The Effects of Innovation on Manufacturing Competitiveness of the Leading Countries in the Automotive Industry

Rolando Rodríguez Alanis
Industrial and Systems Engineering Program
University of Monterrey
Nuevo Leon, Mexico
rolandordz@me.com

Luz María Valdez de la Rosa
Engineering Management Program
University of Monterrey
Nuevo Leon, Mexico
luz.valdez@udem.edu

Fernando González-Aleu González
Engineering Department
University of Monterrey
Nuevo Leon, Mexico
fernando.gonzalezaleu@udem.edu

María Teresa Verduzco Garza
Engineering Department
University of Monterrey
Nuevo Leon, Mexico
teresa.verduzco@udem.edu

Abstract

The purpose of this research is to identify and explain the dimensions of innovation that have effects on the manufacturing competitiveness in the automotive industry through a systematic literature review. The definition of the leading countries is based on three different rankings: 1) automotive industry, gathered through the figures publicized by the *Organisation Internationale des Constructeurs d'Automobiles (OICA)* which are then translated into rankings of the industry*;* 2) manufacturing competitiveness rankings based on the Global Manufacturing Competitiveness Index (GMCI) and 3) global competitiveness and innovation, based on the ranks issued by the World Economic Forum (WEF). The final list of such leading countries is then used to develop a regional comparison of available scientific literature gathered through a systematic literature review. Analogously, the quality of the papers found is assessed based on the SCIMAGO Journal & Country Rank to determine which papers are to be used to identify the factors of innovation previously mentioned; leading to the creation of a quality assessment per country of affiliation. Finally, the effects of the different dimensions of innovation are identified in the papers that provided the best quality and that belong to such countries to ensure relevancy.

Keywords
Innovation, Competitiveness, Automotive Industry, Manufacturing

1. Introduction.

Research from the *Organisation Internationale des Constructeurs d'Automobiles* (denominated further as OICA) has demonstrated that automobiles are a representation of economic growth, being propellers of technology development globally. Automobiles provide access to markets, services and interactions and nearly every car trip involves either an economic transaction or some other benefit to quality of life directly or indirectly, this is why it is stated that the auto industry is the single greatest engine of economic growth in the world (*Organisation Internationale des Constructeurs d'Automobiles*, 2017). To put this industry in a scalable perspective and to understand its importance in numbers, the OICA (2017) states that if the auto manufacturing industry was considered as country, it would be the sixth largest economy worldwide. The automotive industry is remarkably competitive, risky and usually characterized by its high-investments. It recurrently undertakes new challenges and constantly demands for new methods to decrease costs and increase production; all of this to obtain a competitive advantage. In the last years, this industry has put its focus on scale and sizing strategies to stay successful in such a fierce environment. This has led to a very important consolidation of vehicle manufacturers and their suppliers. Nowadays, the manufacturers handle a range of brands which are unique. Thus, a need for higher levels of efforts arises as they transfer large quantities of their production and assembly resources to their suppliers (Isac, 2009).

On the other hand, there is a Global Manufacturing Competitiveness Index created by the renowned Deloitte Global in conjunction with the Council on Competitiveness in the US. According to this index, a strong manufacturing sector creates a clear path toward economic prosperity, influencing on infrastructure development, job creation, and contribution to gross domestic product (GDP) on both overall and per capita basis (Giffi, 2016). Similarly, Giffi (2016) states that manufacturing related activities among global nations are rapidly evolving. Manufacturing activities stimulate economic prosperity, pushing countries to increase their focus on developing advanced techniques and capabilities, investing heavily in cutting edge infrastructure and research. Both nations and firms are attempting to break the current paradigms of technology and improve their economic welfare. As digital and physical dimensions merge, advanced technologies have become fundamental pillars for competitiveness. Moreover, technology-intensive sectors are proven to dominate the global manufacturing landscape in most advanced economies and offer a way to achieve or sustain manufacturing competitiveness (Giffi, 2016).

The report published by the World Economic Forum & Deloitte Global (2012), illustrates that innovation, infrastructure, and energy consumption are key areas of focus in which countries and companies in the manufacturing industry should focus on and brace to confront in the upcoming years. In this same report, it is stated that companies and countries that can attract, develop and retain the highest skilled talent are the ones that can innovate to stay ahead of competition and those that can find clean energy schemes and policies will come out on top of the others. The secret of success in these areas is the collaboration between governments and private sectors (World Economic Forum & Deloitte Global, 2012). All the previous facts lead to the assumption that in order to survive in the automotive industry, companies (whether small, medium or big) need to be competitive, therefore core competency tools and innovation are needed to remain competitive (Isac, 2009).

The definition of the leading countries in the automotive industry is a key step for the set-up of this investigation. In this regard, an investigation of the country rankings in the industry is made given the data from the Global Manufacturing Competitiveness Index in the 2016 version and in the projected 2020 version (Giffi, 2016). Likewise the rankings of the automotive industry are based on the manufacturing and financial figures for 2016 provided by the OICA (2017). Additionally, a research on the rankings of the World Economic Forum (2017) on the countries' global competitiveness, innovation & sophistication are collected to define the leading countries in the automotive industry drawing a relationship from all these rankings in the industry with global competitiveness and innovation.

