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COMMUNICATION IN GLOBAL SUPPLY CHAINS IN AUTOMOTIVE INDUSTRY

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Development of information and communication technologies is caused by global economic changes, especially internationalization of business activities, shortening product life cycles, oligopolization of industries and concentration of capital. Automotive industry has been a precursor of modern technology and management strategies for many years. Market changes have led to the need to build new logistics systems which main element is the modularity of production. Communication in global supply chains is largely based on software that uses many communication channels. This phenomenon of media convergence enables efficient flow of information between members of the supply chain and building modified value-added chains, especially by using virtual teams and software agents.

Keywords: information, communication, automotive, logistics, information logistics, media convergence, software agents, global virtual teams

1. Introduction

In the current post-industrial society, employment of persons directly involved in production process has been declined for the benefit of process automation. Knowledge-based economy develops all the time, which is an indicator of the Age of Knowledge, also known as the Age of Information [15]. Commercialization of research, which was the result of innovation developed thanks to two fuel crises [19], led to the creation of hundreds of

companies that today play a key role in the global market. Among sectors dominated by global corporations are those that deserve special attention due to their contribution to the development of management methods. These include automotive industry - for many years a precursor of new solutions, acquired by another sectors.

Emergence of global business networks, which are the highest stage of evolution of network organizations [24; see Table 1], is associated with the relocation of existing international companies to countries with lower cost of production factors. Often in these countries, the economy is dominated by a single type of production or by one industry.

Table 1. Characteristics of global business networks

Attribute	Description
network architecture	building complex systems by establishing links between entities and economies; oligopolization of global business space
cooperation	cooperation based on core competencies
coopetition	competitors cooperation in order to achieve the result (usually in the area of research and development); submission of the common good over own goals
internalization	building internal relationships within the corporation, the interplay of relationships in a dynamic environment
coherence	consistency of action of organization components in order to realize a shared vision of development
multiculturality (interculturalism)	lack of spatial and cultural constraints in the functioning and development of the organization, culture diffusion and the development of global standards
synergy	developing greater results jointly than in the case of a separate activity of system components
innovativeness	development of new production methods and internal and external communication; creating added value through innovative solutions
globality	result of the rapid spread of information and a short life cycle of knowledge

Source: [24]

This leads to the formation of regional specialization and industrial monocultures [19] and to the disintegration of processes resulting from various factors, for example geographical distance, cultural differences, outsourcing development and other. It was necessary to create effective forms of communication between people, but also between intelligent IT systems. Business ecosystems are formed and they integrate not only the whole supply chains (suppliers, manufacturers and customers), but also other elements of the business environment – for example competitors and consumer organizations. These ecosystems are mainly based on integrated

databases and a very good internal communication technologies [18], which is a part of the concept of the information society [9]. With their development are associated the following metatrends [35, 38]:

- progressive convergence of communication processes (market convergence),
- flexibility of organizational structures as a result of changes in the flow of information,
- increasing availability of information and communication technologies,
- increasing usefulness of information.

Development of information technologies and growing role of intangible resources in shaping competitive advantage of enterprises influence the development of flexible organizational forms based on knowledge (Table 2). This includes also the supply chains. Between network elements occurs knowledge diffusion [2], by which one can develop synergy effects which make up the success of the entire supply chains. Information and communication technologies (ICT) are expected to contribute to the acceleration of economic recovery and create a "sustainable digital future" [4]. They will be accompanied by the development of flexible manufacturing systems (FMS), supported by the data communication networks and automation of processes, which will result in an appearance of "insulated factories". Intellectualization of work will occur, both in order to people and advanced software solutions [6]. The aim of this paper is prove that interpersonal communication (virtual project teams) and this between machines (agent-based technologies) significantly contribute to the development of communication in global supply chains.

2. Communication in transnational corporations (TNCs)

2.1. Communication in corporation

Global corporation communication can be divided into:

- interpersonal communication without the use of modern technology,
- interpersonal communication the use of modern technology,
- communication between objects without human intervention.

