Logistics and Supply Chains

Brazilian and Polish experience

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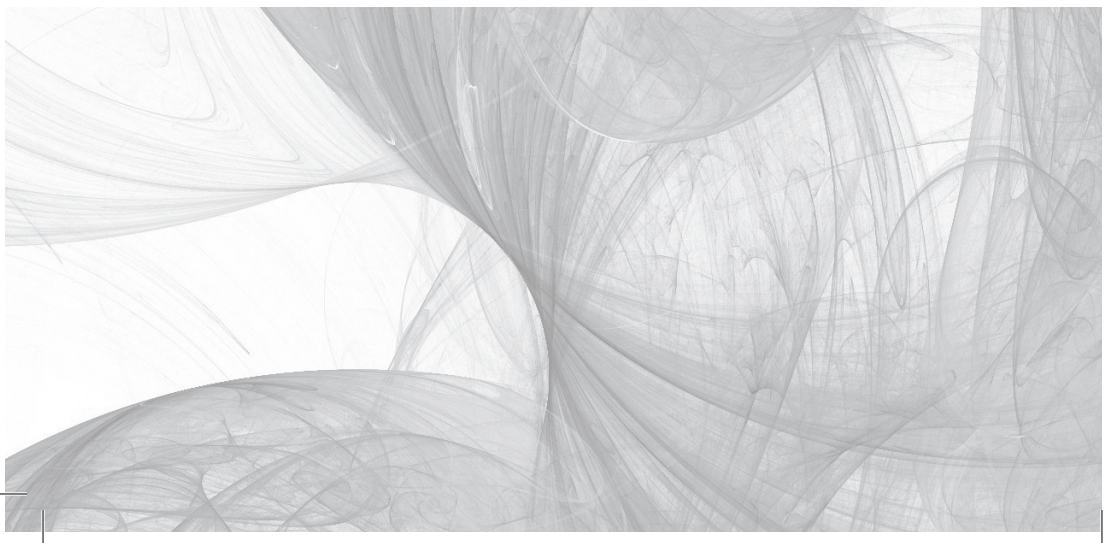


PRESENTATION

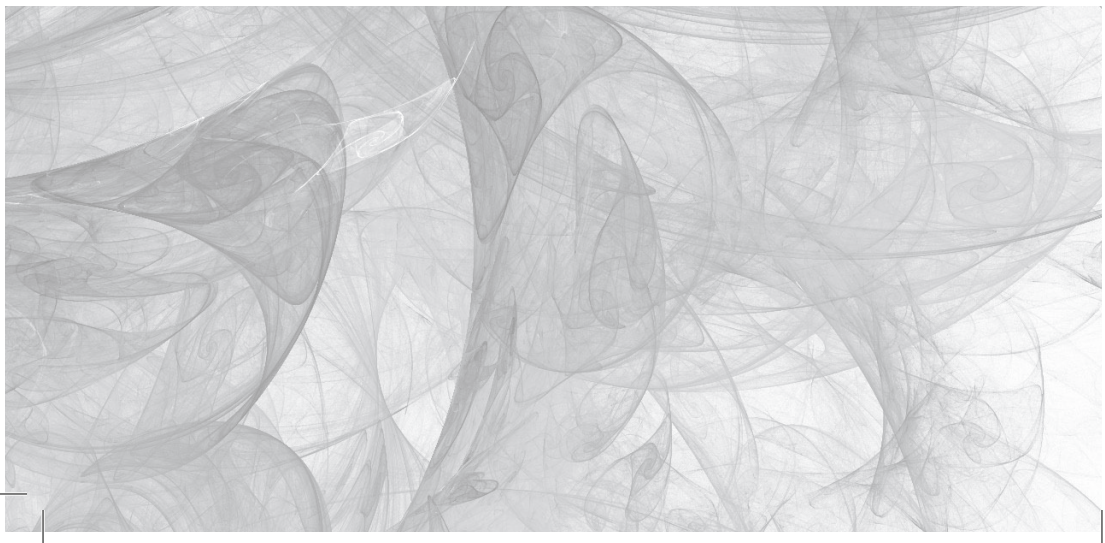
The Postgraduate Programme in Management and Technology of Productive Systems of "Centro Estadual de Educação Tecnológica Paula Souza", complements the nature of the educational action of the institution focused on professional training at its various levels while assuming the challenge of fostering a culture of research and technological innovation within the productive sector through the postgraduate academic training

In this sense, the programme has as differentiated research line the Management of Productive Systems and the Technological Development, which offers students the knowledge to find solutions to practical problems with technological bases that improve applied research in their professional areas. The programme has sought to achieve these objectives through professional training with critical positioning, technical and managerial skills and competencies, which promote a collective efficiency applied to the development, implantation and management of effective productive systems based on scientific methods and focused on the premises of the sustainability.

The "Gestão e Tecnologia em Sistemas Produtivos" collection brings to the public some results of this challenge. The studies and works of professors and students ,converted into the volumes of this collection, offer a sample of the excellence pursued in the training of professionals committed to the postgraduate program and experiences lived in other institutions, such as the Czestochowa University of Technology in Poland.

Thus, the collection is permanently open to contributions from researchers from all areas of knowledge who share the concern to train and qualify in order to improve the Brazilian productive sector in the perspective of innovation.

Professor Helena Gemignani Peterossi, PhD.
Coordinator



PREFACE

Global competition has brought about changes characterized by the manufacture of products with increasingly shorter and uncertain lifecycles through innovative technologies for customers requiring fast responses, low costs and greater customization. Companies are living with continuous or even unexpected changes to be lively and competitive. The ability to respond quickly and effectively to meet customer needs becomes a competitive feature for many companies.

Thus, to sustain and extend their competitive advantage, from quality to cost, from productivity to flexibility, companies need to improve their production and management systems. In addition to the availability of resources and the advancement of technology, the process of transformation occurs quickly, which causes obsolescence of machines, equipment, methods and, consequently, the de-actualizing of the professionals involved, within a phenomenon socio-technical.

The planning and control of the resources applied in the productive processes becomes more and more important. With this, companies see the need to expand the areas that make up their integrated planning and control process. Every day, the demands of the customers increase by the demand of new products and services, as well as information during and after its processing. Therefore, there are great challenges to be overcome by companies in the productive sector.

Among the challenges to be faced is the new industry, based on information and communication technologies, based on strong digitalization, using lean processes and significant respect for the environment. This transformation must also be concerned with an ecologically responsible supply chain with sustainably correct business models. In this scenario, logistics has become the main responsible for this achievement.

In addition, there is also the importance of new business models for the construction of competitive advantages as well as the creation of value for companies. Thus, new business models arise to meet these new paradigms. Among them is the logistics with new processes that improve the performance of the supply chain management.

In order to collaborate with productive systems, research and development institutions have worked closely with organizations to offer solutions that can overcome the major challenges posed by the market.

The proposal of this work seeks to present a significant set of works, the result of a cooperation project between The Faculty of Management of the Czestochowa University of Technology and Professional Master Program in Management and Technology in Production Systems of the State Center of Technological Education Paula Souza, where it is sought to show the various experiences developed in Brazil and in Poland, based on research carried out in the two institutions.

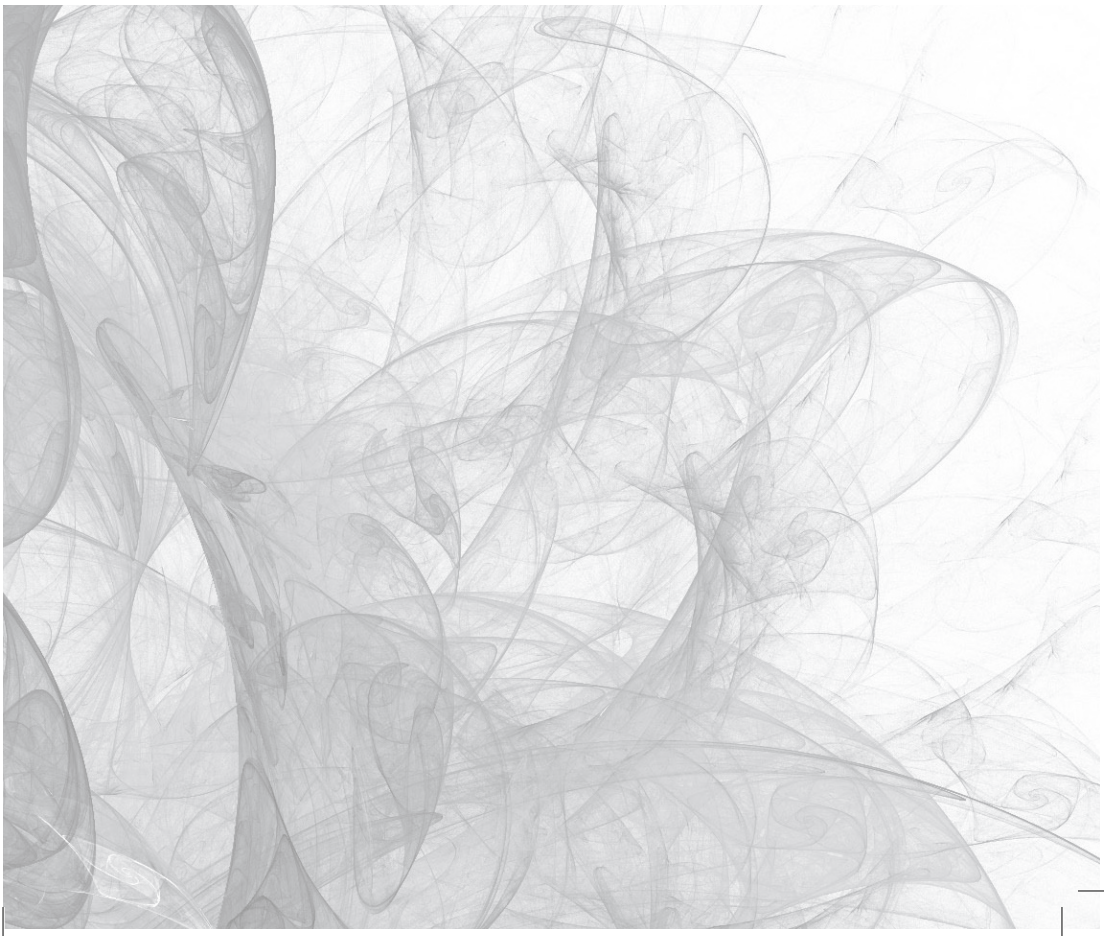
This book brings seven chapters focusing on logistics for production systems. They present papers on business models through a study carried out in Brazilian and Polish logistic transport companies, where it is sought to find similarities between the largest logistics joint-stock companies.

It also discusses the undeniable importance of information systems (IS) in supply chain management, notably in the aid of communication between partners regarding the volume and complexity of information. It also allows information throughout the supply chain to be made available in real time (inventory level, delivery situation, production planning). Furthermore, IS facilitates the alignment of operations between suppliers and companies. Still on the subject of IS, the connectivity and mobility of vehicles from the advances of the fourth generation of mobile telephony (4G), making an explanation of the innovative vehicular applications.

He contributes two papers focused on sustainable development showing the importance of industrial ecology and the supply chain as well as a bibliometric analysis of lean green production. Without leaving aside the contribution of people in this process, it presents characteristics of relations based on cooperation and partnership in the supply chain, having as variables, trust and conflict.

Therefore, this work consolidates the cooperation between the two institutions opening paths for the development of partnership that can help in understanding the challenges to be overcome and offer subsidies for the development of this new company.

Prof. Dr. José Manoel Souza das Neves



THE USE OF INFORMATION SYSTEMS (IS) IN SUPPLY CHAIN MANAGEMENT (SCM)

Marcelo T Okano, Eliane Simões

Abstract: The rapid technological evolution and the need for information to be always available to customers and suppliers, virtually makes it mandatory for all companies involved in any supply chain to use Information Technology. The research is important because it will provide a study about the IT systems used in supply chain management. In order to achieve the objective of this work, a research was carried out with consultants and professionals in the IT and supply chain who work in large companies. For the collection of the information necessary for the analysis, the exploratory research, of a qualitative nature, was used. All the systems surveyed in the bibliographic survey are used by the interviewees, and the most used are those that offer operational benefits such as ERP, bar code, legacy systems, CAD, BI and WMS.
Keywords: IS; IT; SCM;

1. Introduction

The rapid technological evolution and the need for information to be always available to customers and suppliers, virtually makes it mandatory for all companies involved in any supply chain to use Information Technology.

Companies try to adapt to this scenario by focusing on their performance, seeking to improve the level of service and reduce costs in an attempt to differentiate themselves and increase the perception of value of their customers (BANDEIRA & MAÇADA, 2008).

IT plays an important role in business performance, provides a flow of information that makes the supply chain more robust and resilient without compromising efficiency. Most companies are increasingly applying IT systems primarily to Supply Chain Management (SCM) to improve their performance in global competitive markets (MINGLANG et al, 2011).

According to Prajogo & Olhager (2012), IT can assist SCM in the following aspects: First, it allows companies to increase the volume and complexity of information that needs to be communicated with their trading partners; Second, it allows companies to provide real-time information in the supply chain, including inventory level, delivery status, and production and scheduling planning, which will allow companies to manage and control their supply chain activities; And, Third, it also facilitates the alignment of forecasting and scheduling operations between companies and suppliers.

The research is important because it will provide a study about the IT systems used in supply chain management.

2. Theoretical foundation

The CSCMP (http://cscmp.org/) conceptualizes that supply chain management encompasses the planning and management of all activities involved in supply and acquisition, conversion and all management activities Logistics. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, outsourced service providers and customers. In essence, supply chain management integrates supply and demand management into and between companies.

SCM has always been a challenge of information integration. The idea is to enable everyone involved in the flow of goods to make decisions based on the latest information and better than everyone else, both upstream and downstream. The company that manages its supply chain better receives its product from points of origin to points of consumption in the least amount of time with the least cost (DAVENPORT & BROOKS, 2004).

According to Patterson et al. (2003), a variety of factors can affect an organization's decision to adopt and implement a particular supply chain technology. The authors classify them into five broad categories: individual, task-related, innovation-related, organizational, and environmental. The authors also suggest that these factors may be important to varying degrees depending on the context or technology.

IT systems provide the most diverse solutions for virtually every business area, SCM uses a few. Patterson et al. (2003) apud Bandeira & Maçado (2008), point out 18 IT systems applied to SCM. Table 1 shows the description and respective applications of various softwares, hardware and Management Systems.

Table 1 — IT systems applied to SCM and the advantages

Technology	Description	Advantages
Legacy systems	Mainframe-based systems that operate at the operational level in just one stage. They are built as independent blocks, which makes it difficult to communicate with other systems. They were the first systems used in the SCM.	
Bar code	Technology to allocate computer-readable codes to items, boxes and containers. Employee to improve the accuracy of information and speed of data transmission, is used in the management of inventories, warehouses, supermarkets etc.	Replaces the process of collecting and exchanging information on paper, with risks of error and constant rework before; Rapid deployment; Easy to use; Compact equipment
CAD	It allows the realization of industrial designs on the computer screen that can be stored, manipulated and updated electronically.	- Creation of movements in the drawing, allowing to perform tests before the production; - Reduction of time for product development; - Creating better quality drawings to facilitate communication with partners; - Greater flexibility and faster responses in design modifications; Supply of input data for computerized manufacturing.
BI	An application suite that organizes and structures an organization's transaction data, making it easier for analysis to benefit operations and support their decisions.	Data analysis
EDI	It is the electronic transfer of data between business partners. The data are structured according to standards previously agreed between parties. It is divided into two categories: traditional EDI, which uses value-added network services, and WebEDI, with forms access over the internet.	- Possibility of integration between organizations in applications such as accounts payable, inventory control, shipping and production planning.

Technology	Description	Advantages
Fleet Tracking	It can be based on satellite or cellular transmission for vehicle tracking and monitoring, being applied for performance control and transport safety. The data generated by this system power the TMS and the WMS.	Contribute to the management of the fleet and the cargo and to the control of the hours of services of the drivers
AQC	Responsible for monitoring the quality assurance processes, inspection, speci fi cations and calibration of measuring instruments.	Quality
MES	It can be based on satellite or cellular transmission for vehicle tracking and monitoring, being applied for performance control and transport safety. The data generated by this system power the TMS and the WMS. It supports the exchange of information between production planning and control of the production process by monitoring and monitoring the raw material, equipment, personnel, instructions and production facilities.	Flexible and high quality manufacturing process
TMS	Responsible for the control of freight transportation, determining modalities, managing freight consolidation and coordinating transportation efforts.	Reduced costs. Efficient freight management and coordination of transport efforts
WMS	Optimizes operating activities (flux material) and administrative (fl ow of information) in the storage process, tracking and controlling inventory movement in the tank. Its use is restricted to operational decisions, such as: definition of collection routes, product addressing, etc.	Improvement of the distribution process.
CRM	Tool capable of uni fi car information about customers and to create a single view, centralizing interactions and anticipating customer needs. It also provides control of promotional activities and their impacts on demand as well as the control of product guarantee activities.	Customer satisfaction and loyalty

Technology	Description	Advantages
PDM	It manages the information related to the products, serving as an integration tool that connects different areas of product development.	Integration
RF	Facilitates communication by providing essential information on the status of products. Support tool that automates processes and improves operations management, eliminating human failures.	Reduction of expenses with warehouses of distribution, handling in the retail and shortages of stock
SCP	Assists in the planning, execution and measurement of processes, including modules for forecasting demand, inventory planning and distribution.	Obtain real demand, time and inventory data.
DFS	Uses mathematical methods that manipulate historical data and external data to forecast demand for products and services. In general, it integrates other systems, such as ERP and SCP.	Integration

Source: Adapted from Morais e Tavares (2013) and Patterson et al. 2003 apud Bandeira e Maçada (2008)

Other authors also present the following benefits of IT integration and SCM: Sanders et al. (2002) presented the direct relationship between the use of the technology in SCM and it was reported that organizations use IT more than usual in their industry, to more operational benefits, such as cost savings and cycle times.

Levary (2000) suggests that the benefits include: 1. Minimize the whip effect; 2. Maximize the efficiency of conducting activities along the supply chain; 3. Minimize stocks along the supply chain; 4. Minimize cycle times along the supply chain; 5. Achieve an acceptable level of quality throughout the supply chain.

Dias et al. (2003) enumerate the following benefits of using IT in SCM: (i) sharing of instant information; (Ii) sharing programs that increase operational efficiency; (Iii) real-time consumer monitoring of cargo; (Iv) development of global sales channels; (V) reduction of inventories; And (vi) greater flexibility.

These benefits can be achieved by the level of installation and use of IT systems, which directly affects the performance of the supply chain.

3. Methodology

In order to achieve the objective of this work, a research was carried out with consultants and professionals in the IT and supply chain who work in large companies. For the collection of the information necessary for the analysis, the exploratory research, of a qualitative nature, was used.

For Gil (2002), the exploratory research aims to provide greater familiarity with the problem, with a view to making it more explicit.

Zikmund (2002) considers that exploratory studies are conducted to clarify ambiguous problems, research is needed to better understand the dimensions of problems.

The qualitative approach presents a reality that can not be quantified or measured and involves subjective items of the research reality. It is possible to work with the data without specific statistical treatment, seeking the understanding of reality (COSTA, 2001).

The research carried out can be categorized as "survey", since it involves the direct interrogation of the interviewees, who are members of a significant sample of the universe researched and whose behavior one wishes to know, since their results can lead to conclusions corresponding to the data collected (GIL 1987).

The actors of the research are:

1. IT Consultants and Supply Chain.
2. Employees of companies working with IT and Supply Chain.

The questionnaires were sent to 60 companies and 14 respondents, of whom, the majority chose not to divulge the fancy name or corporate name for strategic reasons.

For Gil (2002), the majority of the cases of exploratory research involves the bibliographical survey and interviews.

The interview, for Gil (1987), is the technique in which the investigator presents himself to the investigated one and asks questions to him, like objective of obtaining the data that interests to the investigation.

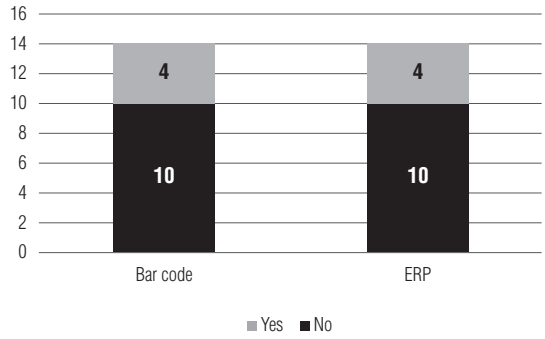
The research instrument of this paper is composed of a questionnaire with closed and open questions. Some of the answers were directed by the interviewer, in the form of performance notes that aim to detect the degree of importance, according to the intensity of perception for that question.

4. Analysis of results

The research pointed out that all IT systems reported by Patterson et.al. (2003), are used by some of the companies surveyed. The systems that are most used by companies are those that offer greater operational benefits, according to Sanders et.al. (2002), highlighting:

1. The Bar Code and ERP, shown in Graph 01, were the most used systems with 11 of the 14 companies interviewed (78.5%). The companies surveyed confirmed the operational benefits offered by the use of the barcode as ease of use and elimination of paper in data collection and integration and efficiency in the flow of information in the organization and / or between it and its partners in the case of ERP (Morais and Tavares, 2013).

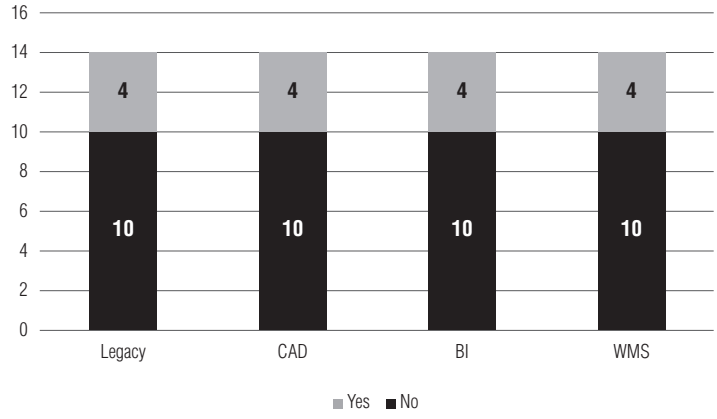
Graph 01 — Use of the Bar Code and ERP



Source: Companies researched

2. The legacy systems, CAD, BI and WMS, had a use of 11 of the companies surveyed (71.4%) as can be seen in Chart 02. The legacy systems offer, as operational benefits, access to data and old systems, but still Are used by companies. BI organizes and structures an organization's transaction data, facilitates analysis in order to benefit operations and support its decisions. For Morais and Tavares (2013), the benefits obtained with CAD are the creation of movements in the design, allows to carry out tests before the production, reduction of the time for product development, creation of drawings of better quality to facilitate the communication with the partners , Greater flexibility, and faster responses in design modifications and supply of input data for computer manufacturing; For WMS, the benefit is the improvement of the distribution process.

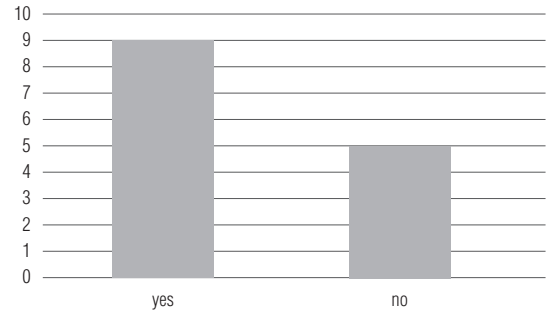
Graph 02 — Use of legacy systems, CAD, BI and WMS



Source: Companies researched

3. EDI and its use, shown in Chart 03, was pointed out by 9 of the 14 companies surveyed (64.2%). The main benefit presented is the possibility of integration among organizations in applications such as accounts payable, inventory control, shipping and production planning (Morais and Tavares, 2013).