Based on all the aforementioned ranks, a list of 30 leading countries with most mentions in the top 20 positions per rank is made and further correlated visually with the innovation and competitiveness factors to prove their relevance as shown in the following table 1. Green colour is used to show the best ranking, while yellow colour is used to display medium and white colour is used to refer to the lowest rankings; the data is sorted by mentions, then by the competitiveness and innovation ranks.

Table 1: Leading Countries and correlation to innovation, competitiveness and automotive industry

Position	Country	Amount of Times in TOP 20 Ranking (out of 6)	WEF Global Competitiveness Rank	WEF Innovation and sophistication factors Rank	WEF 12th pillar: Innovation Rank
1	United States	6	3	2	4
2	Germany	6	5	3	5
3	United Kingdom	6	7	9	13
4	Japan	6	8	4	8
5	Canada	6	15	25	24
6	South Korea	6	26	22	20
7	China	6	28	29	30
8	India	6	39	30	29
9	Sweden	5	6	5	6
10	Poland	5	36	55	60
11	Turkey	5	55	65	71
12	France	4	21	15	17
13	Spain	4	32	34	38
14	Indonesia	4	41	32	31
15	Italy	4	44	28	32
16	Brazil	4	81	72	100
17	Malaysia	3	25	20	22
18	Thailand	3	34	47	54
19	Mexico	3	51	50	55
20	Switzerland	2	1	1	1
21	Singapore	2	2	12	9
22	Taiwan	2	14	17	11
23	Belgium	2	17	14	15
24	Austria	2	19	11	14
25	Czech Republic	2	31	35	37
26	Vietnam	2	60	84	73
27	Slovakia	2	65	57	68
28	Egypt	2	115	111	122
29	Australia	1	22	27	26
30	Russia	1	43	66	56

The problem to be addressed in this investigation is defined on the basis of understanding the reason why some nations or regions are more competitive than others regarding the automotive industry, digging up to find which conditions are enablers for global corporations or local businesses to innovate and grow. There is a gap in the literature that shows a lack of integrated knowledge from different sources to link innovation with manufacturing competitiveness of the leading countries in the automotive industry. Consequently, the problem identified through the preliminary review of the literature is to find and link researches that illustrate how innovation boosts manufacturing competitiveness of the leading countries in the automotive industry. Since the automotive industry has been at the forefront of the globalization process as a result of increasing global design and manufacturing (Lucato, Júnior, Vanalle & Arantes Salles, 2012), it is very important to explore the factors that affect its competitiveness, and in this case especially: innovation.

Therefore, the general objective is to find which dimensions of innovation have effects on the manufacturing competitiveness of the leading countries in the automotive industry through a systematic literature review of scientific journals and studies. The specific objectives that support the accomplishment of the aforementioned general objective are: 1) Create a regional comparison between the leading countries in the automotive industry on manufacturing competitiveness and innovation and the amount of scientific literature produced; 2) Develop an analysis to identify which regions provide the best quality of scientific literature on the topics of innovation and competitiveness within the automotive industry; and 3) Identify the innovative dimensions used in the automotive industry by the leading countries to boost manufacturing competitiveness. Based on the research articles, journals and the research question, the proposed hypothesis for this investigation is the following: Innovation and its dimensions have an impact on the manufacturing competitiveness of the leading countries in the automotive industry. The automobile industry has been an important component of industrial and economic progress and its development has characterized global competitiveness of leading industrialized economies. It is fairly developed and involves huge investments in research and development and technology and is seen as an indicator of the economic progress of the country (Dangayach & Deshmukh, 2001).

The size of this sector in Europe is enormous as it is the largest automobile manufacturing market in the world given that close to one quarter of all cars in the world are manufactured in Europe (Ahmadinia & Karim, 2016). Furthermore, the future viability of the global automotive sector relies on its ability to stay competitive in regards of

size and operations at the same time as being responsive enough to the demands of customers. Equally, a justification for extending the focus also into the Asian market is "because China's large market draws many foreign automobile actors, how to be successful in the competition in China is an essential question for Multinational Enterprises (MNE)" (Min, 2005). Finally, the competition in China's automobile industry is from both domestic and foreign firms. According to Min (2005) there are more than 130 car factories, supplied by more than 3,000 companies delivering parts; covering almost as much as that of the United States, Europe, and Japan together. Nevertheless, the internal production remains below any of these big producer countries, hence its importance on this research.

2. Methodology.

A strict selection of published scientific papers through a search protocol with a defined scope and order of execution is made; the methodology, based on the work of Espitia, F. f., Sánchez, J. j., & Galvis, E. e. (2016): "Systematic Literature Review of the Implementation of Knowledge Codification Process" consists of the following steps: 1) Search strategy and process; 2) Inclusion and exclusion criteria; 3) Quality assessment; and 4) Data extraction. Data recollection is made through the use of three different tools from three different universities accessible through the author's enrolment in universities and personal resources: *Universidad de Monterrey*; *Ecole Supérieure des Sciences Commerciales d'Angers* and; University of Ghent. In the following subsections, these steps will be described.

