor intensity
- Costs of testing
- The value of equipment

**Quality of product**
- The cost of maintenance, fuel, energy
- The cost of repairs
- The cost of spare parts
- Costs of storage
- Costs of disposal

Fig. 7. Deployment cost function and quality function under module production [13]
– for standardization of production process and material financial and information flows,
– for providing an appropriate level of safety,
– for developing new standardized (across brands) spare parts,
– for developing new and improving existing models within the association.

In addition, the authors have singled out 3-PL and 4-PL-operators, as such, which are present at each of the examined stages, and the level of competence which plays a key role in enhancing the competitiveness of prospects of a process optimization.

Efficient cost management of logistic systems is not possible without use of appropriate decision-making algorithm (Figure 6).

As it stands, the proposed algorithm enables better structuring of logistics costs by place of origin, thus extending the chances of transition logistics system to a new level of functioning. However, the decision for optimizing or reducing costs should not have effect on the quality of the final product, thereby reducing its competitiveness. Enforcement of this condition is achieved through a comprehensive analysis of cost function and quality function under module production of automobile enterprises products (Figure 7).

Integrated analysis of cost and quality functions facilitates the establishment of spare parts, systems, modules and vehicles, with the combination of quality and costs that would best satisfy consumers’ requirements, while ensuring the goals of the enterprise. And implementation of structuring the quality and costs of marketing, logistics, engineering, technology, production and operation stages is prerequisite for finding hidden prospects of a process optimization.

FEATURES OF PARTNERSHIP RELATIONS DEVELOPMENT BETWEEN COMPANIES IN THE AUTOMOBILE INDUSTRY

The sphere of spare parts production for motor vehicles is complex and heterogeneous. Successful operation of automotive manufacturers requires a close cooperation with dealers (as they best understand customer needs and can effectively predict demand for a particular product in a particular region) [14, p.1-2], with manufacturers of spare parts and systems (because the level of competence in production and technology of spare parts of those companies are the largest), with suppliers (quality, price and availability of raw materials at the right moment without close cooperation isn’t possible), with repair stations (providing important information about the level of performance of any spare parts in the real conditions, about their safety and ability to wear, ensuring the formation of long-term relations with customers), with logistics operators (availability, speed, possibility to deliver, reliability, low cost storage, catalog, online monitoring of the availability of goods in warehouses or on the road, more experienced management of supply chain, as 3PL and 4PL operators usually have more experience doing business with multiple clients, etc.).

As practice shows, most enterprises in the automobile sector, try to form long-term relationships with the above-mentioned institutions, but generally, these connections are not close, do not provide open information systems, joint research. So, car assembly enterprises are forced to maintain an appropriate level of safety and to avoid existing risks (see Figure 8), forming the base of “secondary” partners. As a result, it becomes impossible to build high-quality, effective cooperation, and core competencies at each element of the logistics system is not used at full level.

One of the ways out of this situation, which has now been implemented in a number of industries in recent years, is the formation of close cooperation between the elements of the logistics system in the limit of core competencies. Strengths and weaknesses of the companies involved in the manufacture, preparation, delivery and sale of spare parts are shown in Figure 9.

Close cooperation include:
– The formation of strategic alliances by exchanging shares parts of companies certain departments (individual entities),
– Based on association - joint development of spare parts technologies, building a common network of repairing facilities, service stations, multi-distribution networks,
– Building a common integrated information system,
- The creation of multi-warehouses;
- The formation of a joint system training;
- Formation of joint modular platforms;
- Creation of a transparent information - effective forecasting demand for raw materials, spare parts, modules, cars, etc.;
- Realization of a reasonable service policy.

Based on analysis of the prospects that opens businesses cooperation and considering the needs of end-users, we can construct the corresponding hierarchy of needs in the field of spare parts (Figure 10).

Performance, as already mentioned, the level and nature of integration in the logistics chain is specific to each system, but changing approaches to the cooperation within the supply chain is critical, especially during the policy module design and production of spare parts, systems or, directly, vehicles [18]. The main cooperation differences are summarized in Table 1.

CONCLUSIONS

Consequently, integration, as the above table shows, involves responsibility growth of all association components, synchronous and coordinated actions, a compromise in resolving disputes, joint development of new
products and their mutual interest in the development of one or another element of the logistics system. However, the requirements that apply to the system give tangible competitive advantage especially at a time when the market has begun to dominate the consumer market producer. Module production in the automobile sector against the background of cooperation of car assembly companies, manufacturers of spare parts, intermediaries, contribute to break down the costs, reduce the duration of the order, increase flexibility, which is effective in competing for the consumer.

### Table 1. The features of enterprises cooperation under integration within a logistics system [17]

<table>
<thead>
<tr>
<th>Factor</th>
<th>Conflict approach</th>
<th>An approach based on cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>profit</td>
<td>following the goals of profit maximization</td>
<td>maximizing for the whole system</td>
</tr>
<tr>
<td>relationship</td>
<td>one party dominates</td>
<td>equal partnership</td>
</tr>
<tr>
<td>trust level</td>
<td>small</td>
<td>significant</td>
</tr>
<tr>
<td>communications</td>
<td>limited and formal</td>
<td>comprehensive and open</td>
</tr>
<tr>
<td>information</td>
<td>limited</td>
<td>integrating the common information system</td>
</tr>
<tr>
<td>control</td>
<td>tight</td>
<td>common control over the implementation of the goals</td>
</tr>
<tr>
<td>quality</td>
<td>emphasizing the shortcomings of the various departments</td>
<td>common issues for improving product quality</td>
</tr>
<tr>
<td>contracts terms</td>
<td>tight</td>
<td>flexible</td>
</tr>
<tr>
<td>focused</td>
<td>on its own operations</td>
<td>on the consumer</td>
</tr>
</tbody>
</table>

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