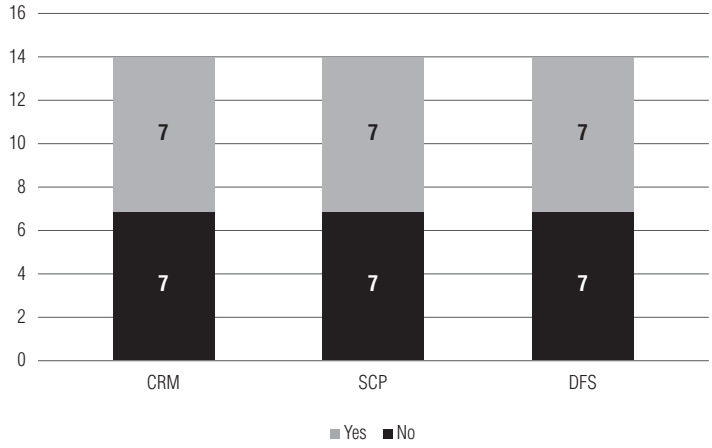
Graph 03 — Use of EDI



Source: Companies surveyed

4. The use of CRM, DFS and SCP systems, according to Graph 04, are present in half of the companies surveyed (50%). Half of the companies replied "No", this may indicate that these companies are cautious in the use of these systems, or are not convinced about the benefits that they can provide since some benefits are geared more for planning than for the operational as Customer satisfaction and loyalty by the CRM, obtaining real demand, time and inventory data by the SCP and the forecast of demand for products and services obtained with the DFS, as indicated by Morais and Tavares (2013).

Graph 04 — Use of CRM, SCP and DFS

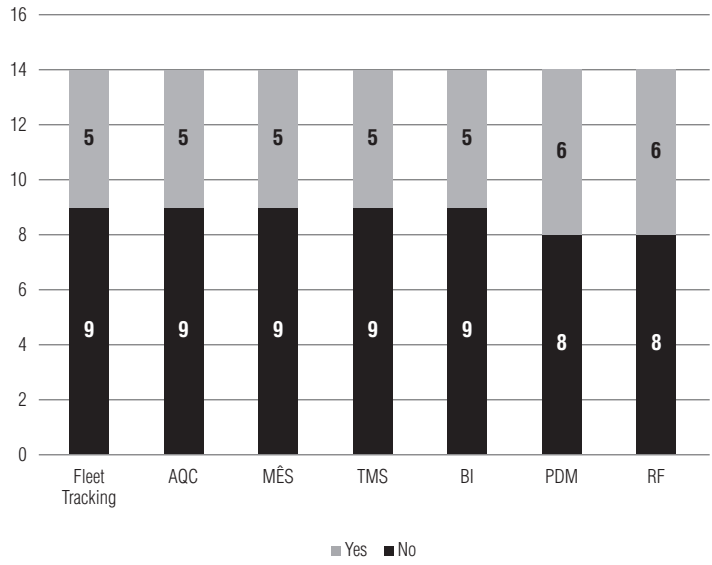


Source: Companies surveyed

5. Among the seven fleet tracking systems, AQC, MES, TMS, BI, PDM and RF, indicated in Graph 05, 5 of the 14 companies surveyed - (35%) answered "Yes" Fleet Tracking, AQC, TMS, WIS and 6 companies (42%) answered "Yes" to PDM and RF. Research has shown that the benefits offered by these systems, such as fleet and cargo management, flexible and high-quality manufacturing pro-

cess, cost reduction and efficient freight management, reduction of warehouse costs, etc. With processes and management and not with the operational benefits, which makes them attractive for use by all companies.

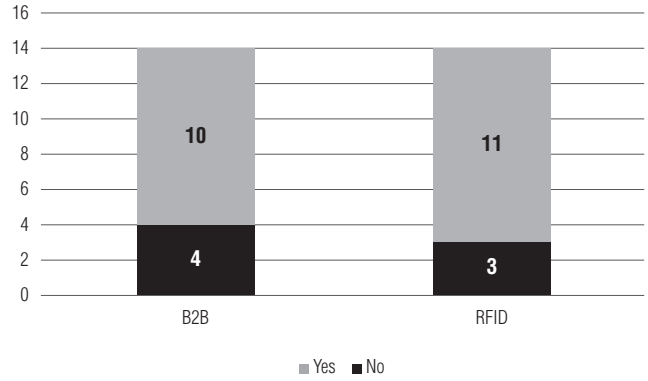
Graph 05 — Use of fleet tracking, AQC, MES, TMS, BI, PDM and RF.



Source: Companies researched

6. In the two B2B and RFID systems, shown in Graph 06, it can be noted that the systems were the least used by the 14 companies surveyed, 4 companies for B2B (28.5%) and 3 companies for RFID (21.5%). It can be deduced that low utilization is linked to the issue that the two systems require specific equipment in the deployment and the benefits are not operational.

Graph 06 — Use of B2B and RFID



Source: Companies surveyed

Respondents were asked what the IT systems applied to the SCM of the future. Two systems were named the Vendor Managed Inventory (VMI) - Vendor Managed Inventory and ERP version 3.

5. Conclusions

The research has achieved the objectives of verifying the main IT systems used in the supply chain and which are the most used by the companies.

All the systems surveyed in the bibliographic survey are used by the interviewees, and the most used are those that offer operational benefits such as ERP, bar code, legacy systems, CAD, BI and WMS.

The new technologies still "frighten" the companies which induces them to not adopt these technologies more quickly when they are launched, as was verified in the research with B2B and RFID.

It has been realized that the systems for SCM planning and management, and their use in enterprises, are increasing.

In this way, it can be concluded that the use of IT in the supply chain impacts directly in the areas of planning, manufacturing, suppliers, customers and delivery.

As a future project, it is expected to use these items for reassessment and creation of indicators in order to measure the level of impact in the various areas of the company.

The subject is not exhaustive here, it is a contribution to future debates on the subject and search of the improvement of the analysis of information technology systems in the management of the supply chain.

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THE SYSTEM OF CLASSIFICATION OF MATERIAL SUPPLIERS IN THE INSULATED GLASS PRODUCTION MARKET

Katarzyna Grondys, Iga Kott, Katarzyna Sukiennik

Abstract: In the paper, there is discussed the issue of selection of material suppliers in the insulated glass production market. There are highlighted the potential factors for the assessment of suppliers and discussed selected problems of supply logistics. On the basis of the analysis of suppliers of the selected research entity, there is proposed the assessment of Key Performance Suppliers - KPS. Setting the criteria for selection of suppliers in each company allows for selecting the best solution and achieving a high level of quality of the services provided.

Keywords: supply logistics, suppliers, logistics, level of service.

1. Introduction

The starting point for the considerations is the definition of logistics, according to which it is "the process of planning, implementing and controlling the effectiveness and economic efficiency of the flow of raw materials, in-process inventory and finished goods as well as related information from the point of origin to the point of consumption in order to meet customers' requirements"[1]. This definition focuses mainly on transport of raw materials and products between extractive, production and storage units and customers. A very important role in ensuring the continuity of production in a supply chain is played by the availability of resources at the input to the logistics system of the specific link, which is perceived in the context of the requirement to provide specific goods and services for the needs of the entity.[2]

The procurement process applies to all activities related to the recognition of needs, location, selection of suppliers or negotiating purchase terms. This process may also be used to assess and select suppliers in relation to specific needs and expectations ensuring the target efficiency of the operational process[3]. An important objective of the procurement area is the continuity of supply understood as product availability at the time of the occurrence of the demand from the customer[4].

In the procurement process, in addition to satisfying material needs, the flow of information[5], which is responsible for appropriate specifying

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orders, is also important. Supply logistics, supported with the flow of information, is thus responsible for acquiring and preparing materials for production in a synchronized and integrated manner[6].

2. The significance of the procurement process due to generated costs of the process

The procurement process, in addition to production and distribution, is one of more important stages of logistics management[7]. The procurement process is significant for the economy of each enterprise[8]. In supply logistics, costs depend on observing three principles of external supply[9]:

1. Individual supply in the area of demand – does not require the storage of materials and the invested capital and costs related to warehousing are low. This type of supply is not entirely safe since, due to the possibility of delays in supplies, this leads to production downtime.
2. Supply based on the concern for maintaining a certain level of resources on the basis of own storage potential in order to satisfy own needs. With this type of procurement materials are available at any time.
3. Synchronization of supply and demand – is based on the supply of necessary materials in time resulting from the needs of the production process. The arising costs of warehousing are very low.

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6 *Kempa E.*, Problemy zaopatrzenia w systemach logistycznych przedsiębiorstw, *Zeszyty Naukowe Politechniki Częstochowskiej, Zarządzanie No. 4/2011, p. 12*

7 *Maciejczuk M. (ed.),* Logistyka wybrane zagadnienia, *Wydawnictwo SGGW, Warszawa 2008, p. 11.*

8 *Ficoń K.*, Logistyka ekonomiczna: procesy logistyczne, *PWN, Warszawa 2016, p. 90.*

9 *Dyczkowska J.*, Logistyka zaopatrzenia – wpływ na logistykę dystrybucji produktów, *Logistyka 4/2011, p. 200.*

One of the basic functions performed at the stage of procurement is arrangement of supplies which, when properly planned, conditions an appropriate flow of raw materials to the enterprise and reduction in procurement-related costs.

The main activities associated with arrangement of supplies are[10]:

– Order development and its delivery to the supplier. The order must contain all necessary information to prepare supplies properly. The acceptance and approval of the order by the supplier is tantamount to concluding mutual contract obliging the supplier to deliver the ordered goods and the ordering party to receive the order and to make payment.
– Registering orders and controlling their fulfillment. Due to the presence of computers and means of electronic transmission of information, full automation of the above mentioned process is being striven for. This allows for immediate transmission of any information related to goods.
– Supervision of arranged supplies with the control of reception in terms of quantity and quality. The finding of non-compliance with the placed order or poor quality of the goods delivered should result in immediate initiation of the complaint procedure.
– Payment depends on people responsible for procurement who are obliged to charge contractual penalties when the goods delivered are not compliant with the terms of the concluded contract.

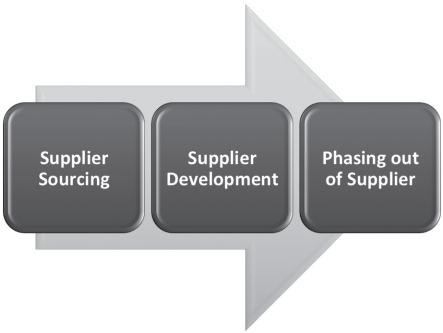
3. Potential factors conditioning the assessment of suppliers

In supply management, the key role is played by the characteristics of the supplier, among which the level of commitment to cooperation is of

10 *Skowronek C., Sariusz-Wolski Z.*, Logistyka w przedsiębiorstwie, *PWE, Warszawa 2008, pp. 181-182.*

the key importance[11]. Therefore, complex supplier management enforces the adoption of the holistic approach to the evaluation of the assessment, taking into account both supplier sourcing, supplier development and phasing out of suppliers (Fig.1).

Fig.1 — The model of supplier management in practice



Source: https://vedantaconnect.com, access: 15.11.2017

Taking into account more detailed conditions for cooperation, one can distinguish many more factors of supplier assessment. One of more important is the quality of supplies expressed as the extent to which the set of inherent properties satisfies customers' requirements12. The quality refers to requirements indicated by the user in relation to the product data e.g. technical characteristics. Product quality also applies to its durability as well as reliability and simplicity in operation.

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11 Grabowska M., Aspects of Relationships in Interorganizational Enterprises, *[in:] Managing Organizations in Changing Environment. Models - Concepts - Mechanisms ed. by J. Andrzej, T. Rojek, Publishing House: Foundation of the Cracow University of Economics, Kraków 2014, pp. 22-23.*

12 Łunarski J., Zarzadzanie jakością*, Wydawnictwa Naukowo-Techniczne, Warszawa 2008, p. 13.*

Reliability of supplies refers to the process of delivery and other factors indicated by experts as important at further stages of the significance of implementation. In order to prevent the production line downtime resulting from delays in deliveries of materials, suppliers are obliged to regular deliveries. Upon detection of irregularities or defects in materials delivered the complaint procedure is the indicator of the supplier's reliability13. The most important constituent of the delivery of supplies is certainty which is about the probability of meeting deadlines of deliveries and also their compliance with the order.

The potential of supply is the criterion taking into account the production components of the supplier as well as organizational, managerial and technical capacities. These factors, due to the information role, prove the ability to ensure the required quality as well as the ability to deliver the required amount of the necessary material at a precisely specified time. The assessment of the supplier is based on the physical ability to deliver the materials ordered to the customer as well as the concern for the customer in the future. Geographical location of suppliers, which allows for evaluating which of the suppliers brings benefits in the form of short delivery dates or the possibility of intervention order fulfillment, is also important.

4. Selected problems of supply logistics

The main problem of supply logistics is the number of suppliers, which significantly affects the reduction in risk of dependence on the supplier and simultaneously ensures undisturbed production. An extensive supply network entails an increased load on the system of supply logistics in the company and makes it complex.

Another problem refers to the concentration on supplies from suppliers located near the point of delivery, e.g. in the environment of the com-

13 *Twaróg J.*, Mierniki i wskaźniki logistyczne, *Biblioteka Logistyka, Poznań 2005, p. 54.*

pany. In this case, the entity has the choice of the warehouse most often supervised by an external logistics company. This solution is beneficial in a situation where the ordered batch of material on request excludes the possibility of placing a larger order (sufficiently large transport of the material ordered from the sources of supply located far from the company). Supply takes place using the external warehouse. In the course of it the supplier consolidates small orders into one large order and sends it to the supply warehouse of the company.

A direct link between supply logistics and the pricing policy generates pricing policy problems. This occurs when calculating the purchase price of necessary materials and relates to the control of prices of goods and the scope of services associated with delivery. It may happen that a better solution is to order delivery with the producer, making own transport available or transferring operations to an external company.

The difficulty is also related to the integration with suppliers. Coherent cooperation with suppliers allows for changing the traditional relationship referred to as "winner-defeated" into the relationship more favorable for fruitful cooperation where both sides are "winners". Based on joint operations, companies gain greater benefits than when functioning without mutual cooperation14.

5. The assessment of Key Performance Suppliers of the components for insulated glass production

The value of the industry of insulated glass production has been significantly increasing year by year, playing an important role in the development of the Polish economy. The latest data show that, in the first half of

14 *Rdzawski Z., Cebulski J.,* Wstęp do gospodarki materiałowej, *Wydawnictwo Politechniki Śląskiej, Gliwice 2012, p. 77.*

2017, exports of doors and windows in terms of value increased by 11%15. Among the main non-European importers there is the USA which, in 2016, purchased by 57% more goods than a year earlier.

Dynamic development of the industry is associated with a larger and more available market of suppliers of semi-finished products and raw materials for window production. Establishing a long-term and effective cooperation with selected suppliers is therefore a serious challenge which requires complex and multidimensional assessment. On the basis of the analysis of the suppliers of the research entity, there has been suggested the concept of assessment of Key Performance Suppliers - KPS.

In order to indicate the performance of the most important suppliers of the components for insulated glass production there has been carried out the analysis of the specific case. The economic entity accepted for the research is one of the largest producers of insulated glass in Poland and in the world. Initial decisions associated with supply of materials or services were made directly at the level of the central office of the company. Due to the intensive development of the company and the related increase in orders, there was an increase in the number of operations associated with the procurement process itself. There was also a change in the related process of supplier selection conditioned by:

– the need for an increase in the competitive position of the company in the market;
– the development of long-term cooperation with selected suppliers;
– the necessity to search for alternative sources of supply.

15 Raport Centrum Analiz Branżowych, *http://cab-badania.pl, access: 12.12.2017*

6. The conditions for the assessment of suppliers

The process of selection of suppliers is evaluated using several important criteria of service which make up a comprehensive assessment of the performance of current suppliers.

1. Quality of supplies specifies the ability of the supplier to meet the expectations of the company in relation to technical characteristics, physical properties or possible service.
2. An important part of service is also the responsibility of the supplier for the goods delivered. The lack of this characteristic disqualifies the potential supplier from further cooperation.
3. Reliability of supply is aimed at reduction in delays. All supplies must be covered by the warranty and the possibility of taking advantage of the complaint procedure.
4. The element ensuring success in mutual cooperation is a stable financial situation.
5. The selection of suppliers located within a short distance significantly reduces transport costs and allows for fulfillment of urgent orders.

Table 1 shows the list of the most commonly used materials and the number of suppliers providing services to the analyzed entity.

TABLE 1 — The list of the most commonly used materials and the number of suppliers

	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Glass – material X	x	x	x	-
Spacer bar –material Y	x	x	x	x
Molecular sieve –material Z	x	x	x	-

Own research

The analysis of inventories indicated that, in the analyzed company, the most frequently rotating materials in the production process are: glass, spacers and molecular sieves, the supplies of which are handled by at least three different suppliers.

7. The characteristics of the supplier assessment method

In order to assess key performance suppliers there was conducted the analysis based on the scoring-based method related to the specific criteria:

– Quality is considered as the most important factor when selecting suppliers and it refers to the requirements which the company sets in relation to its products, e.g. technical characteristics or chemical or physical properties etc.

Average rating	Levels of quality
5	quality exceeding the accepted minimum
4	the highest quality
3	quality at the level of the accepted minimum
2	quality below the accepted minimum
1	quality not meeting the adopted requirements

Own research

– Timeliness of supplies refers to the time of delivery of supplies of goods. Cooperation with foreign suppliers is burdened with a particular risk due to a significant distance that must be covered. Substantial delays in supplies can be the starting point for the initiation of the complaint procedure towards the supplier who provides transport themselves.

TABLE 2 — Average rating of delivery date

Average rating	Delivery date
5	order fulfillment up to 24 hours, deliveries in accordance with the agreed date, maximum delivery distance up to 200 km
4	order fulfillment up to 48 hours, admissible slight delays in deliveries, maximum delivery distance up to 400 km
3	order fulfillment in accordance with the dates included in the contract, delayed deliveries
2	order fulfillment significantly delayed, delivery distance of more than 1000 km
1	order fulfillment at an unacceptable level, delivery distance of more than 2000 km

Own research

Prices of goods and the financial situation of the supplier is a very important criterion in relation to carriers recording a high percentage of bankruptcies. The bankruptcy of the carrier is a very serious problem and the source of destabilization of the supply chain, including the entrepreneur themselves.

TABLE 3 — Average rating of prince

Average rating	Price range
5	prices reduced by up to 10% in relation to the prices of competitors, payments tailored to the customer's expectations, flexibility
4	prices reduced by up to 5% in relation to the prices of competitors, payments less tailored to the customer's expectations
3	average prices, payments at a sufficient level
2	prices higher by up to 5% in relation to the prices of competitors, payments less satisfactory for the customer
1	prices higher by up to 10% in relation to the prices of competitors, payments unacceptable for the customer

Own research

Additional services provided by suppliers concerning the way and type of transport, insurance and the procedure of dealing with the possible complaint.

TABLE 4 — Average rating of additional services

Average rating	Range of additional services
5	the supplier provides own transport, securing inventories in the event of the occurrence of an unpredicted order, recognition of complaints
4	the supplier provides own transport against payment of up to 15% on the side of the ordering party, partial securing of inventories in the event of the occurrence of an unpredicted order, recognition of complaints after negotiations
3	the supplier provides own transport against payment of up to 30% on the side of the ordering party, securing inventories only in ad hoc amounts, rather frequent recognition of complaints
2	the supplier provides own transport against payment of up to 50% on the side of the ordering party, securing inventories in an irregular way, rare recognition of complaints
1	the supplier provides own transport against full payment on the ordering party or transport is on the side of the customer, lack of securing stocks, recognition of complaints only in random situations

Own research

8. The assessment of Key Performance Suppliers - KPS.

Below, there is presented the listing referring to the selection of suppliers of three different products - X, Y,Z. The listing was based on the materials obtained from the X company. The table 5 illustrates the listing of three Polish suppliers of material X.

TABLE 5 — Score-based classification of the suppliers of material X.

Criterion of assessment	Characteristics	Supplier A	Supplier B	Supplier C
Quality	Defects and complaints	4	3	4
Price	Price level in relation to competitors	4	5	4
	Terms of payment	4	3	5
	Flexibility	5	5	3
Timeliness of deliveries	Time of order fulfillment	4	4	4
	Availability of goods	5	3	5
	Distance	5	5	3
Additional services	Own transport	5	4	5
	Stock maintenance	3	4	4
Average rating		4.33	4.0	4.11

In the overall assessment of the performance of supplies of the material, i.e. glass, there are slight differences between individual suppliers. At the same time, Supplier A offers the best conditions, particularly in terms of the availability of supplies, good location, organization of transport and the possibility of negotiating prices.

In turn, Table 6 presents the score-based assessment of the suppliers of material Y. The most specialized in the production and delivery of materials necessary for window production are Austrian and German companies. The X company purchases spacer bars exclusively from German suppliers.

TABLE 6 — Score-based classification of the suppliers of material Y.

Criterion of assessment	Characteristics	Supplier A	Supplier B	Supplier C	Supplier D
Quality	Defects and complaints	4	4	4	3
Price	Price level in relation to competitors	3	4	4	4
	Terms of payment	5	4	5	3
	Flexibility	5	4	4	5
Timeliness of deliveries	Time of order fulfillment	5	4	5	3
	Availability of goods	5	4	3	3
	Distance	3	4	5	4
Additional services	Own transport	5	5	3	4
	Stock maintenance	4	3	4	4
Average rating			4.0	4.11	3.66

In the overall assessment of the performance of supplies of material Y three out of four suppliers are evaluated at a good level. At the same time, Supplier A offers the best conditions of delivery, particularly in terms of the availability of goods, transport organization, time of order fulfillment and the possibility of negotiating prices and the extended time of settlement of liabilities.

Material Z, i.e. molecular sieve, due to its specific physical structure and the resulting high moisture absorption, requires special conditions for transport and storage. In the table below, there is included the score-based assessment of the criteria in relation to three main suppliers of the material.

TABLE 7 — Score-based classification of the suppliers of material Z

Criterion of assessment	Characteristics	Supplier A	Supplier B	Supplier C
Quality	Defects and complaints	4	4	3
Price	Price level in relation to competitors	4	4	3
	Terms of payment	5	4	3
	Flexibility	3	4	5
Timeliness of deliveries	Time of order fulfillment	4	4	3
	Availability of goods	5	4	3
	Distance	4	4	2
Additional services	Own transport	4	5	4
	Stock maintenance	4	3	4
Average rating			4.0	3.33

The table 7 of assessment indicates that Supplier A best satisfies the requirements specified by individual characteristics of the criteria, i.e. long repayment periods and the availability of goods on request.

Conclusions

Logistics supply systems are the driving force of the operations having direct impact on warehousing, inventory management as well as other areas of the functioning of the company. Procurement is responsible for acquiring materials, services and components essential for the production process. Procurement is a very important element affecting the obtained final score by means of achievement of competitive advantage by cooperation with reliable suppliers.

The main problem of supply logistics is the number of suppliers, which significantly affects the reduction in risk of dependence on the supplier and simultaneously ensures undisturbed production. This is associated not only with the maintenance of the continuity of production and the

related costs incurred by the company but also with the maintenance of an appropriate level of customer service. Setting the criteria for selection of suppliers in each company allows for selecting the best solution and achieving a high level of quality of the services provided.