2.1 Search strategy and process.

All the information is gathered from scientific literature based on peer reviewed journals. Based on the research question stated in previous section, a search equation is defined, which is then evaluated and redefined with different terms and keywords allowing the final search equation to be used to find the material in the databases. The equation used is the following: (Innovation)+AND+(Competitiveness)+OR+(Competitive)+AND+(Automotive)+OR +(Auto)+AND+(Manufacturing). This equation filters the database to only display articles referring to innovation, competitiveness, competitiveness, automotive or auto and manufacturing. After this, a wide range of filters, which will be explained in detail in the following section 2.2, were applied on year, integral texts and academic reviews, a variety of subjects contained within the equation languages, different sectors and publishers. Subsequently, a database is created to organise the articles that are to be revised manually in section 2.3. This tool will help to revise articles in the following dimensions: Quality criteria (Q1 or Q2 on the SCIMAGO Journal & Country Rank rating); publication information; country of affiliation; keywords; and abstracts in order to organise the information and to identify the relevant articles.

2.2 Inclusion and exclusion criteria.

The search with the previously defined equation gave approximately 84,920 results. Then, it was refined to only show integral texts and academic reviews (approved by a lecture committee), finding 74,820 and then 3,973 articles respectively. Next to this, the search was limited to the year of 2011 onwards taking into consideration the major global changes in innovation and economy that happened after the 2009 crisis. These further limitations yielded 1,353 results. An additional language filter was applied to only show results in English, German and Spanish; after this filter was added to the previous filters and using the search equation, 1,162 results were obtained. After the previous filters, a filter on type of source was applied to only show results from Journals and University Reviews. The amount of results obtained after these filters was 1,131 articles. Additionally, the filter on Subject: thesaurus term was applied, yielding 870 articles. Successively, a filter per Publication was applied, limiting the amount of articles to 310. Finally, a filter was applied per Sector/NAICS. After this filter was added to the previous filters and using the search equation, a final amount of 122 results were obtained.

2.3 Quality assessment.

The screening was performed manually with the use of the aforementioned database created in MSO Excel, which served as an analysis tool. The relevant articles were selected on the basis of their abstracts, key words and adequacy to the research's objective. At the end, a total of 21 papers were selected for data extraction.

2.4 Data extraction.

The 21 documents were inserted in a database that helped visualize the keywords and most relevant information in their abstracts. The information gathered from these articles was extracted manually and cross-checked with the

content of each article. The results are presented in section 3, in which they are grouped by general results and per hypothesis.

3. Results.

This section is divided in four categories presenting first the overall findings of the literature review and then digging further into the accomplishment of the three specific objectives set for this research:

1. Create a regional comparison between the leading countries in the automotive industry on manufacturing competitiveness and innovation and the amount of scientific literature produced.
2. Develop an analysis to identify which regions provide the best quality of scientific literature on the topics of innovation and competitiveness within the automotive industry.
3. Identify the innovative dimensions used in the automotive industry by the leading countries to boost manufacturing competitiveness.

3.1 General findings.

Innovation is vital for the companies in the automotive industry to survive in the long term. Understanding the fundamentality of continuous innovation is crucial for firms in order to remain competitive (Townsend & Calantone, 2014). In addition, Bhamra & Bhamra (2011) agree that innovation is one "distinctive capability" that a company can develop in order to remain competitive. Likewise, Kraft & Kraftova (2012) further state that science, technology and innovation are often considered as the main driving forces of development and economic growth, asseveration concurrent with the information provided by the authors in the preliminary literature review. Consequently and according to Townsend & Calantone (2014), comprehending the phenomena linked with the process of innovation within the automotive industry is vital and will provide far-reaching results. Additionally it is stated that the globalization of the automotive industry has introduced major variations into the means by which products are developed as well as affecting where innovations are born and how they correlate with the environmental market conditions, affecting the nature of their conception and application; thus, innovation can take a wide range of forms that adapt to the challenge to overcome, whether achieving less emissions, providing more safety, reliability, speed, etc. (Townsend & Calantone, 2014). Similarly, Basile (2012) states that the role of cooperative research & design in the enhancement of a company's competitiveness has been a topic widely investigated by the management literature, mainly because of the increasing intensity and competition worldwide due to globalization. Basile (2012) also remarks that entrepreneurial competencies and internal resources alone are insufficient to achieve proper competitiveness levels; innovations must be introduced.

On the other hand, Kraft & Kraftova (2012) explain that socio-economic processes are tightly related to the dynamics of technical and technological progress intertwined with science, research and development. Moreover, Lacka (2013) affirms that the European Commission has recognized and accepted that the key factors for overcoming recession and improving competitiveness are innovations and creativeness of companies. Globalization and the intensification of competitiveness have augmented the relevance of methods and measures for retention and increase in the competitiveness capabilities of every nation, articulating the need for a competitive advantage for countries to guarantee long term stable growth of economy (Navickas, Sujeta, & Vojtovich, 2011). Navickas et al. (2011) also mention that scientists make a distinction between two groups of factors of economic growth and competitiveness: general factors related to the business environment and specific factors related to each sector or activity. Furthermore, the World Economic Forum uses these factors adding a third group: innovation and sophistication factors, thus confirming the importance of innovation when assessing a country's competitiveness globally or on an industry scope (Navickas et al., 2011).