Interpersonal communication without the use of modern technology is to conduct interviews by persons being in the same place at the same time. The use of modern technology usually bases on using telephone, computer or another information messenger over a geographical distance. IT systems used in the largest extent in this type of communication are [8]:

- workflow systems,
- groupware systems (np. Intranet),

- teleconferences, videoconferences,
- Customer Relationship Management systems (CRM),

Table 2. Characteristics of modern organizations

Type of organization	Characteristic
learning organization	• openness to criticism, • flattened organizational structure, • system of collective learning, • willingness to take risks, • high innovation level, • continuous improvement, gaining new competencies, • involving all staff in learning processes, • delegation of power, • expanded expert knowledge, • management commitment, • exploit the potential of employees (including intellectual capital).
intelligent organization	• investing in core competencies of professionals, • organizational culture based on mutual respect, trust, willingness to co-operate with other employees in various configurations, • IT infrastructure characterized by innovation and support of organizational communication within the permanent and temporary groups of employees, • collaborative organizational forms (project organization, matrix organization) - creating innovative ideas through the synergy of work of all team members (especially interdisciplinary teams), • full internal openness to sharing information, • blurred boundaries between different types of information used, but also technologies, tools and information distribution channels (convergence), • pressure on multiplication of knowledge and competences.
fractal organization	• structural similarity, • freedom of decision-making , • self-organization, • self-optimization, • system of objectives resulting from fractal targets, • dynamism, • orientation to create added value for the customer, • developing synergy effects through fractal interaction, • horizontal communication, • removal of space-time barriers.
virtual organization	• task nature (project nature), dynamic project groups • intangible nature • large role of planning of communication processes and implementation of accompanying technologies, • telecommuting or fieldwork (geographic dispersion of workers), • the use of modern communication techniques (Internet, Intranet and Extranet), • minimal possession and consumption of physical resources.

Source: [8].

- Supply Chain Management systems (SCM),
- Enterprise Resource Planning systems (ERP),
- systems based on self-steering, software agents, neural networks,
- systems designed specially for virtual organizations (for example Business Intelligence),
- corporate portals,
- systems recognizing speech, writing,
- other.

Communication between objects without human intervention manifests itself in the autonomous action and decision-making by units programmed by humans. The main tool in this area are agent-based technologies.

Communication in the organization can be divided according to different criteria [11], but in the context of the issues mentioned in this paper is divided into two main categories: internal and external communication [37]. The first one refers to the organization's internal stakeholders (employees, management, directors, shareholders), while the other - to its external stakeholders (local communities, government offices, local governments, competitors, suppliers, customers, etc.) [37].

2.2. Communication in global automotive corporations

Global automotive corporations are at the forefront of the world rankings in many categories. 3 of them are in the Global Top 100 Companies by market capitalization by PricewaterhouseCoopers (Toyota -21st place, Volkswagen AG - 53rd, Daimler AG - 72nd) [5]. The 33 vehicle and parts manufacturers are in the Forbes 500 in 2014 (ranked by revenues) [7], including 10 of them in the top 100. According to the current World's Investment Report, 11 OEM (Original Equipment Manufacturers) are among the world's top 100 non-financial TNCs, ranked by foreign assets [1].

High sensitivity of automotive sector to economic fluctuations causes a number of current problems and challenges facing it in the future [see Table 3]. Car manufacturers maintain close contact with their most key suppliers. The classic approach for analyzing the communication between them is based on the study of the amount and type of communication channels and the frequency of sending messages between them. In turn the sociological approach to the problem involves the effects of a single-user communication, his cognition, perception and interpretation of message received [21].