In order to assess the key performance suppliers of the research entity of the insulated glass production industry, there was conducted the analysis based on the scoring-based method related to the specific criteria. The conducted research indicates that important assessment criteria are: quality, timeliness, price of goods and the supplier's financial situation and also additional services provided by suppliers concerning the way and type of transport, insurance and the procedure of recognition of the possible complaint. The conducted analysis indicated the regularity of the functioning of supply logistics and its undeniable share in achieving strong position by the X company in the Polish and European market. The selection of an appropriate supplier of materials allows for the continuous and firm functioning of the economic entity.

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BRAZILIAN INNOVATION IN THE AUTOMOTIVE SUPPLY CHAIN – THE "INOVAR AUTO" BRAZILIAN PROGRAM

Antonio César Galhardi, Getulio Kazue Akabane

Abstract: Until a few years ago, innovation was centralized in the USA, Europe, and Japan and only the manufacturing processes of the automotive industry had moved to emerging industrialized countries. The main issue addressed in this article is to understand why current innovation activities are moving to some developing industrialized countries such as Brazil. On the other hand, as the Brazilian experience has been a new space for innovation in global automotive supply chains. Recent changes in the architecture and organization of the process have been little explained, and have rarely been approached as a plausible explanation for the growing geographic dispersion of innovation activities. The latest research conducted over the last 20 years has focused solely on the reallocation of production activities. Few authors have addressed issues related to the role of developing countries as areas of innovation. The main objective of this paper is to analyze how innovation activities are moving to developing industrialized countries, especially the Brazilian experience "INOVAR AUTO".

Keywords: innovation, automotive supply chain, INOVAR AUTO program.

Introduction

Until a few years ago, innovation was centralized in the USA, Japan and Europe (Quadros 2012). Although manufacturing processes moved to emerging industrialized countries, innovation remained in their primitive barns. The main issue addressed in this article is to understand why innovation activities are now moving to some industrialized developing countries like Brazil.

The Brazilian experience as a new space for innovation in global value chains has been little explored and changes in the architecture and organization of the innovation process in global companies have rarely been addressed as an explanation for the growing geographic dispersion of innovation activities.

In the last decade, the Brazilian auto industry faced an antagonistic situation, making it the fourth largest global sales market, but still the seventh largest producer. Imports in the same period reached a growth rate of 46%. In 2011, imports accounted for 25% of sales in the domestic market. Considering these results, the Brazilian government implemented a series of new measures aimed at stimulating the automotive industry, focusing on the deceleration of imports, the development of local industry and the entire automotive supply chain. With the objective of stimulating and strengthening the competitiveness of the local automotive sector, Law 7819/2012 was promulgated, which established the "INOVAR-AUTO" Automotive Supply Chain Incentive and Densification Program.

The Brazilian government, considering these results, implemented a series of new measures aimed at stimulating the automotive industry, focusing on the deceleration of imports, developing the local industry and the entire automotive supply chain.

To achieve the objectives of INOVAR AUTO, many research, development and engineering activities need to be carried out to achieve a technical and economic level until the solutions are implemented throughout the Product Development Process. In this new regulation, aggressive energy efficiency targets are required by 2017 for all vehicles sold in Brazil, but, on the

other hand, the government is providing tax benefits to automakers in Brazil that invest in basic and applied research and engineering development generally. This plan was intended to leverage innovation in products and processes as well as to stimulate local production to accelerate the national industry, a program to foster industry competitiveness, encouraging automakers to produce more efficient, safer and more technologically advanced vehicles by investing in the national automotive supply chain, research and universities (Australian Government –Department of Education 2014, ABET – ECPD Engineers Council for Professional Development 2014).

The Brazilian economy has grown in the last decade; the increase in the industry, especially in the automotive sector is remarkable (representing 21% of industrial GDP and 5% of GDP). In fact, the car market grew by 145% between 2002 and 2011, with an annual average of more than 10%. Sales on the domestic market grew 109% over the same period, averaging 8.6% per year (ABET – ECPD 2014, ANFAVEA 2014). The importance of the Brazilian automotive supply chain can be seen in Figure 1

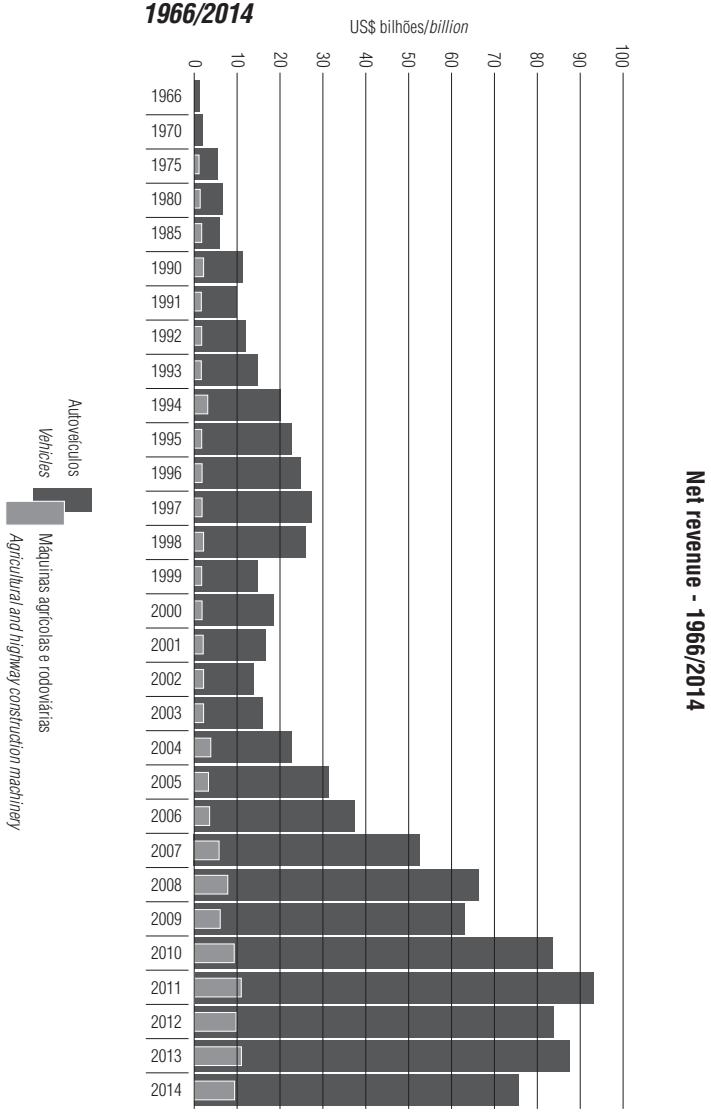
On the other hand, in the same period, imports grew 549% and exports only 336% (2000 - 2012), causing the Brazilian trade balance to become extremely negative, showing the inability of local industry to meet the growing demand and with appropriate vehicles to meet customer expectations.

The possible explanation for this antagonistic situation, among several possible hypotheses, can be pointed out by:

1) Technological obsolescence of the product;
2) Processing technological obsolescence;
3) Supply chain not capable;
4) Inadequate country infrastructure;
5) High cost of production.

Per ANFAVEA (2016), Brazil has higher energy costs, as well as public services. Differences in costs between 40% and 200% are found when compared to prices charged in Europe and Mexico respectively.

FIGURE 1 — Brazilian Automotive Supply Chain net revenue – 1966/2014



Source: ANFAVEA 2016

Similarly, steel prices in Brazil are higher than those charged in Europe and Asia. To survive in this environment of aggressive competition and high costs, technological advances and innovation are necessary, although the Brazilian scientific environment does not seem favorable.

Brazil's R & D investment in 2011 was 1.2% of GDP, while other countries, such as Korea, Japan and the USA, invested 4.03%, 3.39% and 2.77%, respectively.

Another indicator that may explain the lack of innovative products and processes in established companies in the country is the distribution of doctor's researchers among government institutions, companies and universities. Per MCTI (2014), countries such as Korea, Japan and the USA have 78%, 75% and 80% of their doctors contracted by companies respectively. In Brazil, companies established in the country hire only 26%, while 68% are allocated to universities and 6% work in government institutions. As for the number of patents presented, Brazil's participation is almost negligible in relation to developed countries.

The Brazilian government aware of this scenario has initiated a national program known as "Plano Brasil Maior". This plan established an industrial, technological, services and foreign trade policy for the period 2011 to 2014. This plan was also the embryo of the INOVAR AUTO program. The INOVAR AUTO program offers incentives to automakers established in the country in two ways:

First, the IPI (Industrialized Products Tax) was increased by 30% for all vehicles and light commercial vehicles, and then the Brazilian government imposed a series of requirements for the automakers to obtain up to 30% IPI. In summary IPI will not be changed for manufacturers that meet the requirements.

In addition, an additional incentive is being offered to manufacturers that have invested in R & D (1%) and in engineering activities (1%), but these investments must be made in the Brazilian Country (INOVAR 2012).

However, the main problem has been how to identify which activities can be considered R & D and what activities can be considered an

engineering development in a complex and technological vehicle development and manufacturing cycle. "How to identify which vehicle development activities can be considered R&D and/or Engineering to meet INOVAR AUTO requirements?" "What is R&D and what is engineering? What is the difference?" Theoretical Background

The literature on multinational companies shows that there has been internal re-organization of innovation activities, which has been combined with geographical dispersal (Ariffin, Bell 1999).

About the latter research in the past 15 years privileged the re-location of production activities and the role of global value chain in the co-ordination of production, either in manufacturing on in the services. Few authors have addressed issues concerned with the role of developing countries as spaces for innovation, feeding global innovation chains. So far, research dealing with the implications of globalization for innovation activities in industrialized developing economies has concentrated on multinational corporations' re-locating R&D.

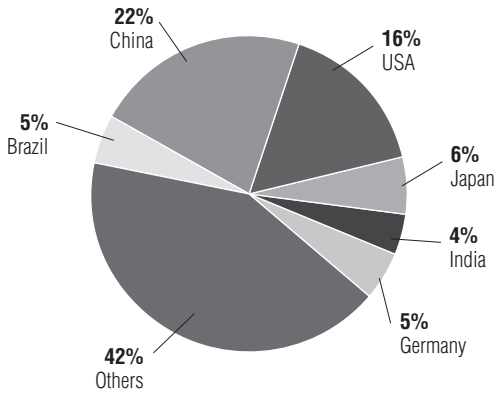
Ariffin and Bell (1999) on Malaysia, Reddy (2000) on India, Quadros and Queiroz (2001), Figueiredo and Arrifin (2003) and Consoni and Quadros (2006) on Brazil, have explored the fact that the international division of labor within countries in the Global R&D network coordinated by their respective headquarters.

Schmitz and Strambach (2009) point this subjects as an Organizational Decomposition of Innovation Process – ODIP, but an issue which has been much less explored is how the ODIP in global companies is contributing to the geographical dispersion of innovation activities. In addition, how ODIP contribute in the form of engineering and R&D relocation by global corporations and its implications for the outsourcing of such activities from suppliers and engineering services providers located in developing countries.

The ODIP in the auto industry is not a new trend, about Jürgens (2003), Freyssenet and Lung (2000) who concluded that, suppliers were pressured by mounting costs, which contributed to re-locating labor intensive activities to low wage countries at the peripheries of the triad: USA, Europe and Japan.

Ernst (2008) point that in recent years, encouraged by unprecedented sales and output growth rates in Brazil, China and India, well known business leaders suggest that the future of the auto industry lies in emerging markets and has arrived, just now. The author suggests that these countries will have an important role in designing the product, components, materials, and manufacturing process to match the specific needs of the markets.

FIGURE 2 — Brazil's Global sales position



Source: ANFAVEA 2016

The capability of developing country firms to create distinctive innovation trajectories which are compatible with their consumers' and corporate clients' needs, particularly their income constraints. It means finding new technological and product design solutions, which will be simultaneously cheap and effective (Zeng, Williamson 2007).

Brazil is a country, which presents one of largest and most developed automotive industries. Moreover, previous empirical research has shown mounting evidence of car manufacturer is relocating product development (R&D) activities to Brazil (Consoni 2004, Quadros, Consoni 2009).

The Innovation Capabilities in Brazilian Automotive Industry

The economic importance of the Brazilian market automotive industry is well known, even before its more recent leap in volume. However much less known is it the importance as an engineering and design basis.

Since the early 1950's, the Brazilian automotive industry has had a huge importance in the political economy of Brazilian industrialization. The implementation automotive industry was a successful industrialization plan.

The accelerated expansion of the automotive industry in 1970's was the economic growth project of the military. The 1980's and early 1990's comprised a period as stagnation in the automotive industry as import substitution industrialization model has been exhausted.

The liberalization of the economy in 1990's particularly the relative opening of markets allowing greater integration of the Brazilian automotive industry, into the global value chain has contributed to be modernizing and specializing, increased competitiveness and to resuming growth.

Since the middle 1990's, the Brazilian automotive industry has widened its role and strategic importance in the global value chain Brazilian subsidiaries both assemblers and suppliers have gradually become sources of global product, processes and organizational innovations on top of their consolidated role mas manufacturing platform.

The Brazilian Automotive Industry have invested in increasing local product development (R&D) capabilities to meet the fiercer competition brought about by new entrants and imports, and subsequently, to sustain exports. Indeed, Brazilian subsidiaries of multinational assemblers, particularly those with long experience in designing, manufacturing in the country have been enlarging R&D mandates in Brazil, and stepping-up product related technological activities.

The GM' R&D Proof Ground in Indaiatuba state of São Paulo, is the third in term of importance, and value of investment amongst GM's

proof grounds in the world. Recent R&D infrastructure investment by GM in Brazil comprised the implementation of a virtual reality, 3D project room, a facility that only the aircraft manufacturer Embraer had in Brazil until then.

The project of the architecture of Meriva, which was launched as global model, was entirely carried out by GM's R&D in Brazil. The Meriva project led GM Brazilian subsidiary to substantial upgrading in R&D capability staff has mastered all phases of R&D from concept to validation. GM's investment program in Brazil for the period 2008/2012 has comprised a major expansion of technological infrastructure in both sites (Consoni, Quadros 2006).

The VW Brazil, the fox model was the crossing point towards mastering all phases of the product development process (Quadros, Consoni 2009).

Recent R&D infrastructure investment by VW Brazil comprised a US$ 2,5 million in virtual reality, 3D Project Room in 2009, and the 10 new VW car models scheduled designed in the São Bernardo R&D unit as compared with 15 models developed along the subsidiary history.

The Fiat Brazil R&D engineering is a global center of competence in some technologies such as suspensions systems an electronic systems magnetic systems an electronic systems magnetic interference. However, the development of new models is carried out jointly with the Italian headquarters. The Fiat is a rare case of option in the research collaboration between Fiat Brazil and researches institutions in the country and abroad. From 2004-2008, Fiat has developed a multi-project, multi-institutional research program funded by CNPq.

Ford Brazil has the most distinctive evolution, as compared to the previous cases in the terms of the trajectory of its R&D unit. In the middle 1990's, following the closing Auto-Latin. Ford had decided to radically centralize compact automobile R&D in the British engineering center and implied the reduction of R&D engineering staff in Brazil to less than 100 engineers. However, this decision has proved to be disas-

trous in terms of Ford's competitive positioning in Brazil, and the situation was changed quickly.

The Brazilian Ford Product Development Center is one out of five networked, global development center of the company. The second generation of the Eco Sport was launched globally in 2012 was a result of 800 engineers task-force from various Ford R&D Center, which were coordinated by the Brazilian R&D Center.

Following the steps of the market leaders, Renault has increased substantially its R&D unit in São José dos Pinhais, PR and inaugurated in 2009 the South American Design Center in São Paulo city, has raised 600 engineer's jobs. For the period 2010-2015, Renault's investment programmed has set out creating an Engineering Center in Brazil in terms of implementing the R&D capability with a 1.000 engineering work force.

As compared to the before situation, only Japanese's players as Toyota and Honda, in domestic market still stick to the policy of keeping product development/adoption entirely centralized in the Japanese on North American R&D units.

Brazilian government plan history

Brazil agrees with other countries by considering the auto industry as one of the most important and strategic industries for the entire economy. Most of the other production chains have a connection to the automotive chains. Attracted by a market of high potential and access to Mercosur, several automakers decided to transfer their investments to Brazil, bringing their plants (Hyundai, Mercedes Benz, Audi, Fiat Iveco, Honda, Peugeot, Citroen, Renault, Toyota, Mitsubishi, Nissan). And more recently, the Chinese auto industry has arrived, looking for a piece of the South American market with brands: JAC, Cherry, etc.

Currently, the automobile industry represents an important variable in

the national account, accounting for 2% of national GDP, 21% of industrial GPD and 13% of general exports.

Latin America currently has a ratio of six inhabitants per vehicle, and Brazil is above that average with 6.5, while in developed countries these relations reach the rate of 1.2 in North America and 1.7 in Japan and 1.4 in Australia (ANFAVEA 2016).

The Brazilian auto industry had four periods, during the development of the automobile industry:

– *First:* Considered from 1920 to 1950, where the main flow was the assembly of the finished import parts, called kits. The government does not have as many influences on the auto industry and its chain. However, from the 1920s until the 1950s, we could consider that the seeds of industrialization were established because of the influence on all the competitive forces. Workers who used to come from the farm, with a complete lack of industrial skills, began to be trained; the engineering school began to teach more and more students, small metal workshops began to familiarize themselves with car components and forms of changing the automotive industry as a leading segment to boost the Brazilian economy.

– *Second:* Considered from 1950 to the 1980s, when the Brazilian automobile industry was forced to nationalize whole cars.

– *Third:* started in the 90s with a consolidated production in terms of human and natural resources developed over the last 40 years. Market globalization, resources and technology characterized the 1990s. Brazil once again promoted exchange parity and opened its borders to international trade, so quickly there was an invasion of imported products, due to its better quality and cost compared to a local product. At the same time, the Brazilian government banned the importation of Information Technology and Automation. The

Brazilian industry had to survive with its technology and obsolete processes so that, day after day, they lost competitively. The Brazilian government acted again with a new tax reduction to:

– Automakers already installed in the Brazilian territory, updating and perfecting their technology and processes to achieve a global competitive level;
– New (new car manufacturers or auto parts manufacturers) to install their factories in Brazil, with the promise of a reduction of the import tax for the technology.

– *Fourth:* to encourage automakers to invest in innovation and technology, the Brazilian government created INOVAR-AUTO.

In this program, all car manufacturers who doesn't have an interest in getting a 30% tax increase on their product price need to start from 2013 through 2017 to direct part of the profit by investing in technology and engineering to obtain efficiency targets. The federal government adopts this rule to boost the Local Automotive Industry to better and more efficient engineering solutions.

The guidelines for the automotive sector were:

I. Leveraging the auto parts supply chain:
– Evaluate and implement plans to reduce the cost of steel, plastic and energy;
– Increase investment in the production of electronic components;
– Evaluate small businesses and minimize inefficiencies along the production chain;
– Support and improve management skills in micro, small and medium-sized auto parts,
– Implement regional content control systems in automotive products (certificates and traceability);
– Increase quality certification requirements.

II. Expanding the external market to export vehicles and parts:
– Negotiate the expansion of bilateral trade;
– Increase export destinations.

III. Take advantage of innovation, value added, technology, safety and fuel efficiency in all vehicles produced in Brazil:
– Improve the regulatory framework for safety and energy efficiency;
– Support the activities of Research and Development (R & D) and engineering/TIB (Technology Industrial Basic);
– Encourage the production and sale of hybrid and electric vehicles;
– Attract Automotive R & D centers;
– Improve the development, production and use of local tool development.

IV. Increase in production capacity:
– Promote technological upgrading along the production chain;
– Grant financing and incentives to projects with high benefit to the country,
– Evaluate and create strategic plans to induce the renewal and recycling of the fleet of national vehicles.

V. Training and qualification of the workforce:
– Strengthen national engineering skills related to automotive engineering;
– Train and perfect technical workforce, with special attention to new professions.

The fourth largest global sales market and seventh overall producer, however, over the last few years, this seemingly prosperous scenario contrasted with the growing trade deficit. This imbalance has focused on vehicles with high technological added value.

The reversal of this scenario is very complex, in the short term, since the environment for the country's scientific development has also been stagnant.

Within this scenario of apparent prosperity and potential market, in addition to the inability to reverse the trade balance in the short term, the Brazilian government's "INOVAR AUTO" program was launched to foster industry competitiveness, encouraging automakers to produce more efficient, secure technologies and technological advanced vehicles investing in the national car industry and R&D.

The "INOVAR AUTO"

The Brazilian government, with the objective of stimulating and strengthening the competitiveness of the local automotive sector, has sanctioned the program of incentive to technological innovation and densification of the automotive supply chain called "INOVAR-AUTO", through Law no. 7819/2012, extending to importers of vehicles planning to build factories in Brazil (Australian Government – Department of Education 2014).

The local government is promoting the competitiveness of the automotive industry through this program that offers incentives through tax benefits for automakers in two ways:

First, the IPI (Industrialized Products Tax) is increased by 30% for all passenger and commercial vehicles, and then the Brazilian government imposed a series of requirements so that automakers could obtain up to 30% IPI discount. In summary IPI will not be changed for the manufacturers that meet the requirements. An additional incentive is also being offered to manufacturers that have invested in R & D (1%) and in engineering activities (1%), but these investments must be made in the Brazilian Country.

For a better understanding, IPI (Industrialized Products Tax) is a tax on industrialized products manufactured or imported into Brazil. In the

case of products manufactured in Brazil, taxes are imposed on the selling price of the product, while in the case of imported products; the taxable base is the selling price plus import taxes and other required fees (transport, insurance).

The IPI rates for passenger cars, as a function of the power engine and fuel type, illustrating Brazil's long-term incentive for smaller engines (Table 1).

TABLE 1 — Increase in IPI [14]

Engine Displacement (L)	IPI Before 2012	New IPI
Less than 1L	7%	37%
1-2L Flex/Ethanol	11%	41%
1-2L Gasoline	13%	43%
Above 2L	25%	55%

Source: INOVAR - Brazilian Ministry of Development Industry and Commerce (2012).

This program is limited to vehicles manufactured between 2013 and 2017, after which IPI rates return to pre-2013 levels.

As previously mentioned, the objective of the INOVAR-AUTO program is to offer competitiveness, technology and safety to vehicles produced and sold in the national territory.

Considering this high market potential, it allows fiscal incentives to place national vehicles on a global technological route.

The program encourages R & D investment by providing the total innovation used by Original Equipment Manufacturer – OEM, increases the volume of engineering spending, the basis of industrial technology, and the qualification and capacity of suppliers. With all of this, the program aims to develop, build and sell economical vehicles, increasing safety

and energy efficiency. The program brings benefits to OEMs that produce vehicles in Brazil, OEMs that only sell vehicles here and OEMs that present national investments such as BMW example. These benefits come from of IPI reduction.

The reduction of IPI will be made depending on the energy efficiency achieved by the OEM for the mix of vehicles sold in the country. By October 2016, OEMs were committed to achieving the minimum energy efficiency proposed by the program and necessarily invest in modern technologies such as efficient / clean engines and lighter parts.

The current average fuel consumption is about 14 km/l in the use of gasoline and 9.71 km/l in ethanol. The target is respectively 17.26km/l and 11.96km/l. In addition, the mandatory target for the program, the–OEM can get an additional reduction of 1% or 2% tax. Considering this scenario, the end consumer will potentially save about $ 552,88 a year on fuel costs.

TABLE 2 — INOVAR AUTO Requirements

Year	Minimum Number of National Manufacturing Processes	Minimum R&D Investment	Minimum Englineering Investiment	Minimum Participation in PBEV
2013	6	0.15%	0.50%	36%
2014	7	0.30%	0.75%	49%
2015	7	0.50%	1.00%	64%
2016	8	0.50%	1.00%	81%
2017	8	0.50%	1.00%	100%

Source: INOVAR - Brazilian Ministry of Development Industry and Commerce (2012).