3.2 Regional comparison: Leading countries in the automotive industry on manufacturing competitiveness and innovation vs scientific literature available within the methodology.

After the leading countries were defined in Figure 3, an investigation on the available scientific literature was made to further prove that the leading countries in the automotive industry, which are globally competitive and have high innovation rankings, also provide high quality scientific literature. The results of this investigation can be seen in Table 2.

Table 2: Relation of Country Rank and Scientific Literature

Country	Amount of Times in TOP 20 Ranking	WEF Global Competitiveness Rank	WEF Innovation and sophistication factors Rank	WEF 12th pillar: Innovation Rank	Amount of Scientific Articles by Country of Affiliation	SCIMAGO Best Ranking of Most Papers

						Written
United States	6	3	2	4	13	Q1
Germany	6	5	3	5	6	Q1
United Kingdom	6	7	9	13	6	Q1
Japan	6	8	4	8	0	0
Canada	6	15	25	24	1	Q1
South Korea	6	26	22	20	6	Q1
China	6	28	29	30	26	Q1
India	6	39	30	29	13	Q1
Sweden	5	6	5	6	2	Q3
Poland	5	36	55	60	10	Q1
Turkey	5	55	65	71	4	Q1
France	4	21	15	17	2	Q1
Spain	4	32	34	38	19	Q1
Indonesia	4	41	32	31	0	0
Italy	4	44	28	32	13	Q1
Brazil	4	81	72	100	27	Q3
Malaysia	3	25	20	22	2	Q1
Thailand	3	34	47	54	3	Q1
Mexico	3	51	50	55	2	OoS
Switzerland	2	1	1	1	2	Q1
Singapore	2	2	12	9	0	0
Taiwan	2	14	17	11	7	Q1
Belgium	2	17	14	15	0	0
Austria	2	19	11	14	0	0
Czech Republic	2	31	35	37	6	Q1
Vietnam	2	60	84	73	0	0
Slovakia	2	65	57	68	0	0
Egypt	2	115	111	122	0	0
Australia	1	22	27	26	3	Q2
Russia	1	43	66	56	1	Q2

This table provides a graphical overview on the aforementioned factors for the 30 leading countries. The table is similar to Table 1, with the addition of the last two columns: the first column is the amount of scientific articles by country of affiliation: It refers to the quantity of articles found with the mentioned formula and restrictions in the methodology section, segmented per country by which the authors are mainly affiliated to. The second added column is the SCIMAGO best ranking of most papers written: This is the best ranking of SCIMAGO per country given the highest amount of papers written with that category. The findings will be presented per Category given the amount of times in which they appear in the top 20 places in all the six rankings of the automotive industry (first column).

Category 1: Countries with 6 instances on the top 20 places of the automotive industry rankings. It can be seen at first glance that the top rated countries in the industry, competence and innovation also produce a substantial amount of scientific literature with the given restrictions. United States, Germany, United Kingdom, South Korea, China and India score high on the amount of papers available (13, 6, 6, 6, 26 and 13 respectively) and with the top quality, being all of them ranked as Q1. Among these eight top Category countries, Japan is the only exception with zero articles found; this is probably due to some of the set restrictions (language, publisher, etc.) but needs further investigation to confirm this assumption. On the other hand, Canada has a high score on the industry and global competitiveness (15th place) but its place in the innovation rankings average (25th and 24th); it is concluded that this is the reason for its low amount of scientific literature produced (1) but its top quality (Q1).

Category 2: Countries with 4 – 5 instances on the top 20 places of the automotive industry rankings. This category shows also a substantial amount of produced scientific literature; namely almost half of the collected papers. It shows a congruence of results between the rankings and the literature produced. The only exceptions are Indonesia and Brazil; the first one has average rankings on competitiveness and innovation (41th, 32th and 31st), but zero articles related to that country were found, Brazil for its part presents the opposite situation, it scores low in the competitiveness and innovation ranks (81th, 72nd, 100th) but produced the highest amount of papers (27) within the Category, although with low quality according to the SCIMAGO ranking (Q3).
Another note would be that Sweden, the first place of Category 2 scores very high on competitiveness and innovation ranks (6th, 5th, 6th) and produced some scientific literature (2 papers) but the level is low (Q3).

Category 3: Countries with 1 – 3 instances on the top 20 places of the automotive industry rankings. Concerning the quantity of papers produced, the percentage shows a good distribution: 40,80% for Category 1, 44,25% for Category 2 and 14,94% for Category 3; thus confirming that the better the ranking, the more literature is produced. Finally,

regarding the average quality of the papers, the comparison between : 1,58 for Category 1 vs 2,25 for Category 2 vs 4,42 for Category 3 shows that indeed the leading countries provide better quality papers within the established research field and its parameters.