Convergence of electronic media supports the creation of value chain in the automotive industry. It manifests itself in cooperation of various ICT to create value chain. Examples of this type of convergence are offboard diagnosis and surveillance of the vehicle at a distance, teleservice devices (phone and navigation system). The previous lack of control over goods

being transported caused the development of satellite communication systems [23], which significantly shortened the time of acquisition and processing of data and information in the supply chain. Converging processes are now further enhanced by strategic information systems (SIS), which largely affect developing competitive advantage and other goals of the organization [3, 22].

Table 3. Characteristics of current automotive market situation, trends and future challenges

Current situation	Trends/megatrends	Main future challenges
1) Pressure on costs minimizing: • stagnation of markets in the traditional sales segments, • low level of readiness for innovation, • declining profitability (EBIT) from 5.5% to 4%, 2) Pressure on innovation: • increasing requirements from the legislation, especially in area of safety and environmental protection, • growing expectations of buyers of luxury cars, • increasing investment in product development by more than 5% in OEM and 9% among suppliers.	• rapidly changing technological trends, • increasing complexity of products, • shorter product life cycles, • large variety of products, • increased involvement of suppliers in product development, • reduction of the depth of commitment to the development of OEM, • changes in vertical integration of OEM • change of the responsibilities of OEM in supply chains, • increasing number of JIT system implementations, • outsourcing development (eg. final assembly) • reducing the number of suppliers cooperating directly with the OEM.	• increasing complexity, • increasing level of mobility, • changes in retail sales, • conducting global business, • maintain close partnerships in supply chains.

Source: [16, 25, 33]

2.3. Convergence in automotive industry

Convergence is defined as the interaction of the new elements of reality, in particular, pervading of the telecommunications, media and information technology. This is a phenomenon of assimilation of technology and equipment, which originally played quite different roles, and now have similar functions [13, 27]. Its technological dimension is mainly based on digital communication, that is saving particular message by a system of 0-1 code understandable to microprocessors. Technological convergence allows also to receive the same message at any time and at different stationary or mobile devices. Therefore, not only the differences between different media

are blurred, but also between devices that enable reception of the message. Pervading different media with each other makes that the message recipient can receive it many times on various media platforms, which is called the multi-channel transmission of message [32]. Media convergence contributes to the creation of a "thick information universe", also called hyperspace or hyper-reality.

H. Wozniak believes that convergence can be a solution to stabilize and develop the automotive industry in the face of cyclical economic crises affecting this branch [36]. This phenomenon is especially important for the automotive sector because it is very sensitive to demand changes, for even small variations on market and the effect of transferring global economic fluctuations on the sector is always very much exponentiated.

In the value chain in the automotive industry, there are three forms of convergence: vertical, horizontal and functional [12]. Vertical convergence is strongly determined by the relations resulting from market position and bargaining power of supply chain actors. An example of vertical convergence in the automotive industry is the creation of R & D centers by suppliers (OES - Original Equipment Supplier) and manufacturers (OEM). Horizontal convergence involves the interaction of entities with various profiles, but being on the same level in the supply chain (eg. Tier One). The strategic focus of their cooperation are research and development activities and knowledge transfer. Functional convergence is the added value and involves the integration of technology and services controlled by the lifestyle and needs of individual clients. Convergence is thus an instrument through which on saturated and volatile markets innovative products and services are implemented, including logistics services, enhancing opportunities for development of business partners [12].

3. Global virtual teams

Global virtual team is a combination of "virtual team" and "global team." Technical tools to support communication in global virtual teams can be divided into two categories: electronic tools and Web 2.0 tools such as Intranet. Intranet is the most commonly used tool in the Web 2.0 both the access to data organization and to communicate with other employees. Repositories of knowledge can be created in it and are often accompanied by discussion forums. Supplements of communication systems in corporations can also be educational portals. The highest value for task being realized is brought by interview conducted via videoconference (frequently defined as a live meeting). Social relations are also quickly established, and these

relationships based on emotions and feelings connect team members with each other.