A – Automakers must implement at least 6 up to 8 Manufacturing Processes locally (in accordance to Table 2):
– Stamping; – Welding – Anticorrosion treatment and painting; – Plastic injection; – Motor manufacturing; – Gearbox and transmission manufacturing; – Steering and suspension system assembly; – Electrical system assembly; – Axle and brake system assembly; – Monobloc manufacturing or chassis assembly; – Assembly, final review and testing; – Laboratory infrastructure for Product development and testing.
B – R&D - research & development in Brazil
Automakers must invest in R&D activities in Brazil corresponding to the minimum percentages indicated in Table 2, and applied over the gross revenue of products and services, excluding taxes and contributions over sales.
C – Engineering in Brazil (in accordance to Table 2):
Automakers must invest in Engineering activities, industrial technology and supplier's capacitation in Brazil corresponding to the minimum percentages indicated in Table 2, and applied over the gross revenue of products and services, excluding taxes and contributions over sales.
D – Labeling (in accordance to Table 2):
Automakers must comply with Brazilian Vehicle Labeling Scheme (PBEV – Programa Brasileiro de Etiquetagem Veicular), with the minimum percentages of vehicle sales.

Beyond energy efficiency, INOVAR AUTO program requires that over the next few years' automakers need to conduct:

i) Minimum number of manufacturing;
ii) Engineering activities & infrastructure;
iii) Investment in R&D;
iv) Labeling (PBEV – Programa Brasileiro de Etiquetagem Veicular)

There is a consensus, all over the world, that research and development activities are an important input to foster innovation and the objectives of any nation's government agencies. R&D is part of a class of intangible inputs that also include software, higher technology development and implementation, higher education, and worker training.

Intangibles are at least as important sources of long-term economic growth as are physical investments in machinery, equipment, and other infrastructure (Corrado et al. 2006, Jorgenson 2007, Van Ark, Hulten 2007).

It's clear that Brazilian government trying to level up the country competitiveness implement the INOVAR AUTO program, where every automaker to qualify for the program and get the entire benefits, they must choose 2 out of 3 activities (B, C, D).

However, within this scenario of exchange of tax benefits by encouraging the development and strengthening of research and development of entire automotive sector and densification all supply chain, some pitfalls can be found.

The potential pitfalls are on understanding and translation of the concepts of what the R&D activities are, and what the usual engineering activities are during a vehicle development performed by the automakers located in the country.

Last Thoughts

The Brazilian automobile supply chain given the fact that it is currently more internationalized than it used to be 20 years ago. Yet, this research has shown that the processes of innovation capability accumulation of both Brazilian subsidiaries suppliers and Brazilian no homed supplier have been a decisive factor in explaining the increasing importance they have been assuming in the global supply chain.

The important change in the economic and regulatory environment, in the past 20 years, has had a role in promoting a change whose effect on the business environment is so overwhelming that is often underestimated. This is an increasing adoption of liberal trade and investment policies, which that have normalized the economic environment across countries and regions, contributing to enlarge market and scales of operations and pushing the most successful local/regional players towards globalizing their operations.

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INDUSTRIAL ECOLOGY AND SUPPLY CHAIN

Maria Lúcia Pereira da Silva, Waltson Limad

Abstract: This chapter deals with the main concepts involved in environmental and process management and also points out the main correlations between them. Therefore, this item will describe for these two areas the main concepts, tools and indicators required for improve integrated management.

1. Introduction

Sustainable development, Sustainability and Industrial Ecology (IE) are fundamental concepts in manufacturing sectors nowadays. In the last two decades of XX century, definitions of sustainable development and sustainability were reviewed several times and many researches concluded that the concepts were usually misunderstood or not properly defined. Lélé's (1991) review pointed out lack of consistency and weaknesses in the sustainable development concept and also indicated that these weaknesses could lead to inadequacies and contradictions in policy making. The author also correlates sustainability with renewable resources and "the existence of the necessary ecological conditions to support human life at a specified level of well-being through future generations".

At the end of XX century, Mebratu (1998) already pointed out that "the vagueness of the concept of sustainable development, coupled with its increasing importance, has led to a large political battle … linking interpretation to the concept, which has resulted in a wide variety of definitions and interpretations". Mebratu also remarks that, although in the 80s the environmental debate assumed that environmental concern is linked to industrial pollution, mankind has produced significant environmental impact since 8,000 years ago, when some tribes did not migrate but domesticated animals in order to solve their needs due to population increase. After that, several "waves" occurred, due to agricultural and industrial development, 5,000 and 200 years ago, respectively. Nonetheless, as a counterpoint view to the inevitability of environment modification, economic and political issues appear – as the theory of limits, by Malthus and others, or scale of organization, for example by Kropotkin. These theories are considered by Mebratu as precursors of the sustainable development concept and similar to the definition stated by The Brundtland Commission, in the report "Our Common Future", as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The

concept was considered vague for many stakeholders and, according to Mebratu, three different versions arose: Institutional, Ideological and Academic. The institutional version corresponds to the World Business Council for Sustainable Development (WBCSD) and to the International Institute for Environment and Development (IIED) viewpoints. For these institutions, three systems are "basic to any process of development: the biological or ecological resource system, the economic system, and the social system"; the main difference on the viewpoints is only the chosen leadership, communities and industry, respectively. The ideological version is mainly centered on social issues; therefore, leadership is mainly attached to NGOs (non-governmental organizations). The academic version reviews the concept of environment itself and creates new hypotheses, such as Gaia´s. In that context, sustainability is the permanence of an equilibrium condition, i.e., the time parameter is clearly considered. However, Goodland (1995) states that "sustainable development (SD) should integrate social, environmental, and economic sustainability and use these three to start to make development sustainable", which means that sustainable development is a consequence of sustainability; nonetheless, the leaderships are the same considered by Mebratu. Correlation between sustainability and continuation is common. Johnson (2004) points out that eleven related terms, which include sustainability, address maintenance or continuation of an innovation. Although sustainability has been defined in a variety of ways, Johnson considers that "the continued ability of an innovation (infrastructure or program) to meet the needs of its stakeholders is central to the sustainability process … depict the continuation process that encompasses a diversity of forms that the process may take". Vanegas (2003) quotes that sustainability goes beyond sustainable development definition because, as defined by Liverman, sustainability is "the indefinite survival of the human species (with a quality of life beyond mere biological survival) through the maintenance of basic life support systems (air, water, land, biota) and the existence of infrastructure and insti-

tutions, which distribute and protect the components of these systems". The author also mentions, within the international community, several stakeholders that defined sustainable development and sustainability, such as WBCSD, the World Federation of Engineering Organizations (WFEO), the World Bank, the United Nations (UN), Lead International and NGOs. Furthermore, Laloë (2007) commented on sustainability definitions and perceptions. The author observed

> a great diversity of perceptions and definitions of sustainable development but these differences are more likely due to the way relationships between the three fundamental natural, economic and social capitals are considered ... *Therefore, different models and consequent data analysis will appear from the same definition and the author exemplifies that analyzing fishery.* Then, although simple data can be easily obtained, the consequences of harvesting in different species are difficult to model, even with statistical analysis ... *Furthermore*, everything depends on the context, and the practices of exploitation are a deciding factor for choosing a modeling approach (Laloë, 2007).

Rassafi (2006) suggested the use of stability and chaos theories for defining sustainable development. The authors´ assumption is that there are common grounds on sustainable development definition: the economic, environmental and social variables, the dynamism – that embody the temporal trends, and quantification - a process of converting inputs into outputs of any system. Therefore, dynamic stability is related to the concept of sustainability and, similarly, socio-economic systems are related to the chaos theory due to the nonlinear behavior. Thus, a sustainable system is, according Rassafi´s definition, stable and non-chaotic. With a similar perspective, Calvo (2008) defined a sustainable manufacturing system as the one that "interchanges its goods, energy and disposals with the market and its environment at low internal entropy". The worthiness, utility of manufacturing output for society, is the energy the system interchanges.

Thus, at the dawn of the new century definitions of sustainable development and sustainability still raised controversies but some ideas seemed to be common to most researches: sustainable development was well defined by the Brundtland Commission, sustainability implies time as a main parameter along with the relevance of stakeholders' opinion. On the other hand, if the terms seemed to be settled down, the consequences are that other controversies will rise. For instance, how to address sustainability measurements, i.e., how to clearly state that this or that entrepreneurship is sustainable ? Poudel (2002) approaches considered the sustainability concept as "an effectiveness of the management approach being implemented to achieve defined goals … However, questions of effectiveness require specification of the criteria suitable for the defined goals, objectives and stakeholders involved. Several methods have been developed and tested to assess changes by different authors. Development of Criteria and Indicators has resulted in significant tools for assessing trends". Therefore, according to Poudel´s view, sustainable development is a concept whereas sustainability is actually its praxis. Moreover, indicators and stakeholders play an important role on sustainability efforts.

For many decades now, authors have accepted that sustainability indicators should consider the triple bottom line (YOUNG, 1997) (YOUNG, 2001): environmental, social and economic issues (Global Reporting Initiative 2002). On such view, sustainability means the system perpetuates itself for a long period and, in order to do so, governability corresponds to a fourth perspective. The triple bottom line is a system of performance measurement that helps management decisions and must be integrated to companies policy to favor sustainability (HOPWOOD, 2005).

Stakeholders, as defined by United Nations (UNEP 1992), (UNEP 1989), comprise a lot of different agendas but also consider the triple bottom line aspects. More than indicators, the last decades originate new concepts and terms. Young (2002) proposes the term non-product to specify any product that cannot be considered part of the production. The existence of non-products negatively affects the environmental performance

and industries should be penalized properly. This approach includes all products normally described as waste in such penalty and Rossi (2000) considered it an indicator on GRI (Global Reporting Initiative) report. In Brazil, the correspondent term (*co-produto*) (SOUZA, 2001) is used to all products involuntarily produced but that can be reused internally or externally to the company. A similar definition (using co-product spelling) was made by Zhu and Cote (2004).

Andersen (2007) considers that sustainable development is closely related with circular economy and Industrial Ecology as well. Although both terms, circular economy and Industrial Ecology, perceive sustainability punctiliously linked to the idea of closed industrial cycle, circular economy is more inclined to economic aspects. Thus, in order to secure to the next generations the same welfare of this generation, in an economic viewpoint, consumption must be maintained, which implies keeping constant stocks of environmental resources. Thus, environmental resources were evaluated as capital that should remain constant. Although it is virtually impossible to maintain constant stocks in the industrial production cycles, the concept of circular economy aroused and helped to minimize human impact. Circular economy has "conceptual roots in industrial ecology, which envisions a form of material symbiosis between different companies and production processes. IE emphasizes the benefits of recycling residual waste materials and by-products through … the development of complex interlinkages ...and industrial symbiosis projects". Therefore, circular economy may be beneficial to the environment, society and economy, which leads von Hauff (2008) to published an article with a suggestive title: "Industrial ecology: engineered representation of sustainability". Von Hauff considers that White (1994) produced the best definition of IE when he stated that "Industrial ecology is the study of the flow of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influence of economic, political, regulatory and social factors on the flow, use and transformation of resources." Since

the triple bottom line is clearly incorporated in this definition and flow, transformation and processes are identified as drivers of sustainable development, von Hauff suggests that "industrial ecology is to be understood as a generic representation of sustainability". The premise that IE and sustainability are clearly correlated leads von Hauff to propose some steps to apply the concept of Industrial Ecology in one company: a) using the "Triple Bottom Line" concept but taking care of totally integrating its three perspectives; b) creating an evaluation system, called Integrated Sustainability Triangle, based on such integration. This triangle is quite similar to another important tool, the balanced scorecard (BSC).

Other researchers also reviewed the Industrial Ecology concept. Seuring (2004) listed four different definitions and concluded that all concepts are interrelated, although relevant differences occur, and, also remarkable, "Ashford and Côté characterize IE as 'a new unifying principle for operationalizing sustainable development' and Allenby labels IE as the 'science of sustainability'". Basu (2006) points out that there is no single definition universally accepted to IE. However, two of them, from Graedel and Tibbs, are widely accepted. Graedel quotes IE as "the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. The concept requires an industrial system to be viewed not in isolation from its surrounding systems, but in concert with them." Tibbs states that "the aim of industrial ecology is to interpret and to adapt an understanding of the natural system and to apply it to the design of the manmade system, in order to achieve a pattern of industrialization that is not only more efficient, but that is intrinsically adjusted to the tolerances and characteristics of the natural system". This approach leads to the creation of an industrial ecosystem, Dematerialization, Improvement of metabolic pathways of industrial processes and materials use. Basu viewpoint considers IE as a framework to achieve sustainable development that requires social, environmental and economic indicators.

Thus, a new concept that helps the sustainability goal is Industrial Ecology. Therefore, the main idea in Industrial Ecology approach (ERKMAN, 1997) (COTÉ e SMOLENAARS, 1997) (MANAHAN, 1999) (GRAEDEL, 2003), resources used and reused continuously, leads to less waste and claims materials flow analysis, symbiosis, industrial metabolism (AYRES, 1994) and ecosystems considerations (SHEN, 1995). Moreover, Life cycle analysis (LCA) became an important requirement if sustainability is the goal (HUNKELER, 2005). LCA requires a life cycle inventory (LCI) and, although specific software was developed, some authors propose the use of Enterprise Resource Planning (ERP) platform software to specify LCI indices (HENDRICSON, 2001). ERP software is commonly used for process control and is quite common in the industrial sector (AZEVEDO, 2006).

This chapter will deal with all this concepts in a way that favors industrial sector road map towards sustainability.

2. Main concepts

In a recent review, Curkovic and Sroufe (2016) stated that Environmentally Responsible Manufacturing (ERM) is the most comprehensive amongst all possible entries to describe the enterprise that is committed to Sustainable Development. Moreover, the authors pointed out that Industrial Ecology is one of the "many different labels used to describe a company's effort to integrate environmental thinking into its decision-making processes", also according to the authors, these different terms "differ mostly by their labels and not in core elements" whereas ERM describes "the integration of environmental issues into decision-making processes." Therefore, on the authors view ERM should be described as:

> "a system grounded in quality management which integrates product and process design issues with manufacturing pro-

> duction planning and control, process management, and data analytics, to identify, quantify, assess, and manage the flow of all forms of waste with the goal of reducing and ultimately minimizing negative manufacturing effects on the environment while also maximizing resource efficiency, human resource development, and proactive management opportunities". (CURKOVIC AND SROUFE, 2016)

Achieve profitable growth is a challenge in many ways; SCM it is a bet on getting if treated as a strategic variable. To do so, it is a priori necessary to think of the SCM as a whole, from the management of the flow of materials, services, commercialization issues and logistics in general to client-supplier relations, as well as pursuing tangible results, such as: reducing inventories and/or improving their use, increasing profits and reducing Operational costs. But these important points are not enough to describe the adequate scope in which the SCM needs today, especially to respond to the Market within a new culture towards sustainability. Therefore Seuring (2013) by its review of modeling approaches for sustainable supply chain answers this need. He defines SSCM as a flow materials administration, knowledge and information management and capital flows control as well as integration between companies in their operations based on triple bottom line aligned with the views of stakeholders and shareholders. That is why environmental and social criteria must be met by managers in order to manage the supply chain in a sustainable way, even if this challenges competitiveness and does not compromise the satisfaction of customer needs and respective economic criteria.

It is worth noting that sustainability issues have been increased their importance among businesses. Inspired by Dahlsrud methodology (2008), will be presented the relations among EMS, ERM and SCM according to his focal points on Table 1 whereas the Metrics description is described on Table 2

TABLE 1 — Correlations among EMS, ERM and SCM

Item	Categories	EMS	ERM	SCM
1	Economic focus	◊	⇧	⇧
2	Environmental focus	⇧	⇧	⇧
3	Social focus	⇧	⇧	⇧
4	Stakeholder focus	◊	⇧	⇧
5	Volunteer focus	◊	⇧	◊
6	Resilience focus	⇧	◊	◊
7	Long term focus	◊	⇧	⇧
8	Flow focus	⇧	⇧	⇧
9	Value focus	⇧	⇧	◊
10	Efficiency focus	⇧	⇧	⇧
11	Performance focus	⇧	⇧	⇧

Degree of relationship: strong ⇧; weak ◊; '—' no existence

TABLE 2 — Metrics description according to (PAYMAN et al., 2013)

1. *Economic focus:* corresponds to the economic dimension of sustainability.
2. *Environmental focus:* corresponds to related to the environmental dimension of sustainability.
3. *Social focus:* corresponds to the social dimension of sustainability.
4. *Stakeholder focus:* considers explicit reference to stakeholders, including (but not limited to) customers, consumers, and suppliers.
5. *Volunteer focus:* considers reference to the voluntary nature of business sustainability.
6. *Resilience focus:* considers reference to resilience, defined as an ability to recover from or adjust easily to misfortune or change.

Long-term focus: considers reference to the long-term nature of sustainability. Reference to end-of-life management, reuse, product recovery, reverse logistics, the closed-loop supply chain, and the product life cycle were taken as indications of a long-term focus.

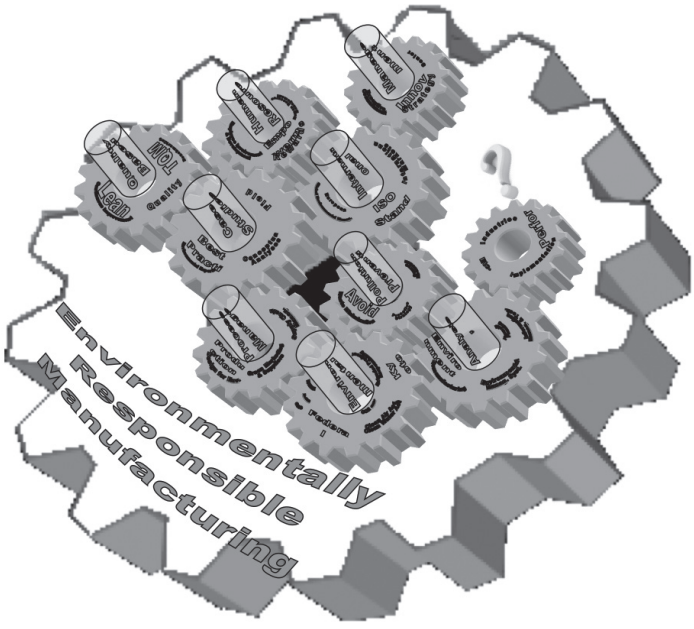
7. *Flow focus:* corresponds to the flows of materials, services, or information. Reference to the supply chain was considered to implicitly refer to this focus area.
8. *Stakeholder focus:* considers reference to stakeholders, including (but not limited to) customers, consumers, and suppliers.
9. *Value focus:* corresponds to value creation, including increasing profit or market share and converting resources into usable products.
10. *Efficiency focus:* corresponds to efficiency, including a reduction in inputs.
11. *Performance focus:* corresponds to performance, including applying performance measures, improving performance, improving competitive capacity, monitoring, and achieving goals.

Therefore, ERM and SCM presents important adherences as addressed on this chapter. Regarding ERM´s CURKOVIC AND SROUFE (2016), the authors see this definition as a foundation that leads to major dimensions, called meta-categories, of a taxonomic system that includes "sustainability and supply chain management." These categories were evaluated not only to provide their main keywords but also to delimit new required Research and Development actions and Figure 1 summarizes such authors´ view. The analysis of this figure shows interesting correlations. Regarding the first meta-category (Environmental Regulations), there is a clear global trend for more environmental regulations, which triggers a better performance and can lead to innovation. Information analysis (second meta-category) has a drawback to face: environmental data is usually apart from the corporate data. That is an interesting conclusion since Industrial Ecology – as it will be addressed further – envisions the formation of

Industrial Ecosystem, in which information is vital and environmental data is qualified in a broader way, e.g., sometimes consumption of raw material may be even more important than emission information, etc. Such scenario led some researcher and/or companies to use, or even tune, ERP (Enterprise Resource Planning) as/for data mining (ARBUCIAS, 2008) (QUEIROZ, 20006). Another visceral question is the environmental accounting, which also implies supply chains issues along with stakeholders´ demands. These driving forces would be managed in the strategic level using "Environmental Management Systems (EMS) as a resource to enable the measurement and management of ERM activities inside and outside the organization" (CURKOVIC AND SROUFE, 2016).

Process management is a huge meta-category since it comprises not only production itself but also all supporting functional areas. Thus, ERM links all areas on an enterprise and Curkovic and Sroufe (2016) suggests focus on "1) product design and production processes; 2) support business processes; and 3) supplier's environmental performance as internal operations are linked to supply chains". Aside the obvious connection with supply chain concept, the authors emphasize the needs on favoring design in relation to manufacturing during project phase and the importance of Life Cycle Assessment (LCA), which up to now presents lack of accurate data and tested methodology for such tool. Industrial Ecology struggles with the same issues, since Design for X comprises an extensive series of specialized behaviors hard to comply; IE also considers on LCA its major tool. But, most important, the authors pointed out the importance of the environmental performance on the supply chain. That is an interesting perspective since IE major focus is also on Industrial Ecosystems.

FIGURE 1 — the foundation (ERM), its 9 meta-categories and respective keywords aside with main required research & development issu



Pollution prevention (another meta-category) presents so many ramifications that it is impossible to be comprehensive about the topic. On the other hand, considering the great emphasis in closed cycle and Industrial Ecosystem formation presented on IE concepts, sometimes prevention would be considered less effective than co-product utilization. In fact, waste and co-product definitions are quite tricky. For instance, Katcher (1994) explained the differences of these definitions in Pennsylvania´s law regarding solid waste management. Therefore, whereas product is defined as the primary goal on manufacturing any other material that does not attend the specifications but has useful char-

acteristics is named co-product, which means that virtually any material discarded during production could be analyzed if it can be defined as co-product in order to add value to that processing. If the material cannot be used as co-product but it can be recycled in the manufacturing process or released to the environment without any harm, it is categorized as non-waste. The advantage of such approach is the possibility of analyzing any material and determines if it can be classified as less hazardous, which favors reuse and/or simpler disposal. A decade later, this concept could be considered settled down.

Anecdotal cases, according to Curkovic and Sroufe (2016), are important to show, among other facts, that green consumer movement is a primordial driving force to changes on the enterprises´ ERM. However, SCM does not deal with environmental questions, such as waste formation. Thus, although case studies are essential to allow benchmarking among enterprises, it also exposes a gap between the society behavior and the enterprises´ priority. This gap could be fulfilled by IE concepts, such as the pursuit for closed cycle's production. These cycles could benefit from the tools developed by SCM. In fact, as the authors stated, "there are now a myriad of books on clean, green, responsible, and sustainable supply chain management practices". Another injunction point could be the circular economy.

Stem from 'green' component applying on supply-chain management impacts at relationships between supply-chain management and the natural environment.

According to Srivastava (2007), Green SCM is defined by "integrating environmental thinking into supply-chain management, including product and process design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life".

Generally, Circular Economy covers the actions of reducing, reusing and recycling (3Rs) in processes which comprise actual production, distribution and consumption. Ying (2012) points out that circular econo-

my is nothing more than an ecological economy that requires that society to develop works based on the principle of 3Rs.

Reduce means reducing the amount of substance in the process of production and consumption; For that, is important highlight that reduce means reducing the amount of substance in the process of production and consumption; reuse is involved in extending the time intensity of product and service; recycle focuses on the regeneration of renewable resources after use. The main change of this mindset is circular economy brings new vision about the traditional one-way linear economic model of "resource – product – waste" into feedback circular economy mode of "resource – product – waste – renewable resource".