Table 3: Category Analysis Summary

Analysis dimensions	Category 1	Category 2	Category 3
Average Global Competitiveness of Category	16,38	39,50	35,64
Average Innovation And Sophistication Factors of Category	15,5	38,25	39,43
Average Innovation Rank	16,63	44,38	40,21
Average Amount of Literature	8,88	9,63	1,86
Average SCIMAGO Rank	1,58	2,25	4,42
Amount of Literature	40,80%	44,25%	14,94%
SCIMAGO Rank Q1 %:	41,18%	29,41%	29,41%
SCIMAGO Rank Q2 %:	0,00%	0,00%	100,00%
SCIMAGO Rank Q3 %:	0,00%	100,00%	0%
SCIMAGO Rank Q4 %:	0,00%	0,00%	0,00%
SCIMAGO Rank OoS%:	0,00%	0,00%	100,00%
SCIMAGO Rank 0 %:	12,50%	12,50%	75,00%

The results shown in the table 3 has congruence if taken into account the average competitiveness numbers: 16,38 for Category 1 vs 39,50 for Category 2 vs. 35,64 for Category 3 (this last one is biased to the lower bound by the presence of Switzerland and Singapore, which rank 1st & 2nd in global competitiveness). Similarly, the average innovation and sophistication factors: 15,5 for Category 1 vs 38,25 for Category 2 vs 39,43 (also biased by Switzerland ranking 1st place) for Category 3and average innovation rank: 16,63 for Category 1 vs 44,38 for Category 2 vs 40,21 (also biased by Switzerland ranking 1st place and Singapore ranking 9th) for Category 3.

3.3 Regional quality analysis of the available scientific literature within the automotive industry

The second specific objective is closely related to the analysis made in the previous section. The difference relies on the focus given to it, as it is to identify the regions that provide the best scientific literature, rather than classifying the countries by categories. The following figure 1 (in next page) shows the amount of papers per country categorized by the SCIMAGO quality ranking.

Firstly, it is important to understand that the country denominated “NCoA” in the x axis corresponds to an abbreviation for “No Country of Affiliation” and refers to the papers whose authors did not express a formal affiliation with any nation. It is especially important to direct one’s attention to the green and dark blue bars as they represent the top quality papers. It is evident that China excels in this area with 26 papers, all of Q1 level. Along with China, “NCoA”, Spain, United States, Brazil, Italy, Poland, Czech Republic, United Kingdom, Germany, South Korea, Taiwan, Colombia and India make up 80% of all the Q1 papers; the only country that is not in the defined leading countries but is in this list is Colombia, hence proving once again the accuracy of the definition and the relationship with innovation. It is needless to state the evident relationship between the countries that lead the industry and the percentage of top quality papers produced by them.

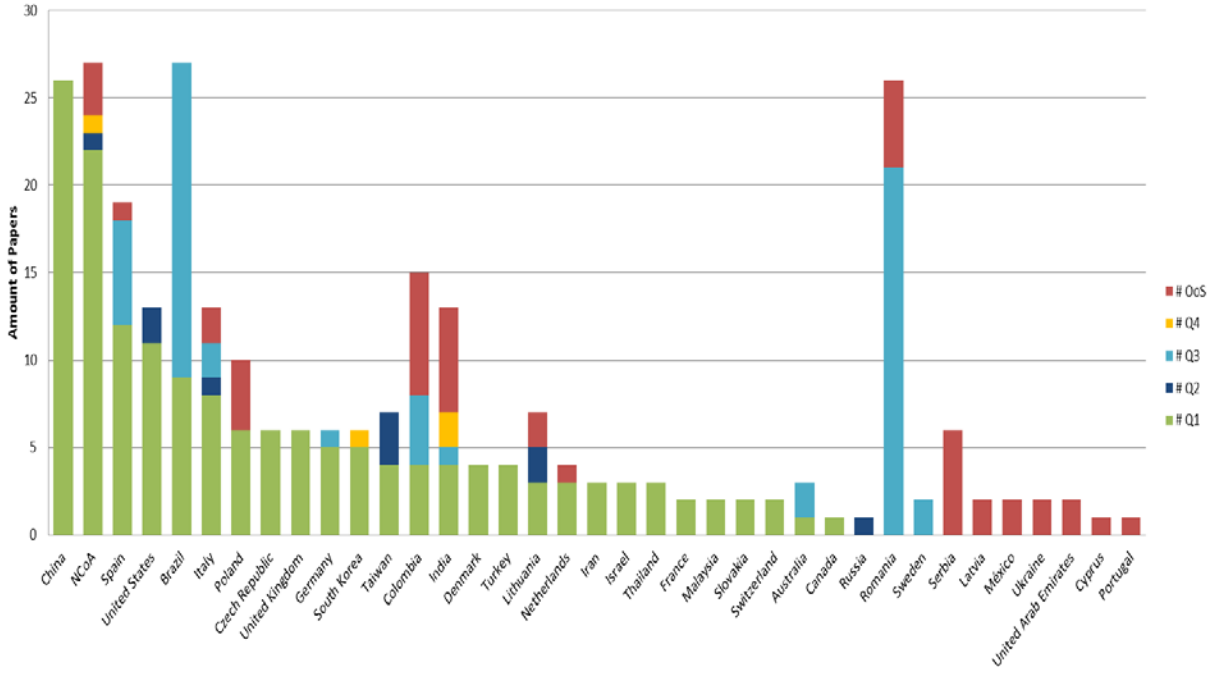

Figure 1: Papers per country categorized by SCIMAGO ranking.