One example of work in virtual project teams was the Team-based European Automotive Manufacture (TEAM) program, which aimed to examine the role of information technology and telecommunication in supporting cooperative work along the supply chain in the automotive industry [14]. Based on customer requirements a special software was developed that links video conferencing, shared whiteboard, and access to various applications and tools, including CSCW systems (computer supported cooperative working systems). 40 engineers from 4 countries, representing OEMs and suppliers, co-operated in virtual teams. This made it possible to minimize the cost and reduce time-to-market for new product portfolio positions [14]. Reduction of time-to-market can range from 20% to 50%, if there suitable solutions and process are implemented. This is conducive to enhancing cooperation in the context of the entire value chain. But often it is necessary to re-define the roles and responsibilities in the supply chain and reengineer particular business processes.

Undoubtedly, this kind of communication in teams is complex due to the number of elements of the communication system and multidirectional relationships that exist between these elements (one-to-one, one-to-many, many-to-one, many to many). Communication networks constructed in this way require the determination of effective ways to communicate between nodes, both synchronous and asynchronous. They should be characterized by functionality and intuitiveness of interface. A major challenge in this area can become integration of IT systems owned by the various participants in the supply chain. This integration can make a lot of problems due to the characteristics and features of the software, as well as the ability to communicate with each other.

Research conducted by A. May and C. Carter shows that by working together the various links of supply chains in the automotive industry by creating virtual project teams can achieve a great improvement in the performance indicators of the whole chain [14]. In solutions in the area of ICT, there is a lot of potential that has not yet been used. Media convergence in teams often bases on VoIP (voice internet protocol) combined with mobile telephony, which enable connection of audiovisual and data transmission in real time, which at the beginning of the twenty-first century has contributed significantly to improve the performance of companies in the automotive sector [31]. Today, however, these solutions are being expanded with many new functionalities.

4. Software agents

Self-steering in logistics is mainly based on intelligent agents - IT software which independently control their own behavior on the basis of previously entered algorithms and control parameters [28]. Their work consists primarily of control process automation so much that the logistics objects take independently some of the decisions that affect them [29].

One of the examples of their use in the automotive industry was carried out ILIPT (Intelligent Logistics for Innovative Product Technologies) project, also known as 5-Day Car program, which aimed to design a supply chain so that the individual customer order was carried out within 5 days of receipt (order-to-delivery process). In the project were involved OEM, supplier (Tier One) and the European Association of Automotive Suppliers (CLEPA, Comité de Liaison de la Construction d'Equipements et de Pièces d'Automobiles). The aim of ILIPT was to create a system in 100% based on the Build-to-Order strategy at the same time offering a short time of customer waiting for a product that he has chosen.

For this purpose actions have been taken in the following areas [10]:

- area I: product configuration for BTO production including new technologies and management methods,
- area II: new concepts of supply for flexible manufacturing systems, cooperation across the value chain,
- area III: new methods and tools for BTO model applications in the European automotive industry.

The production process, improved and elasticized by commonality (using the same components in building different products or variants of particular product) is associated with the concept of a product consisting of modules (modularity of production). One of the main elements of the project was to introduce innovation throughout the chain, which consists to a large extent on the construction of intelligent self-steering systems, advanced electronic solutions. Smooth flow of real-time data has been provided by the virtual orders base (order banks) and the self-steering systems (software agents) to quickly assign the order to a specific supplier. OEM and suppliers cooperation process should be based primarily on data from the maximum and minimum production capacity, bandwitch, the conditions of a temporary change in of capacity (eg. the extension of the capabilities), which enables the automation of cooperation.

Within the ILIPT project a simulation was carried out that used real business data in the area of supply. The following supply network was taken into account: 25 OEM - some of them implemented BTO strategy, some - BTS strategy (Build-to-Stock). In addition, implemented properly virtual

order bank handled the information flow system between OEMs and suppliers. Location of OEMs and suppliers was organized so that they could easily send various products to each other. For these data a simulation was performed. The results of analysis carried out within the network have shown that the half of orders was completed in 5 days, 97% within 6 days, and 100% within 8 days [20]. This was a surprising result because the best score in the industry at the time was 40 days. Therefore BTO strategy was proved to be technically feasible.