Therefore, To manage SCM considering an integrated management proposed by GrSCM and having as motto the 'do more with less', reduce waste through a new reading of how to do production, it is necessary to introduce a control system from the product conception until its distribution, i.e. to bring to light the concepts of industrial ecology backed by the classic tools of quality control in collecting data, prioritizing according to established criteria, analyzing the context and proposing improvements in the origin. With this, the circular economy presents itself as an alternative methodology to manage the flow of processes and materials and its distribution to execute the project respecting its specifications and meet the last level of the chain – the consumption, but in a sustainable way, closing the Green system.

Therefore, the taxonomy, proposed by (CURKOVIC AND SROUFE, 2016) and synthesized in the conceptual map in Figure 1, shows a series of common terms/meaning used in ERM, supply chain and Industrial Ecology. In fact, a recent book addressed (GALLAUD and LAPERCHE, 2016) these three themes. The book emphasizes the difficulties and barriers to implement them. Although some case studies were produced, they were focused in one single activity (food production on a previous chosen area).

3. Case studies

Going on "hands on" state can be frightened; therefore, some small examples previously developed by ourselves are listed bellow. Thus, at the beginning we deal with the world class electronic sector, from the global analysis to punctual solutions, using different indicators and tools. After that, we show the similarities with really small enterprises, such as a restaurant run by a family business.

The Electronic sector

Apparently, a huge transnational corporation is not the better way for applying such concepts. Nonetheless, Arbucias (2008) faced this tremendous task and for that matter began just considering that internal Industrial Ecosystems could be the best solution. Thus, the defined methodology joined the premises of Industrial Ecology and the Integrated Management Systems. In order to do so, the establishment of industrial ecosystems, evaluation of sustainability levels and communication with stakeholders using customized software was provided. It is interesting that the Printed Circuit Industry, one small area on the whole business company showed not formalized industrial ecosystems for water and solid waste. Industrial symbiosis cooperating to mitigate process or material loss was also found in another process. Furthermore, external ecosystems for metals and oils were developed. AS stated by the author:

> It was possible to conclude that the Industrial Ecology concept tools used in the company did benefit its industrial sustainability because it allowed more efficient processes through the use of metrics, involved most of the employees and operations, favored better process standardization, enhance the systemic approach making the decision process easier once it is based on real time facts and it finally contributed to the adoption of methods, systems

> and procedures that enabled deep strategic change and as a consequence improved cultural change, which is one of the essential aspects of the sound sustainable development. (ARBUCIAS, 2008)

ERP softwares are the main core of enterprise indicators control; however, a decade ago no one saw the tool as a useful way to define material flow analysis. This is quite important on the electronic sector due to highly spread use of electronic devices aside with this high aggregated value even on the discharged instruments. Therefore, Queiroz (2006) defined a simple method to customize ERP software in order to implement Industrial Ecology concepts and to optimize co-product utilizations along the production chain. It is worth noting that the solution make possible not only cost reduction but also environmental and social improvement as well. ERP facilitates the co-product exchanges inside the plants but also indicates, due to the high control of suppliers and consumers, possibilities among different plants. Moreover, the software customization turns feasible exchange among distant partnership, i.e., favor logistic solutions. But, more important, micro and small industries, using simpler software, such as database, can also implementation Industrial Ecology concepts with very low cost.

An important case study (LIMAD, 2010) was the application of the concepts of sustainability, and especially Industrial Ecology, in the form of managing SC in an electro-electronic industry. From the question – what to do with obsolete stocks and manage the flow of materials in such a way that inventories do not grow beyond strategic expectations, forced the Company to treat logistics by first measuring available resources and only after such analysis, think in the project in a win-win relationship with the Market. This meant revising the products in order to reuse the obsolete items and proposing a simplification of products that culminated in an increase in the standardization of parts and components, without detracting from the customer's requirements for service. The destination of obsolete items not only transformed the way in which projects were done, but it

was also necessary to review the entire production process in order to identify wastes and bottlenecks that only increased operational costs, but also led to delays in delivery. But how to integrate design methodologies, manage the flow of materials, serve the customer and reduce production costs in a sustainable way?

This management was only possible with the learning and incorporation of the concepts of sustainability and sustainable development in the praxis of manufacturing, ie - the engagement of the 3 main organizational levels (strategic, tactic and operations) within the same common goal – to improve productivity on a permanent basis.

The small enterprise

It is worth noting that the concepts of Industrial Ecology can be adequately applied for example in the service sector, such as the description of the following case study, where workflows were evaluated under the approach of reducing food losses in a restaurant located in the metropolitan region from Sao Paulo. The first question was – how to allocate the generated coproducts (food wastes, food scraps) in a good way? After preliminary quantitative surveys, it was noticed that besides the wasted volumes, a series of impacts generated in the process, not being the only source of problem, such as: loss of time, poor sizing of quantities, disordered logistics and excessive variety among others.

In this line of review of the processes, it was necessary to start from the norms that govern the criteria of hygiene and conservation of food, and with that a series of technical information were shared as a result. Next step was to treat the operations of the restaurant as productive processes inserted in a system of transformation activities. In this case, the methods have been created or revisited as a form of management, according to the adopted service strategy, in this case a la carte or self-service.Finally, the production processes were adjusted to meet the 3Rs principle, and even if co-products were formed (waste in general), a destination system was

adopted within the Company's business plan. It is important to note that a new production diagram has been generated and deployed in the company, which made possible the analysis of each stage of the process. The concept of sustainability was strongly studied and applied mainly during the 'operation' phase of the restaurant's activities, seeking to minimize the waste and the work of Industrial Ecology at the end (GOMES, 2012).

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A TRUST AND CONFLICT IN COOPERATION AND PARTNERSHIP

MARTA DAROŃ

Abstract: In the article there is attempted to distinguish the relationships taking place in supply chains in relation to two basic variables: a trust and conflicts. On the basis of the literature, there were indicated characteristics for relations based on cooperation and partnership. These two types of relations have been defined and indicated. The problem of trust and conflicts between partners of both types of relationships was examined on the basis of conducted surveys on a representative group of enterprises in the clothing sector. Using the available statistical tools, it was shown that in partnerships the degree of trust between partners is significantly greater than in the case of cooperation. In addition, the frequency of conflicts among companies cooperating in distribution channels was analyzed and there were given their reasons. Additionally, a matrix of trust and conflicts was presented in relation to the entire surveyed population and in distinction on the type of relations between the partners.

Key words: conflict, cooperation, partnership, relations, trust

Introduction

Today's market requirements determine the cooperation of economic entities. What's more, the cooperation of the organization with the environment, which it is a part of, allows achieving the efficiency of business (Krzakiewicz, Cyfert 2015, p. 243). A cooperation as a kind of (positive) relationship may take various forms, depending on the type of entities, industry, development strategy of a given unit, purpose of cooperation and others. Such relationships may have a greater or lesser impact (for the purposes of this study, the terms "cooperation" and "partnership" have been respectively adopted).

The subject matter of cooperation and partnership is widely described in scientific studies, particularly in the field of supply chains. There are many scientific papers that deal with the classification of this type of relationship. Selected ones were presented in the next item of the article. Also, the issues related to the achieved effects of cooperation (both positive and negative) in the supply chains are widely described in the literature, including problems of conflict between partners. These two types of positive relationships were the subject of the presented considerations. A particular attention was paid to the issues of trust between partners and the occurrence of conflicts as elements of integration relations (Ciesielski 2011, p. 34). At the same time, there is a certain research gap regarding the confrontation of these two phenomena in both types of relationships. Therefore, the aim of the study was to compare the relations of co-operation and partnership in the context of trust in partners and the occurrence of conflicts between them. These issues were analyzed on the basis of available literature and on the basis of empirical studies carried out on a sample of over 100 enterprises in the clothing sector, having their headquarters in Poland.

A relationship and partnership in supply chain in clothing sector

Supply chains are of interest to many researchers. Over a dozen or so years, a whole spectrum of definitions describing this model of cooperation was created (Rutkowski 2004, Christopher 2000, Kot, Krzywda, Starostka-Patyk 2009, Nowicka-Skowron 2009, Ślusarczyk, Kot 2012, Brzozowska, Nowakowska 2013, Tarasewicz 2014, Mesjasz-Lech 2016, Kot 2017 i in.). For the purpose of this work one of the simpler definitions is adopted, in which the supply chain is nothing but a network of organizations cooperating with each other in order to deliver desired products to the market. (Tarasewicz 2014, p. 13).

In such complex creations as supply chains, there are many types of connections between players. It is not possible to describe everyone in such a limited study, therefore the main attention has been focused on cooperation and partnership that may appear in the lower parts of supply chains - distribution networks. The considerations were referred to the clothing industry enterprises, as the units described in the further part of the study were carried out on these units.

In the case of enterprises of the clothing industry, it is possible to have four types of relationships depending on the form of ownership of the distribution channels used and the type of products offered (complementary or substitutional), namely:

1. A competition - lack of cooperation opportunities or very limited opportunities - this is the case when companies offer substitute products and run their own supply networks,
2. A cooperation on the basis of competition (Jelonek 2012, p. 39), having the nature of both cooperation and competition - in a situation where enterprises produce substitute products, but sell them

in shared sales networks (it is also possible for the cluster[1] to appear as a form of joint action),

3. Sales of products in existing networks - occurs when companies offer complementary products in common distribution channels, e.g. shopping malls, hypermarkets, wholesale bazaars, but here the cooperation is limited, and even may not occur at all,
4. A cooperation, which may be the basis of partner relations - will occur in a situation when enterprises of the clothing industry offer complementary products and jointly create supply channels.

On the other hand, cooperation between clothing manufacturers and its recipients, agents and sales facilitators[2] can transform into partner relations in almost every situation with the right conditions. At the same time, such cooperation will rather develop between participants at the neighboring levels of distribution channels, due to their direct nature of contacts.

It is important to distinguish between cooperation and partnership here. One of the simpler and more commonly cited definitions of cooperation is given by Coyle, Bardi and Langley (Coyle, Bardi, Langley 2006, p.195). According to them, cooperation consists in undertaking by participants of the supply network a joint effort, so that it is possible to achieve the intended and common goal for those participants. There are no features that would indicate a particular commitment of contractors, and the goal of this cooperation is usually to achieve a higher profit.

1 *Regulation of the Minister of Economy of December 11, 2006 on granting financial aid not related to operational programs by the Polish Agency for Enterprise Development defines the cluster as follows: "A cluster means a spatial and sectoral concentration of entities acting for economic development or innovation and at least ten entrepreneurs doing business on one or more neighboring voivodships, competing and cooperating in the same or related industries and connected by a developed network of formal and informal relations, with at least half of the entities operating within the cluster being entrepreneurs. "*

2 *In the clothing industry, sales facilitators will be mainly logistics centers specializing in the preparation of clothing for sale, transport in special systems - on hangers, labeling, attaching anti-theft devices and others.*

However, partnership is a special type of cooperation, stronger and usually associated with the management of this relationship. In the literature on the subject, there are various definitions of partnerships defining them as (Szymonik 2011, p. 58):

– bringing changes of several physical quantities to synchronism, simultaneity, compliance in time,
– coordination of at least two phenomena (processes), i.e. striving for a parallel, independent course of events, coordinated in time or to conclude them at the same time,
– bringing two or more phenomena, processes and activities to compliance over time.

In turn, J. Witkowski considers partnership as the basic condition for the creation and development of the supply chain (Witkowski 2003, p. 34).

Mutual trust of partners is not visible in the balance of profits and losses of buyers and suppliers. However, the researchers suggest that the level of trust between companies can have a significant impact on how they work and what their achievements are (Trebilcock 2017). Regarding conflict issues, it is noteworthy that the purpose of the partnership is to eliminate or neutralize them as they result in time losses and excessive costs (Kauf, Tłuczak 2015, p.151).

However, it is also necessary to identify the basic barriers that may hinder or prevent the building of partnerships in the distribution channels of clothing enterprises. According to A. Harrison, they are (Harrison, van Hoek 2010, p. 372):

– the unequal bargaining power of the partners and the greater ability of one of them to put pressure on the other. The source of conflict in this case may be, for example, store space: a clothing store, like any retail outlet, strives to maximize the use of com-

mercial space, while the supplier of a given clothing brand is interested in the best possible exposure of its goods;
– focusing attention on the negative aspects of partner systems - for a retail clothing store the reduction in the number of suppliers is one of the main threats and may cause them to resist in the process of building relationships;
– opportunism and the desire to obtain benefits at the expense of the partner - resignation from many institutional recipients for the benefit of several partners, may increase their weight in the commercial chain, which is connected with increasing their bargaining power to dictate the conditions. From the point of view of the clothing manufacturer this is very unfavorable, while retail outlets may, contrary to established rules, aim at changing the existing conditions in order to achieve additional benefits;
– taking care of the individual interests of partner enterprises - even when the supplier and institutional recipient are connected by a special supply contract and when their own individual interests are higher than the need to cooperate for the benefit of both parties;
– price perception as the main factor determining the selection of a partner - the price of clothing products varies considerably, there are many producers on the market offering very similar products, but elements such as the quality of material, accuracy of the product's finish or choice of colors and accessories are of particular importance.

In summary, partnership differs from other business relationships (eg. cooperation) with two essential elements: reciprocity of partners and identifying such a system by partners as one organization while maintaining full independence of entities operating in this relationship.

Methodology

The presented results are part of a wider questionnaire survey carried out among clothing industry enterprises based in the Śląskie Voivodeship (Poland). Out of over 3,000 entities registered in the PKD database were drawn for the study 180 units. The companies were randomly selected for the sample based on previously generated pseudo-random numbers in Excel. 103 questionnaires were collected and the representativeness of the test sample was checked using a median test. The following statistical hypotheses were adopted:

H_0 – the sample of enterprises of the clothing industry, having their headquarters in the Slaskie Region, is of a random nature,

against the alternative hypothesis:

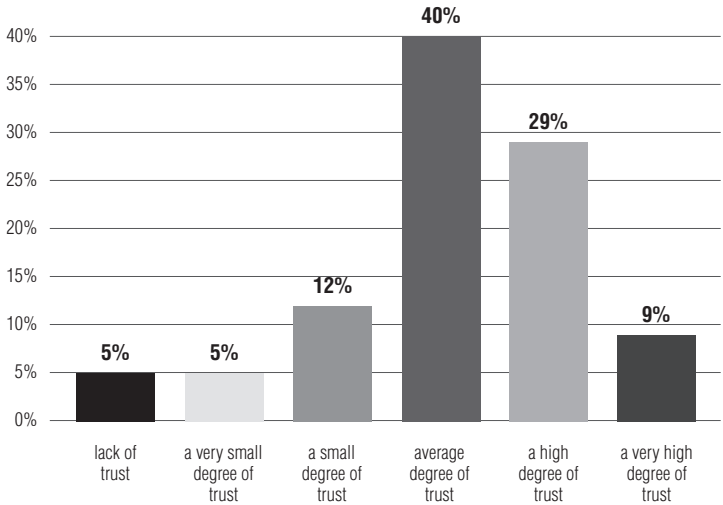
H_1 – a sample of clothing industry enterprises having their headquarters in the Slaskie Region is not of a random nature.

Due to the fulfillment of the condition that $n_1>20$ or $n_2>20$, the empirical value of Z calculated according to the formula given earlier was 1,64. Because for the level of significance α=0,05 critical value u_a for a two-sided test, read from the normal distribution table is 1,96, therefore: $(U = 1{,}64 < 1{,}96 = U_a)$, so there is no reason to reject the H_0 hypothesis that the sample is random. The hypothesis has been proved that the sample of clothing industry enterprises having their headquarters in the Slaskie Region is of a random nature. Therefore, it entitles to making proposals for the general population.

A trust in a cooperation in distribution channels – research results

As regards trust in the main partner / contractor, respondents from the surveyed companies were rather cautious. However, the distribution of responses presented in Figure 1, taking into account all the examined units (both those that show partner relationships and those in which no such relationships have been recorded), can be considered satisfactory.

FIGURE 1 — A partner trust degree

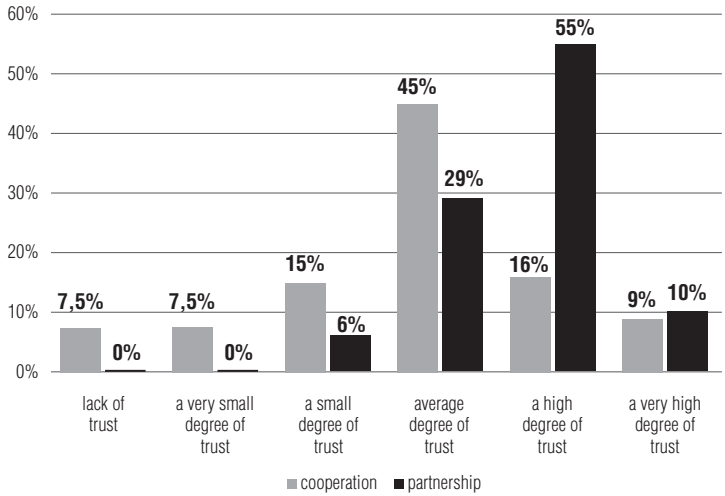


Source: own study

In turn, on the Figure 2 it was presented the indications regarding the degree of trust in the partners, distinguishing between the type of relationships occurring between the surveyed entities. They show that enterprises cooperating on the principles of partnership much more often indicated that they have a high degree of trust in the main partner. In turn, the answer

"the average degree of trust between a partner" was more often chosen by other enterprises.

FIGURE 2 — A partner trust degree



Source: own study

At the same time, it was decided to show whether there is a relationship between the occurrence of partner relations and the degree of trust in the main partner. In order to investigate the existence of statistically significant dependence, the following null hypothesis was made:

H_0 – "Type of relationship" and "trust in a partner" are independent,

and an alternative hypothesis that defies the null hypothesis:

H_1 – "Relationship type" and "trust in the partner" are dependent.

The test results are shown in Table 1.

TABLE 1 — Test χ^2 results for variables: "relationship type" and "trust in a partner"

Tested characteristics (variables)	The empirical value of statistics χ^2	Number of degrees of freedom	Severity level α	Critical value of statistics s χ^2_α	Test probability (p level) for the test χ^2	C-Pearson Factor
dependent: type of relationship	20,390	5	0,05	11,0705	0,001	0,40
independent: trust in partner						

Source: own study

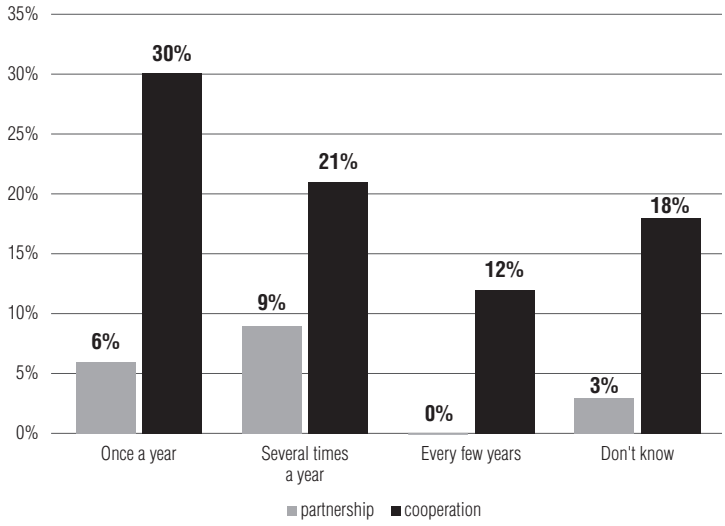
On the level of significance a = 0,05 calculated value of statistics χ^2 amounting 20,390 (table 1.), for k = 5 degrees of freedom, exceeds the critical value of the statistics χ^2_α amounting 11,0705. Therefore, at the level of significance α = 0,05 we reject the zero hypothesis, assuming that trust to the partner and the type of relationship are independent because χ^2 = 20,390 > 11,0705 = χ^2_α. On this basis, it can be stated that the type of relations between participants in the distribution channels of clothing industry enterprises depends on the level of trust they endure. The detected dependence was also evaluated in relation to the strength of this relationship. For the given variables, the C-Pearson coefficient is 0.40, which indicates a moderate power of dependence between the existence of partner relationships and the level of trust in partners.

Conflicts in a relationship and in a partnership in the light of the research

The occurrence of conflicts was recorded among 33% of all surveyed enterprises. At the same time, the occurrence of this phenomenon among enterprises maintaining partner relationships was estimated

at 18%, while the percentage of other enterprises in which there was a conflict with contractors was 82%. In the Fig. 3 there was presented the frequency of conflicts in relation to the type of relationship observed - cooperation or partnership.

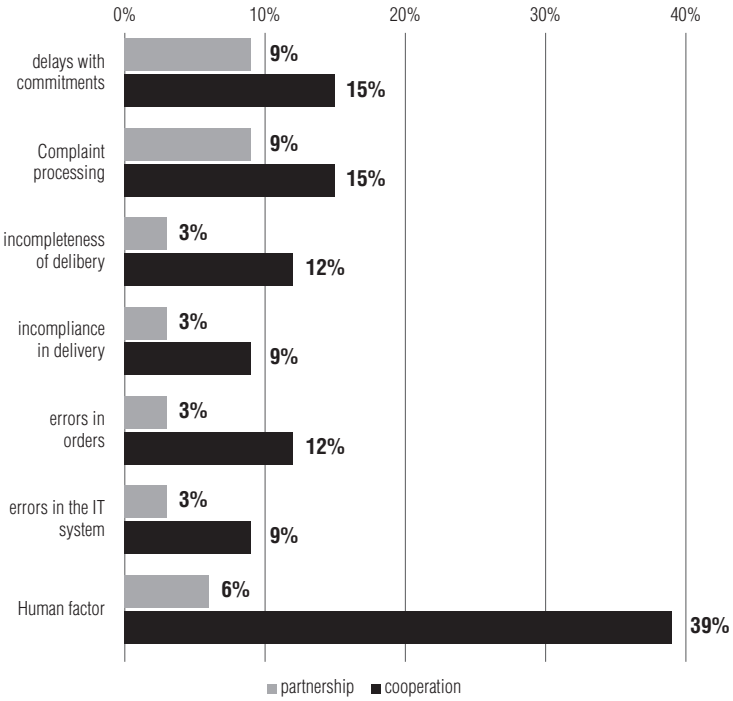
FIGURE 3 — A cooperation and partnership - frequency of conflicts



Source: own study

Analyzing the above results, it is concluded that the occurrence of conflicts in partner relations is a much more rare phenomenon compared to the occurrence of conflicts in cooperation. An important difference is noted in particular in relation to the answer determining the frequency of conflicts at the level of once a year. Also the reason for thinking is the result of the answer "I do not know" - in the case of a partnership, the share of this answer is much lower, which allows to state that these partners are more aware of the conflict.