It is also remarkable that the countries enlisted are the countries of affiliation of the authors of the articles obtained with the search procedure; therefore the following countries do not pertain to the defined leading countries list: Colombia, Cyprus, Denmark, Iran, Israel, Latvia, Lithuania, Netherlands, Romania, Serbia, Ukraine and United Arab Emirates. On the other hand, there are countries defined as "leading" but that do not figure in the list of articles gathered for reasons unknown: Japan, Indonesia, Singapore, Belgium, Austria, Vietnam & Egypt. Taking this into account, a radar chart was created to show the distribution of the papers and their quality among the leading countries that do exist in the list, filtering out the aforementioned countries that have scientific literature but do not pertain to the top places in the automotive industry. These are shown in the figure 2.

Figure 2: Distribution of papers among the leading countries of the automotive industry per quality level.

Then, these were classified by continent to show the actual distribution per region: Asia 33%; Western Europe 29%; North America 13%; Eastern Europe 13%; South America 4%; Oceania 4%; and No Country of Affiliation 4%. Additionally and going to specific information per continent, figure 3 shows the distribution of the different SCIMAGO ranks per continent.

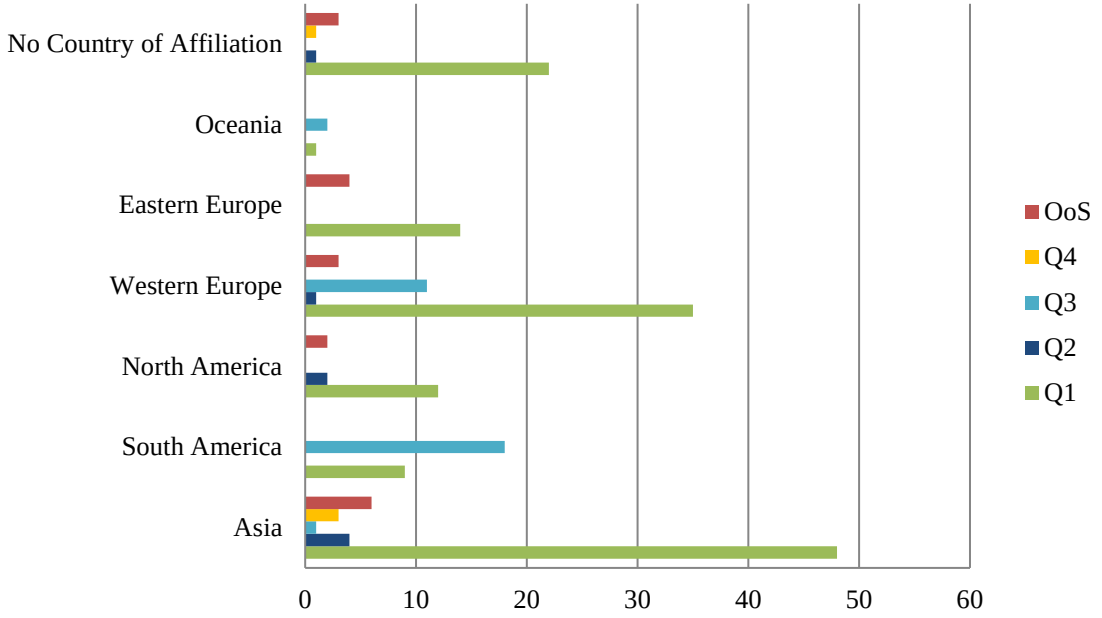

Figure 3: Distribution of SCIMAGO Rankings per Continent

3.4 Innovative dimensions used in the automotive industry by the leading countries to boost manufacturing competitiveness.

Throughout the literature review of the selected articles in the methodology section, the following dimensions of innovation were found to be present and recursive amongst the articles:

3.4.1 Product & process innovation.

According Townsend & Calantone (2014), advances in product innovation have an enormous impact in product and service categories and industries, as the case of the automotive industry. Consequently, product and process innovations exist and proliferate in this sector and have important implications in the individual, firm and society scopes. Product development is one of the most important and costly investment for car manufacturers. The product life-cycle management is one of the main factors that drive these costs given the substantial amount of resources and financial costs associated to it, nevertheless, it is vital for product acceptance in the market (Townsend & Calantone, 2014). Companies apply diverse strategies at each stage, remarkably in their location choice for production. Additionally, Fujimoto (2014) presents one of the most used frameworks to describe the dynamics of industrial innovation: the Abernathy-Utterback model of the industry life cycle. This model is also known as the product-process life cycle and it states that an industry starts with the invention of an unfinished but functional model, followed by a wave of numerous innovations that enhance its functionality. The consumers at this "fluid stage" tend to be fewer, richer, and product-function-oriented, rather than price-sensitive (Fujimoto, 2014). As products become more sophisticated, a highly competitive model is introduced into the market that uses all past product innovations called the dominant design. "The focus of competition then begins to shift from functional maturation to price-cost reduction as the competing models become less differentiated by functional-structural designs" (Fujimoto, 2014, p. 9) Additionally, Townsend & Calantone (2014) explain the reciprocal relationship between innovative product development and support infrastructure or externalities that are present in industries, being particularly applicable to the automotive industry (Townsend & Calantone, 2014). Another important element of this dimension is the relationship between the firms and their suppliers; research has shown the tight relationship between product co-design and innovation performance (Townsend & Calantone, 2014). Furthermore, Fujimoto (2014) claims that heavier investments in product-specific technologies and equipment become acceptable, and therefore a series of process innovations follow along with them, while product innovations come to be less recurrent. At this phase of the industry life cycle, products and processes are more standardized and equipment, materials and skills shift into