Software agents (also known as softbots) are the main element of self-steering systems. Their characteristics [see Table 4] enable the construction of intelligent, flexible [26] supply chains in the automotive industry. These are programs that run independently and react to changes in the environment in a similar way as human being [34]. Manufacturers and suppliers who were the main target of the project, should coordinate their production and delivery dates in accordance with the incoming orders of dealers or individual customers using the Internet and softbots. The role of the human in the process was mainly to negotiate contracts, change them in a case of new market factors appearance, and to configure the softbots.

Table 4. Characteristics of self-steering

Characteristic	Description
decentralization of decision-making	decisions regarding to logistics objects are taken at the level of these objects, rather than at higher levels in the structure of the logistics system
autonomy	logistics objects have a certain degree of independence of the decision-making, can independently carry out the hierarchy of purposes
purposefulness	the behavior of objects is set to achieve specific objectives
intelligence	the ability to measure the statuses and their evaluation, the ability to operate as part of the feedback, the ability to respond to changes in ambient and operating conditions
heterarchy	network of elements with the same position in the structure, strength and power in the system components; those elements are aimed at achieving the same purpose or the group of purposes
interactivity	ability to interact with other similar systems
positive emergence	improvement of logistics system resistance to external interference; the spontaneous creation of new features, characteristics or structures in the system due to the compliant interaction between the various elements of the system and between the system and the environment
synergism	development of synergy effects through interaction of logistics objects and the emergence
non-determinism	under certain initial conditions transition to the next status can be achieved by a number of different ways of action

Agents are frequently used in the automotive industry supply chains. Each agent represents a specific department or position and is able to realize one or more functions. Often they take over price negotiations. The demand for production materials is negotiated by the manufacturer (OEM) with suppliers, they in turn are conducting negotiations with their suppliers, and so on throughout the whole supply chain. If the negotiations do not end up successfully, retrograde negotiation is conducted. In a situation where there are more bidders than the number of target bidders, may occur conducting auction with the participation of softbots. Then the control parameters are introduced in the form of potential production, transport, storage, financial issues and other. If any of the control parameters has changed, an immediate reconfiguration of other settings or even the entire supply chain occurs [17]. In each round of the negotiation the lower and upper limits of prices by both the supplier and the producer shall be introduced. If one round does not end with an agreement, the programs (softbots) move to the next round of negotiating with the new settings [29].

The degree of decentralization and autonomy indicate the degree of self-steering [30]. The aim of logistics management should not become an achievement of full self-steering, but increase the current level of self-steering to the optimum level. With its determination one should take into account the level of complexity of the logistics system, which consists of, among others, variety of products and their quantity as well as the quantity and diversity of the relationships in the logistics system of enterprise (logistics microsystem), supply chain (metasystem) and the market or economy (macrosystem).

In the self-steering systems adaptive behaviors to changing operating conditions can be developed, so that these systems should have a certain level of independent changing hierarchy of objectives earlier introduced by the person placing the control parameters (usually the management of company). Agent-based technologies have become one of the components of modern SIS.

5. Conclusions

The information provided in this study indicate that the automotive industry is one of the fastest growing areas of the global economy. It is represented by the largest transnational corporations that often create new solutions for supply chain management. Their development is stimulated, among others, by the convergence processes and the use of modern ICT.

Communication in the automotive industry supply chains consists of a number of solutions. To build competitive advantage, their TNCs need both

communication between people and between machines. The newest solutions, dynamically developing and contributing to right functioning of supply chains are virtual global teams and agent-based technologies. They allow eg. shortening the time-to-market, processing of orders and material flow between suppliers, OEM and individual clients. In the age of ubiquitous digitization of economic activity should be expected further development, which in the future may lead to subsequent innovative solutions in the field of ICT.

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