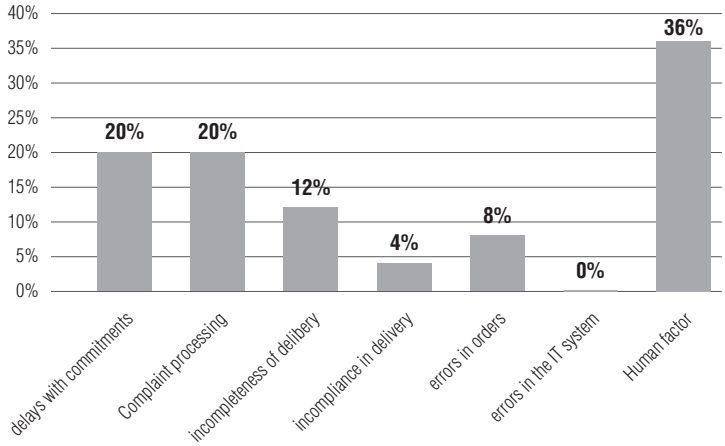
FIGURE 4 — A cooperation and partnership – causes of conflicts



Source: own study

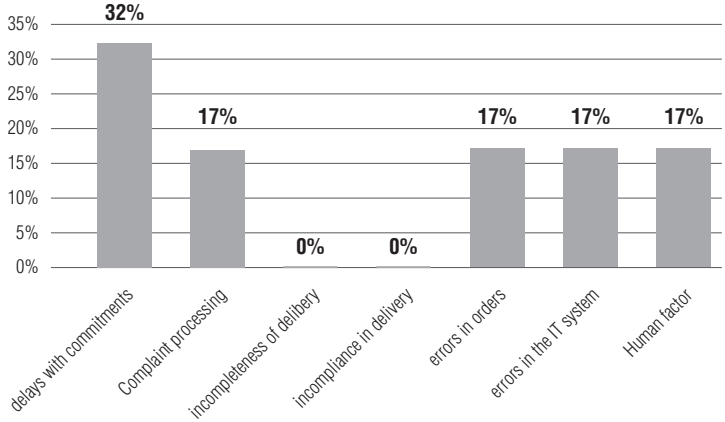
The reasons for the conflicts were also analyzed (Figure 4), where there can be several of them (respondents had the opportunity to mark several responses.) The largest share of respondents whose companies cooperated on the basis of cooperation, outlined the cause of conflicts related to the human factor (39%). Among the companies cooperating on a partnership basis, there were no such high indications regarding the reasons given. In this group, the largest share of respondents indicated such causes of conflicts, delays in commitments and the complaint process (both factors were reported 9% of responses).

FIGURE 5 — A cooperation - the most common cause of conflicts



Source: own study

FIGURE 6 — A partnership - the most common cause of conflicts



Source: own study

In addition, respondents marked the most frequent cause of the conflict - Figures 5 and 6). Analyzing the above data, it is stated that the human factor is the most frequent cause of conflicts in cooperation, while the most common cause of conflicts in the partnership are delays in liabilities. At the end of the discussion, there was made an attempt to compare the results of the collected responses regarding trust and conflict (Table 2 and 3).

TABLE 2 — Matrix of trust and conflicts for the surveyed population

Total	An existence of trust	A lack of trust
An existence of conflict	26%	2%
A lack of conflict	67%	5%

Source: own study

TABLE 3 — Matrix of trust and conflicts in relation to cooperation and partnership

Cooperation / Partnership	An existence of trust	A lack of trust
An existence of conflict	30% / 19%	3% / 0%
A lack of conflict	59% / 81%	8% / 0%

Source: own study

For the whole of the surveyed population, the occurrence of trust in partners was associated with a 67% possibility of avoiding conflict (Table 2). However, significant differences arise when we take into account the type of relationship between partners (table 3). Well, partner's trust in partner relations resulted in no conflict in 81% of respondents. On the other hand, among cooperating enterprises, this percentage was much lower and amounted to 59%.

Summary

The problem of relations occurring in supply chains is very complex, if only because of the number of possible relations between particular links in the chain. Therefore, the study focuses on two types of relations: cooperation and partnership. Both types of relationships were distinguished on the basis of a literature review. The main attention was also drawn to two elements that cannot be omitted when examining relations in supply chains: trust and the occurrence of conflicts between partners. These two elements are an inseparable part of existing economic systems and are interrelated. The presented study showed the existence of a statistically significant relationship between trust in the partners and the type of relationship (cooperation and partnership). What's more, it has been shown that in partner relationships, the degree of trust in partners is significantly greater than in the case of cooperation. In addition, the frequency of conflicts among companies cooperating in distribution channels was analyzed and there were given reasons on conflicts (with indicating the most common of them). A matrix of trust and conflicts was also presented in relation to the entire surveyed population and broken down by the type of relations between the partners.

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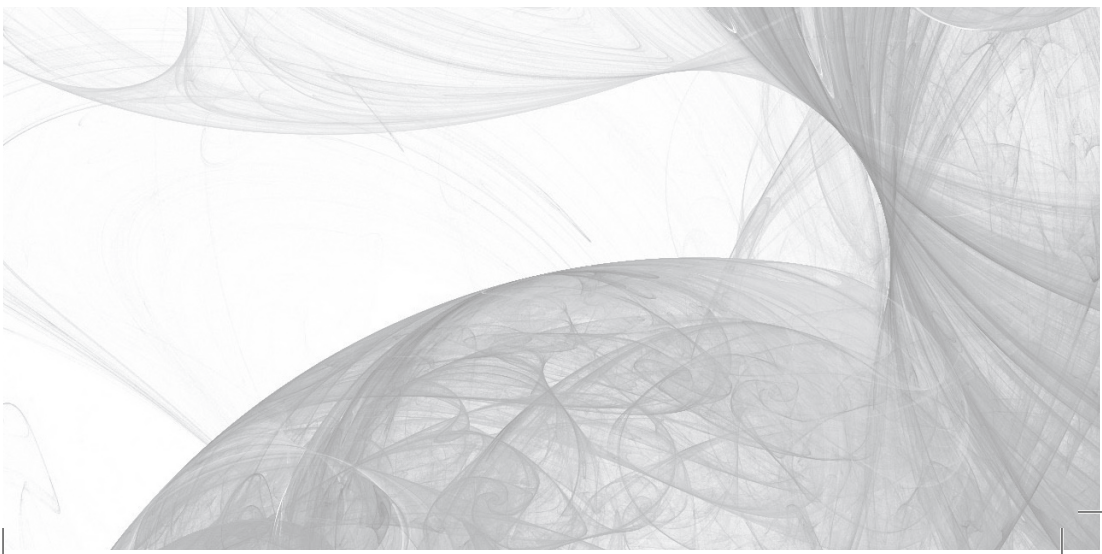
ZAUFANIE A KONFLIKT WE WSPÓŁPRACY I PARTNERSTWIE

Streszczenie: W artykule podjęto próbę rozróżnienia relacji zachodzących w łańcuchach dostaw w odniesieniu do dwóch zasadniczych zmiennych: zaufania i konfliktów. Na podstawie literatury zdefiniowano i wskazano cechy charakterystyczne dla relacji opartych na kooperacji i partnerstwie. Problematykę zaufania i konfliktów między partnerami obu rodzajów relacji zbadano na podstawie przeprowadzonych badań ankietowych, na reprezentatywnej grupie przedsiębiorstw sektora odzieżowego. Za pomocą dostępnych narzędzi statystycznych wykazano, że w związkach partnerskich stopień zaufania do partnerów jest znacząco większy niż w przypadku kooperacji. Dodatkowo przeanalizowano częstotliwość występowania konfliktów wśród współpracujących w kanałach dystrybucji firm i podano ich przyczyny. Zaprezentowano także macierz zaufania i konfliktów w odniesieniu do całej badanej populacji oraz w podziale na rodzaj zachodzących relacji między partnerami Słowa kluczowe: konflikt, współpraca, partnerstwo, relacje, zaufanie



FOURTH GENERATION (4G) WIRELESS AND THE VEHICLE IN THE CONTEXT OF CONNECTIVITY AND THE MOBILITY.

Antonio César Galhardi, Nathan Cirillo e Silva

Abstract: The connected-vehicle application market is poised to explode in the coming years due to the development of mobile application platforms such as Google Android and others and corporate / business / machine-to-machine telematics services. Supporting these platforms is the 4th Generation Wireless (4G) Long Term Evolution (LTE) and its descendants. This article aims to explain that automotive application developers will need to know how data is handled by 4G systems and how innovations such as "traffic modeling" can improve the quality of service for off-board or cloud-based vehicle applications. In addition, "on-board" vehicle applications that use vehicle-to-vehicle communications, infrastructure (such as femtocells, WI-FI and for safety applications, Dedicated Short Range Communications / Wireless Access for Vehicle Environments (DSRC / WAVE) Can also be integrated into 4G. Later versions of LTE (such as LTE Advanced) can establish and manage communication sessions that swarm among many of the above-mentioned wireless technologies, a concept known as heterogeneous or vertical roaming.
Keywords: fourth generation, wireless, connectivity, mobility.

Introduction

The Global System for Mobile Communications (GSM) Association expected around 70 billion connection terminals in 2020, nearly 10 times the human population expected in the world. Approximately one billion of these terminals are probably automobiles. Automotive engineers who create connected systems will face a wide variety of vehicle wireless technology options that offer short-range and long-range connectivity and regional and global connectivity. What the future holds for wireless technology, especially for the expected communications infrastructure, is still speculative. However, the general trends of what could be available are visible today.

The next generation of wireless networks will have a repertoire of different techniques to prioritize communications based on the needs of the application. In addition, not only will the networks be smarter, but future mobile terminals will likely have several standard interfaces (such as WIFI, mobile and even mobile satellite) and can choose the best network based on immediate needs (coverage, quality of service, or costs).

Vehicles will also likely have wireless security, critical or highly mobile communications in place to support local applications such as automatic collision reporting, avoidance of vehicle collisions for vehicles or infrastructure applications (such as signal prediction or toll). Transit and avoid intersection collision). Peer-to-peer communication systems, looking for opportunities to communicate directly with other nearby nodes, without the need to slowly direct data traffic to and from the first towers, are likely to expand as range.

With the 4G mobile phone, will be possible the completion of the extension of the internet protocols to the wireless environment, the fourth generation probably represents the end of the traditional closed-loop approach that has been the result of decades of investment in single purpose built application technologies (radio, TV, land mobile and cellular) and regulatory practices. Current infrastructure investment patterns provide a

strong indication of the technologies that will be available, as well as their quantity, quality, and cost.

This article examines how next-generation systems such as 4G (and, to a lesser extent, 4G interoperable Mobile-Satellite Services) can support vehicular applications. It suggests that, in the long term, shorter-range technologies, such as 4G, WIFI or DSRC / WAVE femto cells, are likely to be used in coordination or in conjunction with "wide area" systems. The paper also alerts that automotive electronics engineers will need to be aware of how application data is handled by 4G systems and how innovations such as "traffic modeling" can improve the performance of off-board (or cloud-based) vehicle applications.

A Short History

Motorola launched the first commercial broadcast AM in the 1930s. Large-scale, two-way interconnected vehicle platforms, however, were born 65 years later when OnStar was formed as an alliance between General Motors, Electronic Data Systems and Hughes Electronics. PSA Citron, BMW and some other telematics systems were implemented, while other companies such as Ford (under the "Wing Cast" brand) contemplated telematics incursions but without to commit to major efforts until the end of 2000. Meanwhile, personal navigation (PND) took off as their prices fell 50 to 60 percent over a period of five years. The aftermarket PNDs connected began to find their way in vehicles. Ford has joined the field of telematics in collaboration with Microsoft to integrate smartphones into its Sync telematics platform. Early telematics service providers used first and second generation (1G and 2G) cellular systems and some other satellite communications systems in the 1990s and 2000s. In 2008, the Federal Communications Commission (FCC) stopped requiring Mobile Network Operators (MNOs) to support the first generation of mobile phones in its infrastructure, requiring telematics pioneers such as OnStar to provide equipment upgrades to hundreds of thousands of existing customers.

Meanwhile, the Intelligent Transportation Society of America (ITS), an industry association composed of auto, telecommunications and information technology/consumer electronics companies, as well as public and private road transport operators, freight carriers and transit operators, and the Federal Communications Commission (FCC) to assign dedicated spectrum to the ITS. In 1999, the FCC allocated a range of spectrum from75 MHz at 5.9 GHz for DSRC to provide vehicle-vehicle-vehicle communications and local infrastructure that could support short-haul mobility and collision avoidance cooperative applications.

Since 2003, the US Department of Transportation (USDOT) has sponsored research on application using DSRC / WAVE. The goal of the USDOT Connected Vehicle Research Program, formerly known as the Vehicle Infrastructure Integration Program (VII) / IntelliDrive, was to establish concepts of operations, systems requirements and high-level architecture of a nationwide interoperable system Which could use DSRC to support enterprise-to-vehicle and vehicle mobility applications for infrastructure and security.

The USDOT is currently determining research needs to conduct a potential National Highway Traffic Safety Administration (NHTSA) sponsored rulemaking. This rulemaking would likely explore a practical approach to wide-scale vehicle-vehicle collision avoidance application deployment. USDOT is on track to measure safety benefits and evaluate deployment strategies as a part of the rulemaking.

The USDOT is looking to the potential for aftermarket DSRC terminals to bridge the long equipment gap between old and new vehicles – DSRC, as an embedded feature in the new vehicles, with aftermarket devices supporting applications for older vehicles.

Finally, the Mobile Network Operators - MNOs such as Verizon, AT&T, T-Mobile, and Sprint have aggressively market 4G technology as the next generation of wireless to retail-level consumers since 2009.

The MNO's are also attempting to convince enterprise customers (and the auto industry), to upgrade to newer generations of equipment

such as third generation (3G), which after a decade of provisioning is closing-in on near nationwide coverage. Once again, history may be repeating itself, as Telematics service providers, who committed to 1G technology in the 1990s only to have that system removed in the late 2000s, face the prospect of being stranded again with equipment in the 2010s that supports a technology that, in the MNO's view, is nearing obsolescence.

The Fourth Generation is likely the most relevant technology as far as the auto industry may be concerned. Fourth Generation is not just an industry quest for a faster radio technology. It is a remake of the entire cellular telecommunications system, with the objective of extending the internet suite of protocols beyond the wired environment. The Fourth Generation represents the complete transition of cellular from a system designed for the unique requirements of voice to a general-purpose system that can manage several applications.

In 1983, for example, mobile users experienced voice throughput of about 10 kilobits per second (kpbs). A decade ago, end users could expect peak throughput of approximately 170 kbps with 2G technologies. The Fourth Generation were designed to meet, or at least approach, the International Telecommunications Union (ITU) requirement that targets peak data rates of up to 100Mbps for high mobility access (i.e. outdoor access with users moving at high speeds) and up to approximately 1Gbps for low mobility or nomadic access (i.e. primarily indoor access with terminal movement at a minimum) (Kim, Prasad 2006).

The ITU originally contended that only two emerging technologies, LTE Advanced and WiMAX release two (802,16m), qualify as 4G because they will be able to achieve peak data rates of 1Gbps for a stationary user. Current systems being deployed (LTE or WiMAX) are marketed as 4G, but do not meet this threshold. The ITU subsequently changed its definition to say that any technology offering a meaningful improvement over 3G can be classified as 4G.

No matter how 3G or 4G are defined, the success of these systems is not because they solved the problem of insufficient data rates. They

have been successful because their deployment coincided with mobile terminals such as app-phones and other computing platforms such as tablets that provide portability ease of use, and application flexibility and upgradability.

These hardware and software platforms or ecosystems parallel wireline internet such as programming interfaces (APIs) and online distribution and maintenance. The Third Generation also marked the point in time when the wireless telecommunications industry abandoned the "walled garden" approach of providing a fixed menu of applications proprietary to their networks abandoning competition at the application layer and leaving in to Information Technology (software) and consumer electronics (hardware) industry.

The ecosystems rely on the convergence and integration of complementary technologies from other parts of technology chain such as wireline networks, hardware terminals, content and applications. Ecosystems thrive on economies of scale (number of users) and scope (the variety of applications, especially those niche sector applications in the "long tail" such as transportation).

Specifically, for automotive consumers, automobile manufactures and telematics service providers have contemplated replicating the same application ecosystem that found on app phones, allowing third parties limited access to programming interfaces into the telematics/infotainment systems.

Ford Sync or OnStar have interfaces with mobile phones and are contemplating the creation of app stores that can be used to the market, and distribute applications to consumers in the same way as companies like Google, Apple, and RIM currently distribute applications.

For enterprise –oriented applications, a new industry value chain is emerging as well. The Mobile Network Operators - MNOs have also begun to establish, through partnerships with telematics providers, application or platform-specific machine (M2M) terminals, and shared network infrastructure.

The MNOs are fast-tracking certification of many new connected terminals beyond consumer handsets such as electric utility meters and telematics units. MNOs have relied upon Mobile Virtual Network Operators (MVNOs), who do not own their own network base stations, but buy wholesale airtime from multiple MNOs across multiple coverage areas.

The Mobile Virtual Network Operators - MVNOs sell wholesale airtime as a retail service to their machine- to-machine - M2M subscribers, and they bulk provision and activate M2M terminals large scalable batches for large enterprise clients (Lucero, 2010).

Mobile Virtual Network Enables (MVNEs) have also come into market. These companies provide infrastructure and services that enable M2M MVNOs to offer specialized shared infrastructure and value-added services such as verification/validation of message receipts and GPS data, remote M2M device diagnostics, and bearer testing of different carriers' services through which a device may be expected to roam (Emmerson 2010a).

There are numerous vertical M2M application specialties as well, which can be broadly divided into six sector categories: Consumer Home, Healthcare, Energy/Utilities, Security, Industrial/Building Control, and of course, Consumer and Commercial Fleet Telematics (Emmerson 2010b).

The Future

The wireline internet was never designed to support wireless services, where transport protocols function poorly because wireless links frequently fail, forcing retransmission, and devices constantly change home addresses as they geographically "roam" across wireless subnets.

The Fourth Generation (4G) radio access and core networks are designed to manage these challenges and will likely improve wireless network performance, specially, higher quality of service, reduced latency, improved reliability, and enhanced capacity.

Despite the ongoing expansion of wireless infrastructure capacity through upgrades to 4G, and continued cell splitting with the introduction of femtocells, latent demand will still like leave MNO capacity constrained soon.

The MNOs will need to manage wireless traffic proactively to ensure that application performance does not suffer. There is one major approach to managing the deluge of data-traffic shaping. This strategy relies on the concept of identifying application needs and prioritizing transmissions, or even prohibiting or re-routing transmission to other networks, based on MNO operational and pricing policies.

The key question is what the impact might be on future automotive connected vehicle applications and specifically how data transmitted from vehicles might be treated by future 4G "traffic shaped" networks.

The MNO recognize that revenue growth hinges upon their ability to deliver a wider range of mobile broadband applications and services, which require higher bandwidth and lower latency. The critical challenge for MNOs is to develop networks where high volume applications (such as video streaming) do not interfere with critical lower volume applications (such as 911 calls or automated crash notification messages).

As cellular systems morph into a general-purpose internet-based wireless network, they will be challenged to meet the needs of all applications with the single "best effort" quality of service class that is typical of the wired internet.

The Fourth Generation describes and combines several Quality of Service (QoS) attributes (such as maximum acceptable delay, jitter, and bit error rate) into a minimum of four QoS categories such as conversational (e.g. Voice-over-IP), streaming (e.g. video), interactive (e.g. web browsing), and background (e.g., email and file transfer).

However, future quality of service implementations might need to be more sophisticated in prioritizing content for wireless networks than they would for a strictly wireline network because multiple real-time streams might look alike, but still need to be further differentiated. For example, a

video stream can be delayed and cached on the terminal, but a 911 call or an automated collision notification cannot be.

Today's mobile networks are carrying many complex combinations of traffic that potentially defy simple classification of data packets into four broad quality-of-service buckets. Using Deep Packet Inspection (DPI), MNOs can automatically sort and classify packets per variety of criteria in real time.

After classification, different traffic shaping policies may be applied to the packet and its associated stream such as prioritization, rate limits, or even blocking. Today's DPI systems can identify many protocols and traffic types while shaping traffic in real-time, at speeds of nearly 100 gigabytes per second. Internet applications are becoming more sophisticated, and application developers are burying data deep inside packets such as voice and other media mash-ups, significantly increasing traffic classification complexity.

Quality of service was not adopted in the early days of the wireline internet because there was little need for it, as most traffic was asynchronous file transfer, email, and web browsing.

Wireline operators could over-provision link capacity, adding additional optic fiber, for example, to combat congestion caused by peak internet traffic.

Overabundance of wire line link capacity has allowed the wireline internet to move beyond bulk, asynchronous applications and has allowed introduction of real-time applications such as unicast video and audio streaming and voice-over-IP (VoIP) (Bennett 2010).

Unfortunately, MNOs cannot add spectrum as wireline telecommunications providers to and, therefore, they must be careful of applications or users that can potentially act as "bandwidth hogs".

Traffic shaping technology will allow MNOs to introduce flexible tiered quality of service and pricing incentives that fit to applications. Fourth Generation core networks and even terminals will likely have embedded operational policies to differentiate and prioritize traffic, and then

schedule it for transmission based on time sensitivity or quality of service requirements.

Differentiating traffic can also be used to charge different tariffs services, to charge by bulk data limits or by on-peak or off-peak usage, or to exclude certain types of usage completely under more affordable data plans.

This effort is dependent in part on long term efforts by standards organization such 3GPP to create an IP Multimedia System as a part of later releases of LTE that will shape traffic on radio access networks for transfer to and from the fixed internet.

Designers of automotive applications must be cognizant of the effect that network congestion might have on their applications in the future. The design on the internet precludes a state where latency is ever sufficient for all applications always, unless the multiplicity of applications is reduced (Bennett 2009).

The wireline Internet and its wireless extension are both dynamic shared bandwidth systems that rely on statistics to gauge quality of service for most applications. A great deal of analysis is needed to understand the impact of different applications to network capacity.

For automotive applications where data is processed "in the cloud", such as off-board navigation, an understanding of the application's demands on the applications the same quality of service as voice calls, application programmers must have quite detailed knowledge of the network's traffic dynamics to avoid creating congestion or other pathological effects on application performance.

If MNOs still cannot cost effectively meet the growing traffic on their networks after network traffic shaping, then one alternative will be for MNOs to "shape" the terminal devices, requiring them to "offload" some traffic to less congested links such as WIFI networks, or to roam to less-congested competitor networks.

The emergence of multi-standard, multimode radios such as those found in applications will have a choice of interfaces beyond cellular.

These systems may incentivize development of vertical "roaming" across heterogeneous networks such as Wi-Fi, ZigBee, DSRC/WAVE, or other systems. Models where lower priority traffic (or lower profit traffic, depending on the pricing model) is "off-loaded" to these redundant links will take advantage of the LTE IP Multimedia System capability to implement traffic shaping in both the network and the terminal (Paolini 2010).

Future versions of LTE SYSTEM Architecture Evolution (SAE) include an "anchor" for roaming between 3G/4G systems and wireless local area systems such as Wi-Fi or DSRC/WAVE (Anristu Company 2010).

The concept would allow an MNO to establish interfaces to WI-FI or DSRC/WAVE hotspots, maintaining a contact list of trusted nodes that LTE would use to off-load data traffic in the event the normal 4G network is congested.

LTE's future IP Multimedia System represents a different approach to the more traditional telecommunications architecture of a set of specific network elements implemented as a single telco-controlled infrastructure.

Services will be created and delivered by a wide range of highly distributed systems (real-time and non-real-time, possibly owned by different parties) cooperating with of each other as part of LTE IP Multimedia System.

There will likely be some tension between opening IP Multimedia System for third party development to make it more accommodating of new M2M and telematics applications, and keeping the architecture simple and easy to understand and efficient to operate.

Since the Third Generation (3G), MMOs have sought "flatter networks" with fewer jump between the radio access network (cell tower to mobile terminal) and the core network (cell tower to the internet gateway) because generally the more hops on a network, the greater the chance for bottleneck failures and congestion.

For example, LTE currently supports radio access network round-trip times of less than 10 milliseconds, but this does not measure latency as data hops to core wireline gateways or to other base stations.

Flatter networks are also cheaper to build and maintain, and are critical in keeping MNO's operating cost-per-bit low, which is occurring with many wireless data plans. Again, there may be a conflict between keeping the wireless telecom infrastructure flat and simple to drive down MNO operating costs and adding complexity via more accommodating application-aware interfaces supported in the LTE Multimedia System.