specifics of the product in question. Moreover, Fujimoto (2014) states that the traditional industry-life cycle model applies to some of the history of the automotive industry, but not to all of it. Therefore he presents an additional framework that explains the evolutionary patterns of this industry: the long tail of the automotive industry.

3.4.2 Regional innovation.
The regional dimension of innovation has become very important in scientific debate and innovation policy; the influence of local factors on regional innovativeness has been attributed to the concept of a "technological infrastructure" present in the different regions. The combination of the geographical dimension and the nature of innovation have led to a new research branch called "innovation systems approach" (Buerger, Broekel & Coad, 2012). One of the reasons companies become multinational is by the fact that the transfer of innovation from the home country to the host country is empowered and provides several benefits and competitive advantages (Colovic & Mayrhofer, 2011). Correspondingly, Buerger et al. (2012) declare that it is a prerequisite to know about the processes in order to design the appropriate regional innovation policies and Navickas et al. (2011) add to this stating that in globalization conditions for each country it is very important to increase the level of its economy competitiveness, determined by the evaluation of various indicators: infrastructure, macro environment, activity and intensity of the market, innovations and others. This means that high-employment regions benefit more from an increase in patents (innovation). For the automotive industry, the growth of employment is associated with subsequent growth of R&D (Buerger et al., 2012). Location is one of the key elements in the automotive industry and it is guided by several elements such as the proximity to the local markets, the obligation to produce locally or the willingness of MNCs to tap into the local knowledge (Colovic & Mayrhofer, 2011).

Colovic & Mayrhofer (2011) also evidence that multinational companies have made their R&D efforts international adopting a dispersed approach to the company's innovative capacity. Kraft & Kraftova (2012) express that given the increasing competitiveness from emerging markets, companies from the developed countries have begun to implement the following survival strategies: 1) Reduction in production costs and product sale price; 2) Increase in productivity and effectiveness by a developing and implementing of new, innovative production technologies and processes; 3) Production or other activities transfer from high costs localization to cost-effective ones; and 4) Implementation of product innovations. In concordance with Godlewska-Majkowska & Komor (2017), it can be said that the globalization and integration processes, affect the development of national economies and increase the level of competition; thus development factors like innovation should be implemented to maintain or increase their competitiveness.

3.4.3 Open (cooperative) innovation.
According to van Geenhuizen, & Soetanto (2013), R&D and innovation happen in networks beyond the boundaries of a single firm, with consumers having an important role in the learning processes. This occurrence is defined by the term open innovation, which encompasses cost reduction and increased competitiveness opportunities. Spatial innovation theory however indicates that the potential of open innovation is not the same for all urban regions (van Geenhuizen, & Soetanto, 2013). The same authors say that open innovation, can be referred to as the purposive use of inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively. This concept implies that firms can search for new knowledge anywhere from city level to the external environment level. Also Basile (2012) adds that collaborative networking may increase companies' competitiveness, favouring productivity and innovation (Basile, 2012). Basile also evidences that size has a positive and significant effect upon R&D cooperation, since large companies enjoy more absorptive capacity (Basile, 2012): The growing literature on clusters highlights the relevance of networks of interrelated firms as key factors in the ability to produce innovative new products or processes for global markets, in a timely manner. The "cluster" concept incorporates several important dimensions of innovation: the increasing benefits generated by the accumulation of knowledge; recognition of the fact that accumulation is a process dependent on past choices, and is nonlinear and shaped by the interaction of market forces; the importance of organizational innovation in creating institutions and procedures capable of managing more complex forms of interdependence; the role of confidence in avoiding the escalation of transaction costs generated by increased levels of specialization; and the role of cultural and institutional variety in encouraging creativity (Colovic & Mayrhofer, 2011).

Likewise, Lacka (2013) asserts that through technological cooperation with the scientists, entrepreneurs obtain the possibility to manufacture a new innovative product or technological solution for the market, being possible at a lower cost than in the case of independent research and development works. Such cooperation guarantees the access to the support of innovative activities from public domestic and foreign resources. Lacka (2013) also adds that the implementation of innovative solutions in this way makes it possible for industrial partners to: strengthen their competitive position; gain significant economic benefits in the form of a growth in revenues from sales, or reduce

the cost of business; obtain unique skills and competences; export innovative products and technologies; launch innovative products into new markets through the application of innovative solutions in other sectors of economy than before; obtain development opportunities as a consequence of taking up subsequent joint projects with researchers; and achieve ecological benefits such as reduction of raw material consumption, reduction of waste, industrial waste recycling, limiting negative external impacts.