Future 4G systems are being designed to meet the requirements of a wide variety of quality-of-service categories, but application developers will likely still need to experiment with future LTE IP Multimedia System features to ensure adequate performance and priority for applications.

However, MNOs are uncertain what the impact of M2M and telematics will be on demand for their network services. In an environment where M2M applications are growing and "human" subscribers are a minority; network communications traffic will likely occur in bursts based on either timely automated routines or events that may be unpredictable (Bastien 2010).

Predicting the maximum capacity and provisioning networks to support M2M and telematics peak capacity may be a future challenge in maintaining QoS.

The Mobile Network Operators (MNOs) will need to work with the largest machine-to-machine (M2M) application service providers to understand the implication of M2M on traffic patterns and capacity.

The MNOs and application service developers must be cognizant that traffic shaping and simple QoS classification and prioritization might not always work, or might work in ways not intended by application developers (Singh 2011).

On future, wireless networks, application developers must conduct extensive analysis to determine how an application's performance influences, or is influenced by, the variable conditions on the wireless network, and how it may interact with elements with a future LTE IP Multimedia System.

This is especially the case for mission-critical systems, but also for ones where there is a high expectation of reliability from the user. "End-to-end" performance management tools are used by network engineers to monitor the symptomatic impact of applications on end-user and service-level performance metrics, but most network management tools only understand the network in discrete, device-level pieces (Eslambochi 2009).

Consumers might have higher expectations of the quality and dependability of automotive OEM equipment, in contrast to shorter-lived, less durable consumer electronics devices.

Therefore, automotive application developers might need to invest more time and effort to understand how they can build end-to-end quality and reliability into their services that rely on frequent off-board communications.

In the future, as vehicles add new technology such as electric powertrains, drive-by-wire chassis systems autonomous advanced driver assistance features, and even future cooperative collision avoidance systems, these new advances might require new levels of maintenance, service, and diagnstics (Najm et al, 2010).

Final Thoughts

The success of telematics is riding on the ease of use and pratically of integrating multiple generation technologies, from portable consumer devices to embedded equipment, This must, however, be done in a manner that reduces costs and complexity and meets basicneeds of drivers for connectivity, beyond infotainment and mobility, extending to vehicle diagnostics, occupant crash protection, and crash-avoidance.

Connected vehicle applications are set to explode in the next few years because of the development of mobile application platforms such as Google Android and others, and enterprise machine-to-machine support ser-

vices. Supporting these platforms beyond 2015 is 4GLTE wireless and its progeny automotive application developers will need to be cognizant of how application data is treated by 4G systems, and how innovations such as traffic shaping improve quality of service for off-board (or closed-based) vehicular applications.

Furthermore, on-board ehicular applications utilizing vehicle-to-vehicle, vehicle-to-infrastructure communications, such as femtocells, Wi-Fi and, for safety applications, Dedicated ShortRange Communications/ Wiireless Access for Vehicular Environments (WAVE), might also likely be integrated into 4G. Later versions of LTE, such as LTE Advanced might establish and manage communications sessions that hop among many of the above mentiond wireless technologies, a concept known as heterogeneous or vertical roaming.

Diagnostics for a safety system are necessary to ensure reliability (low mean time between failures), availability (readness for service) maintainability (low mean time to repair),safety (no risk of catastrophic failure), and security (authorization of trusted users to operate and maintain the system, plus system resistence to malicious attachs).

Diagnostics for these new vehicle technologies might need to be monitored and analysed off board to improve safety, vehicle performance, and future product quality.

As far as choice of wireless technology, the ideal vision is to have vehicles communicating using any system that is available and secure, if multiple systems are available, choosing the most direct, unencumbered, efficient or lowest cost path, based on the technical requirements of the application and the business needs of the application service provider.

It is likely that the auto industry will see computing platforms in vehicles in the next decade similar to ones found in mobile app-phones, although with device interfaces designed to ensure that they are accessible to the driver in a way that does not reduce attention to safety-critical driving tasks.

With new computing platforms and interfaces, the fixed menu of applications that had been the hallmark of tematics packages in the past will change. Like app phones that allow users to choose à la carte from multiple applications, (app stores) create a platform that allows users to choose the mobility applications they want, making the value proposition for telematics more attractive in the eyes of consumers, especially when weighed against the additional cost of supporting the connectivity elements of these systems.

The LTE will likely not have national coverage for some time, and deployment will likely start in urban areas first. Many in the wireless industry have talked of a targeted deployment strategy known as inside-out deployment.

The inside-out strategy places LTE first in homes and offices with 3G/4G/WIFI fem to cells,and then 4G macro-base stations in major metropolitan areas, eventually expanding 4G outward to other cities and rural areas.

Network infrastructure innovations such as small, self-organizing cells and heterogeneous roaming across different wireless systems, might significantly influence and accelerate 4G deployment.

In addition to several choices of wide area communications such as cellular or mobile satellite services, vehicles will also likely have wireless systems devoted to safety-critical or highly mobile spot communications.

Vehicle applications that are run entirely on-board and very localized, such as adjacent vehicle-to-vehicle cooperative collision avoidance or traffic signal preemption and intersection collision avoidance, will require very fast communication using per-to-peer communications systems such as DSRC/WAVE.

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REVIEW OF RECENT RESULTS RELATED TO METAL DIELECTRIC COMPOSITES BASED ON GERMANATE MATERIALS WITH METALLIC NANOPARTICLES FOR PHOTONICS TITLE

Luciana Reyes Pires Kassab, Davinson Mariano da Silva

Abstract: In this chapter, we review some of the recent results obtained with germanate materials, doped with rare earth ions and metallic nanoparticles, for photonic devices. We will focus our attention to the role of metallic nanoparticles and the mechanisms that improve optical performance. We will expose the experimental procedure used for the metal dielectric composite fabrication (bulks and thin films), the simple alternative, based on thermal annealing for the nucleation of metallic nanoparticles and the techniques necessary for the characterization of the materials. The influence of the metallic nanoparticles on the rare earth ions linear optical properties is presented, the mechanisms associated to the plasmonics effects that contribute to improve the optical properties as well as the possible applications are also shown. This chapter will also devotes attention to the fabrication of waveguides based on thin films produced using the sputtering technique and the role of the nanoparticles in light guiding mainly for application as amplifiers. The role of plasmonics is emphasized and the influence of metallic nanoparticles in light amplification devices is discussed.

Keywords: Enhanced photoluminescence; Germanium and tellurium oxide glass; Silver nanoparticle; Gold nanoparticle; Localized surface plasmon resonance; Rare-earth ion; Optical amplifier; Color display

1. Introduction

The study of the materials' photoluminescence properties is still a very active research area. In this context host materials with small cutoff phonon energy are required to minimize the nonradiative losses and to obtain high photoluminescence quantum efficiency allowing transitions that does not occur in materials with higher phonon energy. Heavy-metal oxide glasses present this characteristic and are normally investigated for photonic applications as temperature sensors, frequency upconverters, optical amplifiers and full - color displays. Among the heavy metal oxide vitreous systems of current interest tellurium and germanium oxide glasses doped with rare earth ions have proven to be highly luminescent. Besides, the inclusion of metallic nanoparticles can enhance their photoluminescence. These glasses have properties such as high linear and nonlinear refractive indices, broad transparency window from the visible to the infrared region, and large stability against devitrification. All these features make them suitable for photonic devices fabrication.

It has been demonstrated that different glass compositions containing metallic nanoparticles may present enhanced photoluminescence properties when the optical frequencies of the excitation beam and/or the emitted light are near resonance with the localized surface plasmon resonance (LSPR) frequency of the nanoparticles [1-18]. Metallic nanostructures and their applications is an area that has been increasing and expanded in a major field called Plasmonics. It is the new type of resonance called plasmon or surface plasmon resonance, localized near the boundary between the metal nanostructure and the surrounding dielectric that produces an enhanced electromagnetic field at the interface that can enhance the photoluminescence properties.

Optical properties of germanium oxide glasses doped with different rare earth ions have been investigated and showed that these new dielectric materials are capable of incorporating metallic nanoparticles and exhibit an extensive range of photonic applications.

Erbium doped waveguide amplifiers (EDWAs) have been extensively studied over the past decades due to the promising applications that may arise, like optical pre-amplifiers and power amplifiers, to name a few [19-22]. EDWAs presenting internal gains up to 27 dB have already been demonstrated. Nevertheless, new glassy materials for EDWAs presenting a high solubility for rare-earth ions, as well as a high refractive index are required, since these factors govern the overall characteristics of the device

In this chapter, we review some of our recent results related to the influence of the metallic nanoparticles on the optical properties of glasses. The chapter is organized in the following way. In section 2 we present the well known melting quenching technique that is used for the production of the samples and also the procedure used for the nucleation of the metallic nanoparticles, based on the thermal annealing. The production of the thin films based on the sputtering technique for waveguides amplifiers is also presented. A brief description is included about the main equipment and techniques employed for the characterization of the samples In Section 3 we present some of the results obtained and discuss the main mechanisms contributing to the improved optical performance of the materials studied. Finally Section 4 presents a conclusion of the main results.

2. Experimental details

Germanate glasses with different compositions (GeO_2-PbO and Bi_2O_3-GeO_2) pure and doped with rare earth ions and metallic nanoparticles were prepared using the well known melting/quenching method and high-purity reagents (99.999%) contained in alumina crucibles [16-18]. After cooling the samples to room temperature inside the furnace to reduce the internal stress, they were polished, cut in order to have parallel faces, and then submitted to additional heat-treatment to nucleate the metallic nanoparticles. This procedure has been used and

enabled the nucleation of metallic nanoparticles in different rare earth doped heavy metal oxide glasses [16-18,23]. Samples without metallic nanoparticle were also fabricated to be used as reference. A transmission electron microscope (TEM) operating at 200-300 kV was used to investigate the size and shape of the nanoparticles. Photoluminescence spectra were measured using for the excitation in the infrared, continuous-wave diode lasers operating at 805 or 980 nm, depending on the rare earth ions used as doping species. The photoluminescence signals were collected in a direction perpendicular to the incident beam and a spectrometer, attached to a photomultiplier and a computer, were used to analyze the photoluminescence signals.

Thin germanate films were also prepared using radio-frequency (RF) sputtering as reported [19,24]. For preparation of germanate targets (GeO_2-PbO) the oxide powders are mixed and then submitted to 8 ton uniaxial pressure, followed by sinterization at 750 °C during 10h. Targets composed by Er_2O_3 pellets (diameter: 1.0 cm) positioned on Yb_2O_3 targets (diameter: 2.0 in.) were used to produce germanate films co-doped with Er^{3+} and Yb^{3+}. The films were deposited on a silica layer formed on a silicon substrate.

RIB [24] and pedestal waveguides [19] were obtained from the thin germanate films using optical lithography and reactive ion etching process. In the first case the etching was performed after the core deposition whereas in the second one the core deposition is the last step.

Scanning electron microscopy measurements (SEM) were performed to investigate the structure of the waveguides. Atomic Force Microscopy (AFM) was used to verify the presence of the gold nanoparticles on the waveguides.

Passive and optical amplification were done in order to study light confinement, optical amplification as well as the advances on pedestal fabrication processes and the influence of gold nanoparticles on the rib waveguides optical gain.

The propagation losses at 633 and 1050 nm were measured using the

top-view technique [25]. The near-field profiles were obtained by collecting the light at the end of the waveguide with a 10x microscope objective lens (numerical aperture: 0.4) and focusing on a CCD.

Optical gain was measured as follows [19,24]; the signal and pump wavelength were combined using a 2x1 multiplexer optimized for the specific wavelengths used. The pump power was supplied by a 980 nm laser diode coupled to a fiber optics with a maximum output power at the end of fiber of 100 mW. A 1.53 μm diode laser supplied the signal wavelength; the power coupled to the waveguides was kept constant at 1 μW, to prevent gain saturation. The input fiber delivering both pump and signal terminates in a fiber lens with a mode field diameter of 3 μm. After propagation through the amplifier, the pump and signal beams are coupled to a spectrometer through a second lensed fiber focused on the output of the guide.

3. Results and Discussion

3.1 Nd^{3+} doped GeO_2-PbO glasses with silver nanoparticles for gain media applications at 1064 nm

Glasses with the starting composition 60PbO-40GeO_2 (in wt%) were prepared using the melting quenching technique; the doping species Nd_2O_3 (1.0wt%) and $AgNO_3$ (2.0wt%) were added to the original composition [26]. The reagents were melted at 1200 °C, for 1 h in an alumina crucible, and then quenched in air, in a preheated brass mold to be annealed at 420° C during 1h. The samples were polished, cut and heat treated for 24, 48 and 72 h to nucleate silver nanoparticles (thermally reduce the Ag ions to Ag^0). A sample without $AgNO_3$ was used as reference. Figure 1 (a) shows TEM image of the sample heat treated for 48h and demonstrates the presence of isolated nanoparticles and aggregates of sub-micrometer dimensions. Figure 2 (b) shows the size

distribution histogram that indicates isolated silver nanoparticles with average size of 20 nm. We remark that at 420° C the material viscosity favor the Ag+ diffusion during the heat treatment and the formation of the Ag^0 atoms occurs by the following reactions: $Ag^+ + Ag^+ \rightarrow Ag^{2+} + A^0$ and $Ag+ + e^- \rightarrow Ag^0$. The, during the different intervals used for the heat treatment, isolated silver nanoparticles and aggregates are formed. Figure 2a) show the simplified energy level diagram of Nd^{3+} indicating the excitation ($^4I_{9/2} \rightarrow {}^4F_{5/2}$) and the photoluminescence ($^4F_{3/2} \rightarrow {}^4I_{11/2}$) transitions and figure 2b) presents the photoluminescence spectrum related to the transition $^4F3/2 \rightarrow {}^4I_{11/2}$ centered at 1064 nm. Results associated to the sample without silver nanoparticles and for those heat-treated during 1, 24, 48 and 72 h are presented and the highest emission can be seen for annealing of 48 h. In this case it is observed enhancement around 160% with respect to the sample without silver nanoparticles that is attributed the increased local-field in the Nd^{3+} locations nearby the nonspherical isolated silver nanoparticles and aggregates presented in figure 1 a); as the wavelengths of the incident light at 805 nm and the photoluminescence at 1064 nm are far from the localized surface plasmon resonance wavelength associated to the individual nanoparticles, no energy transfer is expected. For nonspherical nanoparticles the field enhancement is considerably larger than that for that for a comparable size spherical particle [27] due to the "lightning rod effect" [26]. So the nonspherical nanoparticles and aggregates of irregular shapes contribute to obtain the large infrared photoluminescence enhancement. Larger particles and the aggregates exhibit distinct dipole, quadrupole and even higher multipole resonances; their excitation produces local-fields external to the particles that may be larger than those produced by isolated nanoparticles [28]. For 72 h of heat treatment quenching is observed that may be related to the large nanoparticles concentration and aggregates formation that favor the reduction of the distance between Nd^{3+} and the silver nanoparticles and consequently the energy transfer from the Nd^{3+} to silver nanoparticles [27]

Figure 1

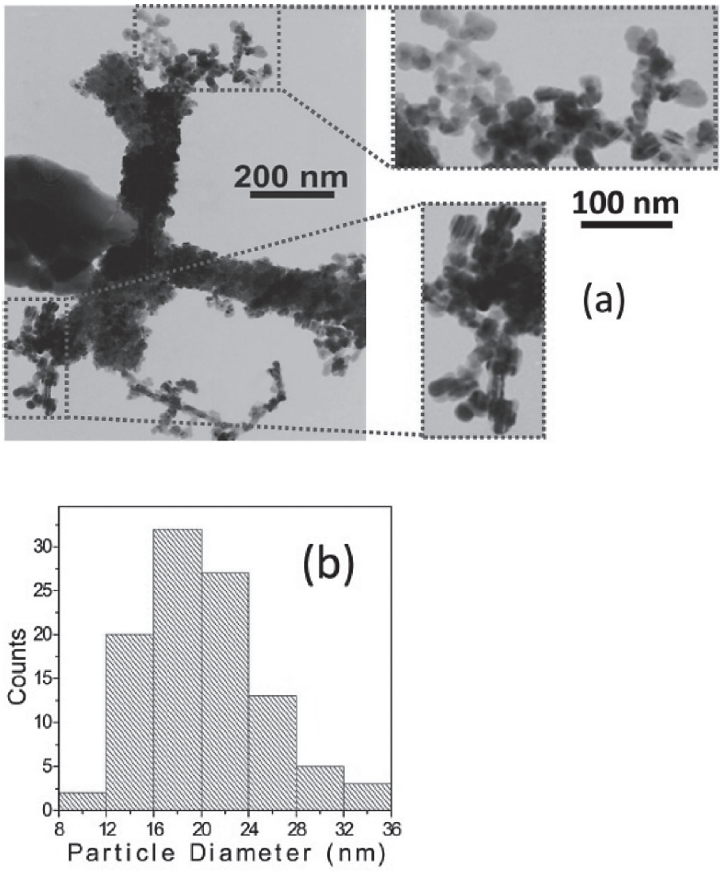


Figure 1. (a) TEM image of the samples annealed during 48h; (b) average size distribution of the isolated nanoparticles [26].

Figure 2

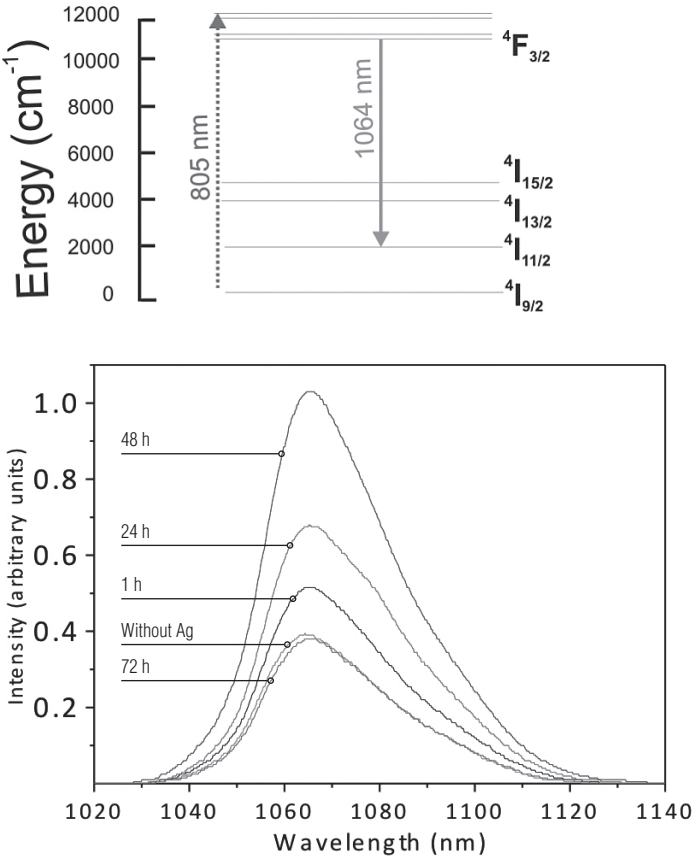


Figure 2. (a) Simplified energy level scheme of Nd3+ with indication of the transitions studied; (b) Emission spectra of Nd3+ studied samples, with and without silver nanoparticles, heat treated during different times: open circles (1 h), triangles (24 h), squares (48 h), full circles (72 h), stars (sample without silver nanoparticles) [26].

The present results demonstrated that Nd^{3+} doped GeO_2-PbO glasses with silver nanoparticles are potential materials as gain media for 1064 nm.

3.2 Intense and large bandwidth luminescence of GeO_2- Bi_2O_3 glasses with embedded silver nanoparticles

The influence of silver nanoparticles on the optical properties of GeO_2-Bi_2O_3 glasses was studied in order to investigate their applications in photonic devices, especially for the situations that require intense and large bandwidth luminescence [29]. Glasses containing bismuth oxide (Bi_2O_3) deserve large attention because of the broadband photoluminescence from 1000 to 1600 nm, due to bismuth ions [30-35] that allows optical amplification, laser action [36] and also new possibilities for optical communications. So, based on these results the main motivation for this work was to obtain a composite material with enhanced optical properties in comparison with the well-known GeO_2-Bi_2O_3 glass. So, following the procedure explained in the last section, germanate glasses with the starting composition 68GeO_2-32 Bi_2O_3 (in wt%) were prepared with and without silver nanoparticles. However, in this case, the samples prepared with 1.0$AgNO_3$ (in wt%) were heat-treated during 1, 12 and 24 h at 420 °C to thermally reduce the Ag^+ ions to Ag^0 and to nucleate the silver nanoparticles as already explained above. Figure 3(a) shows TEM image of the sample with silver nanoparticles heat treated during 1h; figure 3 (b) show the size distribution of the silver nanoparticles where we can observe average diameter around 20 nm. The absorption spectra of the samples prepared with and without silver nanoparticles are shown in Figure 4. We observe that the sample without silver nanoparticles presents a band centered at 500 nm related to divalent bismuth ions ($Bi2^+$), as reported for other Bi-doped glasses.[37-38]. A large broadband in the blue-orange region with an amplitude that increases with the increase of the heat-treatment time is observed for the samples with $AgNO_3$ in the starting composition. This effect can be attributed to the localized surface plasmons band associated to the silver nanoparticles.

The evidence of the large volume fraction of the silver nanoparticles explains the 7-fold increase observed in the absorption band. Figure 5 presents the photoluminescence spectra of the samples excited at 808 nm where we observe a strong band from 1000 to 1600 nm, centered at 1300 nm attributed to the Bi+ luminescence centers. A red-shift of the infrared band for the samples with silver nanoparticles can be observed in Figure 5a. For the sample heat treated during 1 h the infrared band shifted to 1250 nm, whereas for longer heat treatment times the band shifted to 1220 nm. This effect already observed in previous work [39] is probably related to changes of the local environment of bismuth in the glass structure, due to the nucleation of silver nanoparticles. Enhancement of 100% of the photoluminescence intensity can be seen at 1300 nm comparing the samples with and without silver nanoparticles, attributed to the local field growth in the vicinity of the silver nanoparticles. Quenching was observed for heat treatments of longer periods probably due to the larger number of silver nanoparticles nucleated and the reduction of the distances between the silver nanoparticles and the luminescence centers [27]. The present results demonstrates the potentiality of GeO_2-Bi_2O_3 glasses to be used for color filters in the blue-orange spectral region as well as for devices requiring intense and large bandwidth luminescence in the 1200-1600 nm region. The important role of the silver nanoparticles deserves attention because of the 7-fold increase observed for the linear absorption band in the blue-orange region and the 100% enhancement of the infrared region photoluminescence. These aspects of the GeO_2-Bi_2O_3 glasses optical performance are relevant for the future generation of photonics devices.

Figure 3

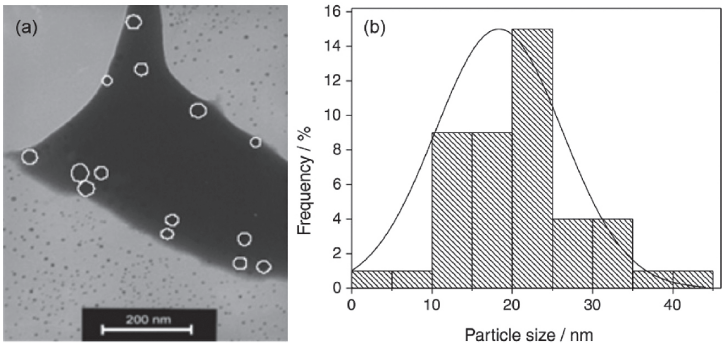


Figure 3. (a) TEM image of $68GeO_2 – 3_2Bi_2O_3$ glass with silver nanoparticles, heat treated during 1 hour, at 420°C; (b) size distribution of the silver nanoparticles [29].

Figure 4

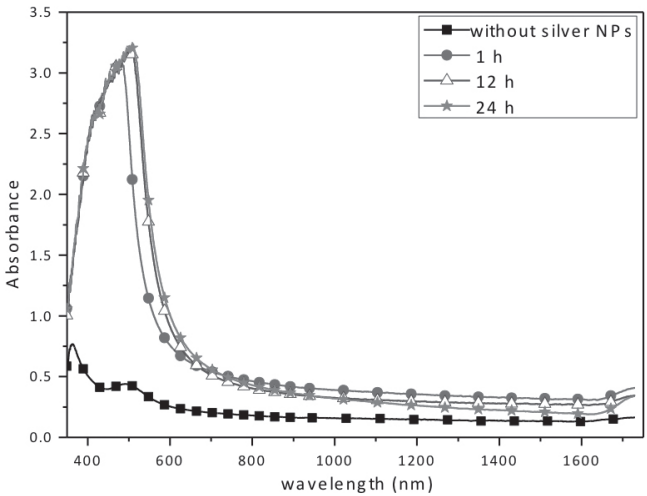


Figure 4. Room temperature absorption spectra of the $68GeO_232Bi_2O_3$ (in wt%) glass with and without silver nanoparticles. Sample heat-treated during: 1 h (solid circles); 12 h (triangles); 24 h (asterisks). The spectrum of the sample without Ag-nanoparticles is shown for reference (squares). Samples thickness: 2.0 mm [29].

Figure 5

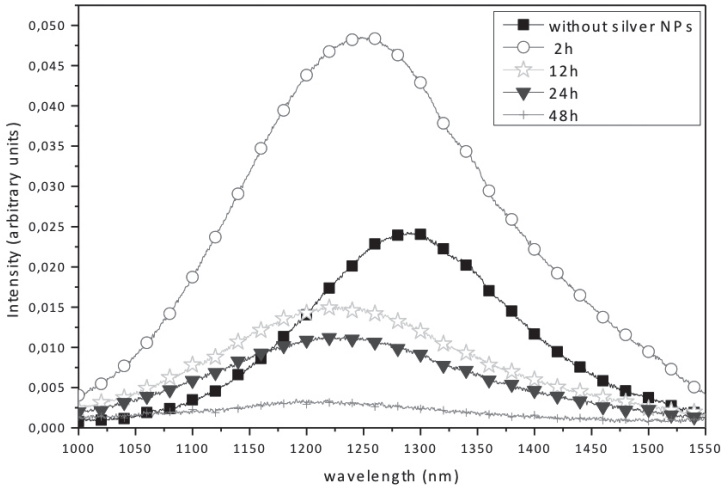


Figure 5. (a) Photoluminescence spectra of the $68GeO_2 32Bi_2O_3$ (in wt%) glass with silver nanoparticles, excited at 808 nm, for different heat-treatment intervals: 2h (open circle), 12h (star), 24h (solid triangle) and 48h (bar). The sample without silver nanoparticles (solid square) is shown for reference [29].

3.3 Production of photonic devices based on Er^{3+} / Yb^{3+} doped GeO_2_PbO rib waveguides with gold nanoparticles

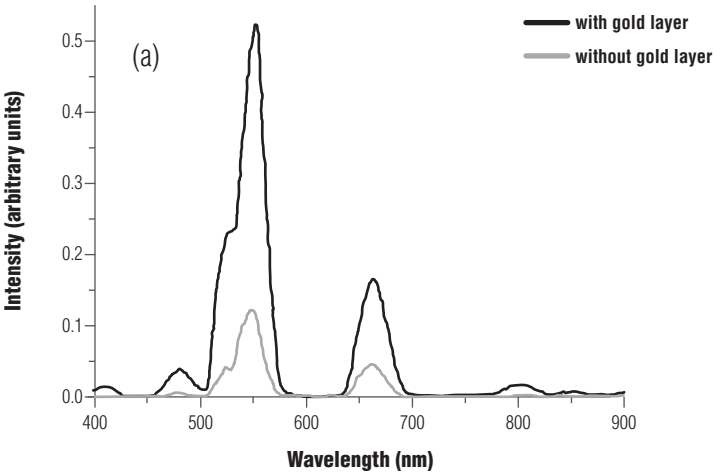
We review the fabrication of rib waveguide amplifiers produced using GeO_2-PbO glass codoped with Er^{3+}/Yb^{3+} [18] RIB waveguides were obtained with amorphous thin films produced by RF-sputtering as explained in the Experimental detail section. Two kinds of targets were sputtered simultaneously to produce the amorphous thin films: a Yb_2O_3-Er_2O_3 target and a glass target with composition (in wt%): $40GeO_2$ –60PbO. The rare earth doped germante films were deposited on a silica layer formed on previously oxidized silicon wafers that

were placed at 15 cm from the targets and after the sputtering process, the films were heat-treated under different temperatures and time intervals in order to become transparent. Films with high adherence to the substrates and high mechanical strength were obtained. Conventional optical lithographic processing, followed by Reactive Ion Etching (RIE), was performed to fabricate RIB-waveguides with 4 μm width, thickness of 1.6 μm and length of 1.5 cm. Layers of gold nanoparticles, obtained by RF sputtering with 5–7 W, applied to a gold target using 5 mTorr of argon during 15 min were used to cover the some RIB-waveguides.

The films photoluminescence bands associated to the Er3+ ions transitions centered at 40, 480, 520, 550, 670, 800, 850 and 1550 nm were measured and are shown in figure 6. For the band at ≈550 nm, an enhancement factor larger than 400%, was observed in the sample with the gold layer. Despite the large difference between the emission and the localized surface plasmon resonance frequencies, enhancement of ≈30% was observed in the infrared. The propagation losses in the Er^{3+} /Yb^{3+} codoped waveguides at 633 and 1050 nm as a function of the waveguides width are presented in figure 7(a); the minimum losses were ≈5.0 and ≈1.0 dB/cm for 633 and 1050 nm, respectively. Figure 7(b) presents optical gain curves as a function of the excitation power coupled in the waveguide. For a waveguide without the gold layer it was observed maximum internal gain of ≈3 dB (2 dB/cm) whereas in the presence of gold layer the gain reached ≈6.5 dB (4.3 dB/cm). Figure 8 (a) shows details of the waveguide with the gold nanostructured and figure 8(b) the SEM image of the waveguide covered with the gold layer. The AFM analysis of the waveguide is presented in figure 8 (c) and reveals that the gold layer is actually a nanostructured thin film composed of islands having diameter of ≈20 nm and height of ≈10 nm. The gain enhancement is correlated to the photoluminescence enhancement being attributed to the local field growth in the vicinity of the nanoparticles. The optimum distance the rare earth ion and

the nanoparticles for photoluminescence enhancement is normally ≈15 nm; quenching may occur when this distance is smaller than 5 nm [27]. We remark that only 1.3% of the germanate thin film is under influence of the gold nanoparticle layer, considering that the range of influence of the gold layer is ≈20 nm. These results indicate that the losses due to ohmic dissipation in the gold layer were small, as most of the optical field was confined to the germanate core. In summary we observed enhancement of the photoluminescence and optical gain at 1.53 μm due to the presence of gold nanoparticles deposited on the RIB waveguide. As far as we know this is the first observation of photoluminescence enhancement and optical gain at 1.53 μm due to the presence of gold nanoparticles deposited on the RIB waveguide. The processes used in the present study represent an important contribution for future applications in integrated optics and opens new roads for the waveguides fabrication with metal nanoparticles.

Figure 6



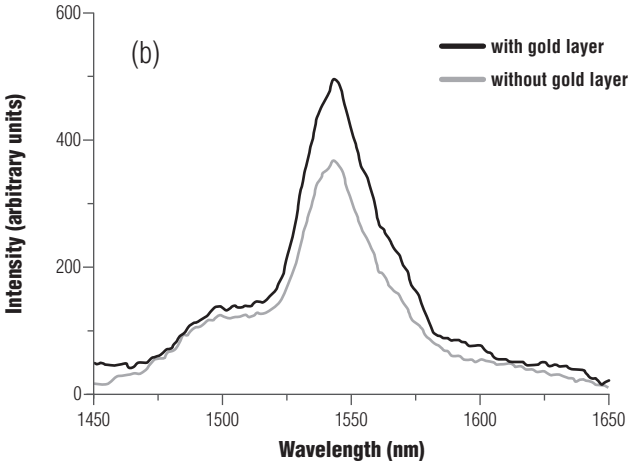
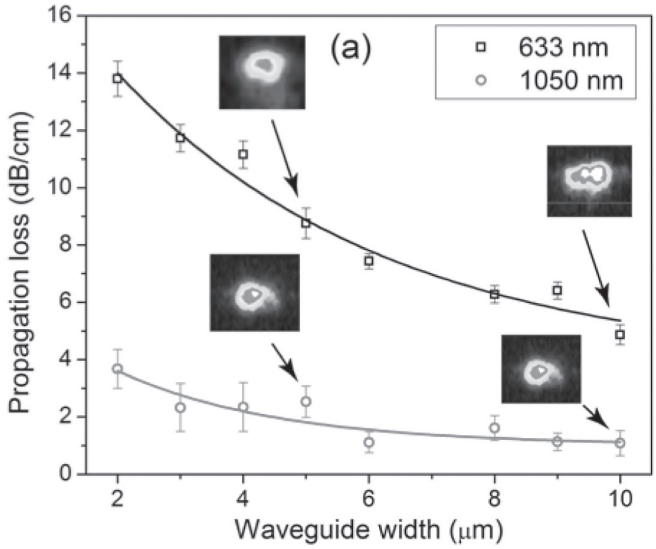


Figure 6. Emission spectra of Er^{+}/Yb^{3+} germanate thin films under excitation at 980nm in (a) visible and (b) near infrared regions [18].

Figure 7



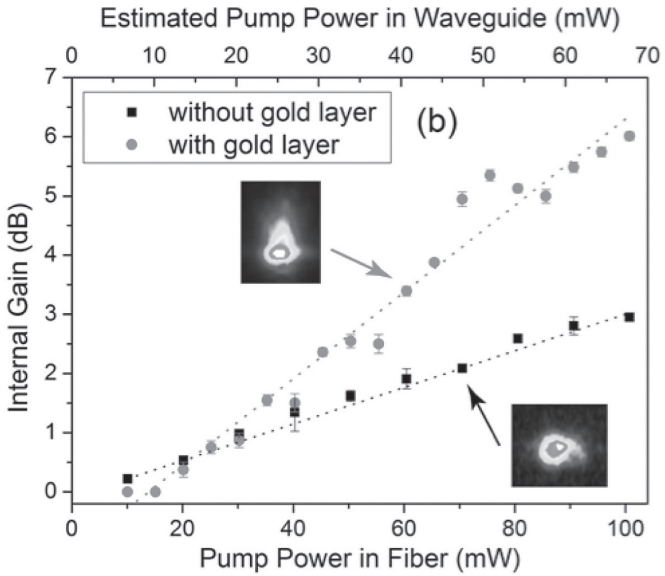


Figure 7. (a) Propagation losses for Er^{3+}/Yb^{3+} codoped PGO waveguides as a function of waveguides width. Insets show the near-field profiles for four waveguides. (b) Optical gain as a function of pump power. The pump and signal wavelengths were 980 and 1530 nm, respectively. The inset shows the near field profile at 1050 nm, at the end of the waveguide with the gold nano layer [18].

Figure 8

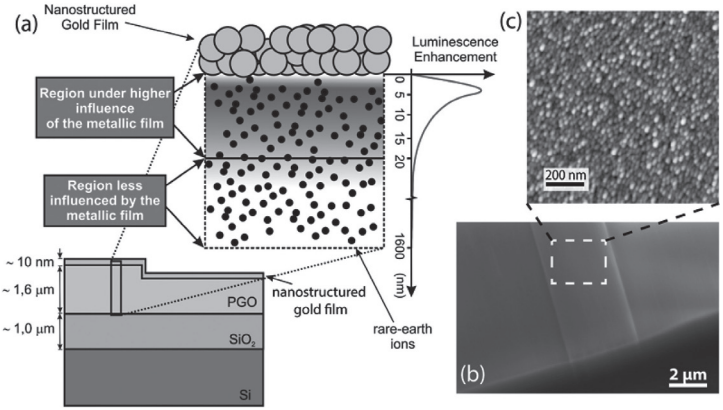


Figure 8 (a) Schematics showing the details of the waveguide with the gold nanostructured thin film. (b) SEM micrograph of the waveguide with the gold nanolayer. (c) AFM analysis of the waveguide, showing the details of the nanostructured gold layer deposited on the waveguide core [18].

3.4 Advances on the fabrication process of GeO_2 – PbO pedestal waveguides amplifiers to be used in the third telecommunication window

We review fabrication, passive and active characterization of Yb^{3+}/Er^{3+} codoped GeO_2– PbO pedestal waveguides [19]. We show the advances obtained in pedestal fabrication by comparing waveguides produced under different processes parameters.

The processes development for the definition of the waveguide core is very important, since the resulting geometry of the device has great influence on its performance [40]. There is a lack of studies concerning methodologies for Erbium Doped Waveguide Amplifiers (EDWA). The search for new materials and geometries for waveguide amplifiers is still necessary and, in this context, pedestal waveguides are very promising, since their fabrication does not involve etching of the core layer

[41]. For pedestal waveguides, reactive ion etching (RIE) occurs before the core definition It represents an alternative method for achieving the lateral confinement in optical waveguides fabricated with silicon technology and an advantage when compared to the one used to produce rib waveguides [24] as the material used as core layer does not need to be submitted to etching procedures, simplifying the fabrication process of the optical waveguides. We remark that the interest in pedestal-type waveguides [42] has emerged recently since they may present favorable characteristics for optical field confining. Waveguides based on Yb^{3+}/Er^{3+} codoped GeO_2–PbO thin films were produced in a silicon wafer substrate using conventional microelectronics fabrication techniques and following the procedure described above. Two different groups of waveguides entitled GP-A and GP-B were produced; figure 9 presents the steps used for their production.

SEM images of the waveguides are shown in Fig. 10. Core surface presented low roughness in both cases. However, pillar structures adjacent to the lateral surface of GP-A waveguide were observed that may be attributed to micromasking effect [43]; in these cases there are residues related to the incomplete removal of chromium mask layer that may contribute to the columnar growth of the subsequent film [44] and that are deleterious since their proximity to the optical field confined in the core layer may enhance propagations losses due to radiation leakage [45].

So the thickness of chromium mask layer was reduced by 70%, in comparison to the one used in GP-A, in order to reduce the amount of chromium residues after its removal. Also, the pedestal height was increased to 1.1 lm in GP-B (for GP-A waveguide this value was 0.9 μm) and the thickness of the core layer was reduced in GP-B to 0.39μlm (for GP-A this value is 1.1 μm). Figure 9 (b) shows that pillar structures were also present in GP-B waveguide, but differently from GP-A waveguide, they are isolated from the guided light in the core layer, since the thickness of the pillar structures is smaller than the SiO_2 pedestal thickness.

Figure 9

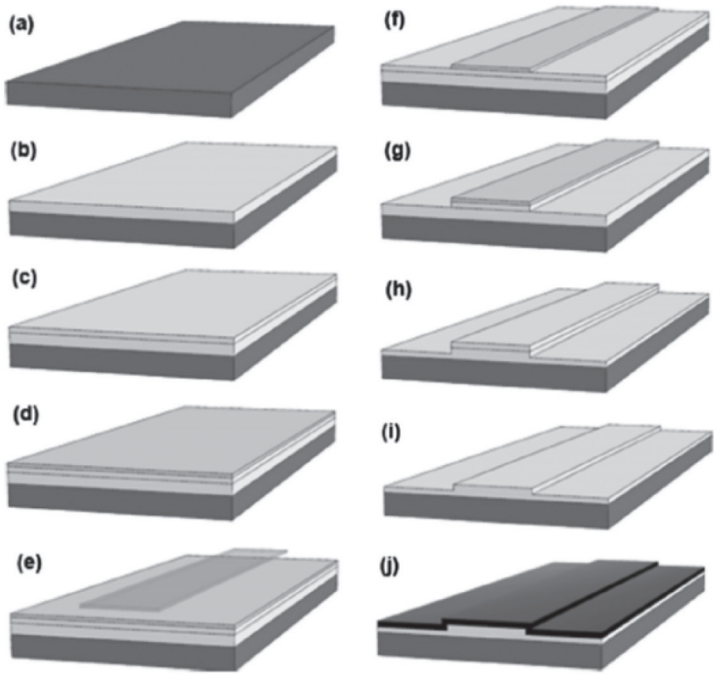


Figure 9. Schematic diagram of the pedestal optical waveguide fabrication process: clean silicon substrate (a); cladding layer deposition (b); chromium film deposition (c); photoresist deposition (d); revelation of the photoresist (e); photoresist mask definition (f); chromium mask definition (g); etching of the SiO2 (h); chromium removal (i);core deposition [19].

Figure 10

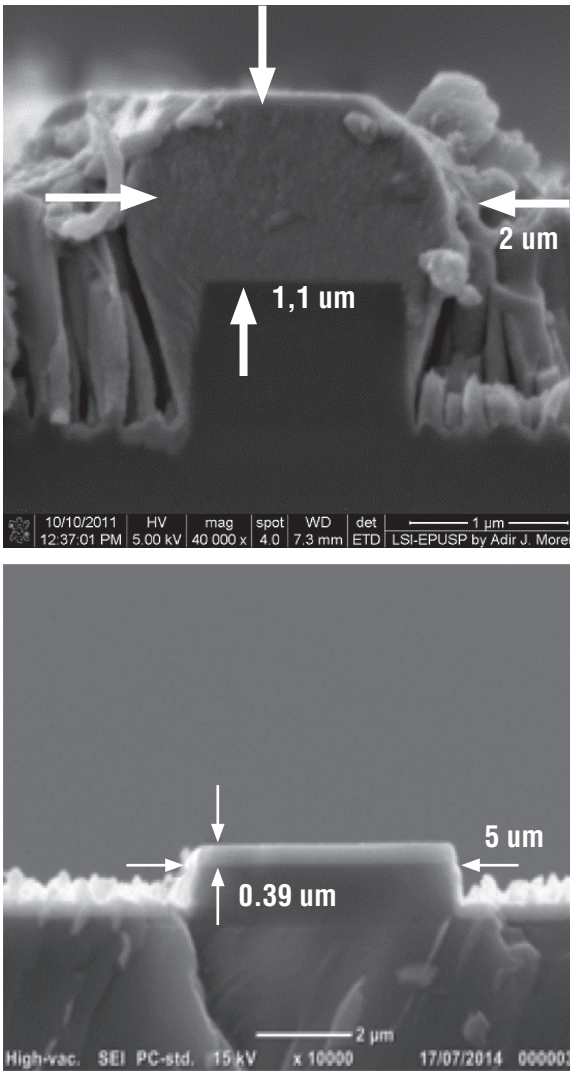


Figure 10. SEM images of (a) GP-A and (b) GP-B pedestal waveguides (values of width core and core height are shown) [19].

Figure 11

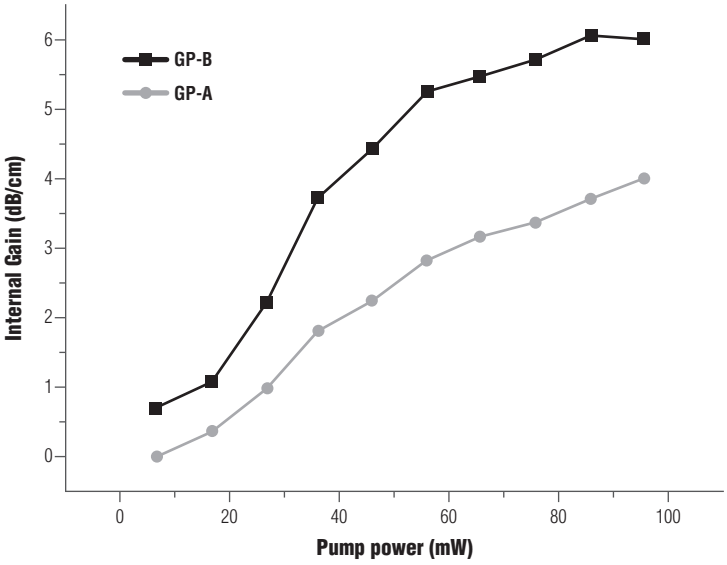


Figure 11. Internal gain for 70 μm width GP-A and GP-B pedestal waveguides [19].

The results of internal gain, at 1530 nm, under 980 nm excitation, as a function of the pump power, is presented in figure 11. The length of the measured waveguides was 1.5 and 1.0 cm for GP-A and GP-B waveguides, respectively and the maximum pump power was about 100 mW. We observed an internal gain of 4.0 dB/cm and 6.0 dB/cm for waveguides width of 70μm, for GP-A and GP-B, respectively.

The previous study of rib waveguides based in Yb^{3+}/Er^{3+} codoped GeO_2–PbO, following the same composition of the samples studied in this work, achieved a maximum internal gain of 2 dB/cm. We remark that, optical gain as high as 3.5dB/cm was observed for 12 μm width GP-B waveguides whereas internal gain for waveguides widths lower than 30 μm, could not be measured in GP-A waveguides, representing another advantage of the current process to fabricate pedestal waveguides.

In summary the improvement in the fabrication processes as the modification in chromium mask deposition/removal and increase in pedestal height, contributed to minimize radiation leakage and to enhance the internal gain (~50%) that reached 6.0 dB/cm. So pedestal waveguides can be used as optical amplifiers at 1530 nm, with advantages to rib waveguides that normally use more complex etching procedure. This is the first demonstration of Yb^{3+}/Er^{3+} codoped GeO_2–PbO pedestal waveguides to be used as optical amplifiers at 1530 nm.

4. Conclusion

We presented a review of recent results related to metal dielectric composites based on germanate materials with metallic nanoparticles for photonics. The influence of metallic nanoparticles on the photoluminescence properties of Nd^{3+} doped GeO_2-PbO glasses was reviewed. The contribution of the nanoparticles to enhance Nd^{3+} luminescence at 1064nm, because of the influence of the large local field on the ions positioned in the vicinity of the nanoparticles, was clearly observed. Also the role of metallic nanoparticles was investigated on the optical properties of GeO_2-Bi_2O_3 glasses in order to study their influence on the Bi^{+} luminescence centers. For both cases it was observed enhancement around 100% or higher with respect to the sample without silver nanoparticles. The herein results show that germanate glasses are suitable hosts for the nucleation of silver nanoparticles and can be used with success in luminescent devices that operates at 1064 nm and in those that require intense and large bandwidth luminescence in the 1200-1600 nm region. Demonstration of the potential use of GeO_2-PbO waveguides for integrated photonics in the optical communication range was also reviewed in waveguides with different core geometries: rib and pedestal. The waveguides were produced with thin films fabricated by the sputtering technique followed by optical lithography and reactive ion etching process. So it was reviewed the first observation of photoluminescence enhancement and optical gain at 1.53 μm due

to the presence of gold nanoparticles deposited on the RIB waveguide.

Also results of pedestal waveguides were reviewed. The improvement in the fabrication processes as the modification in thickness core, chromium mask deposition/removal and increase in pedestal height, contributed to minimize radiation leakage and to enhance the internal gain (~50%) that reached 6.0 dB/cm. So the demonstration of the use of pedestal waveguide as optical amplifiers at 1530 nm, with advantages to rib waveguides that normally use more complex etching procedure, was reviewed.

This review shows that metal dielectric composites based on germanate materials are promising for photonics devices that operate in the infrared region.

Acknowledgments

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