3.4.4. Knowledge transfer.
In terms of knowledge development in the new product development process, this important contribution illustrates the need for capabilities on both sides of an equation. If knowledge development is to be successful, then both disseminative and absorptive capacity must be present in the collaborative relationship (Townsend & Calantone, 2014). The experience of the leading countries in innovation (Nordic countries, United States, Japan, South Korea, Singapore and Taiwan) demonstrates that the innovativeness growth in a country relies on strong relations between scientific and research institutions and enterprises, financial and nonfinancial institutions of knowledge transfer support and technology commercialization, as well as local and regional authorities (Lacka, 2013). There is evidence that such knowledge transfer is more successful if the recipient firm has absorptive capability (Schulze et al., 2014).

Nevertheless, the source firm's disseminative capability is proportionally related to knowledge transfer success, while knowledge application in the recipient firm is inversely proportional (Schulze et al., 2014). According to these authors, the disseminative capability dimension is important not only for knowledge transfer success within firms, it is also important in R&D alliances (Schulze et al., 2014).

3.4.5 Government & consumers.
Townsend & Calantone (2014) declare that the key to the innovation process is found within the influences of consumers and governments.

On the government side, new product development and process innovation are also being affected by the government with energy, safety and environment policies (Townsend & Calantone, 2014). Furthermore, governmental involvement through standards, regulations and taxation shapes future innovations (Townsend & Calantone, 2014) and proves that government intervention has been and still is a major driver for industry innovation, whether by taxation, standardisation (of the industry) or any other similar constraint (Townsend & Calantone, 2014). According to Hemphill (2014), an 'Innovation Policy' approach can best be described by the public policy intervention categories of setting the ground rules and direction and building enablers. In contrast, an 'Industrial Policy' approach can best be described by the public policy intervention categories of tilting the playing field and playing the role of principal actor. One necessary condition for launching products on the high-tech market is their compliance with international rules and regulations, as confirmed by an accredited international agency. On the high-tech market there are specific indicators of quality for each type of product at a given time (Katerinich, 2016).

On the consumer side, it can be said that consumers' expectations are increasing in regards of sophistication of technologies and are being unified throughout the globe. They demand either extraordinary design on the luxury market or extremely low costs for basic features at the average market (Townsend & Calantone, 2014). In modern markets, high-quality but inexpensive products are required (Battini, Persona & Sgarbossa, 2012) and much of the forecasted innovation is driven by the preferences dictated by the consumer demand (Townsend & Calantone, 2014).

3.4.6 Management & organisational culture.
Regarding the strategic management of enterprises, the authors Colovic & Mayrhofer (2011) state that for many years, R&D was kept at the headquarters and was internationalized to a limited extent mainly because of its strategic nature. In general, managers follow a consistent downward trend when it comes to R&D expenditures (Industrial Research Institute, 2014). New business projects remain a key driver of investment as they have been in the past, but this year's data suggest a sizeable decline in support for this area. Meanwhile, the positive forecast in collaboration efforts supports the notion that companies are continuing to participate in coordinated research initiatives and alliances, boosted by open innovation programs. The strategic direction of innovation policies is the creation of information support in the business structure, according to Belarus' example presented by Katerinich (2016). Conversely, there is a big division of opinions concerning the impact of process management on innovation, especially on radical innovation. Additionally, organisational ambidexterity (organizational capability to undertake incremental as well as radical innovation activities) has been emphasized as a strategic foundation of competitiveness (Moreno-Luzon, Gil-Marques & Arteaga, 2014). Nowadays, managers need to redefine their strategies, products and processes and drive their companies towards sustainable development along with the

creation of higher value and improved performance on global and local markets (Vavra, Munzarova, Bednarikova & Ehlova, 2011).

On the side of organisational culture and in concordance with Moreno-Luzon et al. (2014), cultural divergence influenced by process management can affect organizational ambidexterity: the cultural context serves as a base for developing organisational ambidexterity. "Since organisational ambidexterity constitutes the capability of undertaking a rich variety of learning and innovation activities, these results could also have significant implications for practitioners, pointing to the need for close coordination between different functional areas in order to manage cultural change" (Moreno-Luzon et al., 2014, p. 1026). Having a balanced culture comprising cultural values in conflict can be a key for success, particularly in the current environment of global economic crisis, which calls for an increase in efficiency and learning (Moreno-Luzon et al., 2014).

3.5 Contributions in new knowledge generation in the research field.

Townsend & Calantone (2013) state that much knowledge is yet to be discovered in the realm of product and service development as well as Henriksen & Rolstadås (2010) say that the automotive industry is a complex system of suppliers related institutions and industries, and much less research has been addressed to them. Additionally, there is no agreement regarding which competitive factors are the most relevant (Lucato, et al., 2012). This proves that the formal definition of the relationship between the innovation factor and competitiveness within the automotive industry can be regarded as new knowledge generation. Moreover, research effort needs to be undertaken from an integrated and consolidated perspective if the issues are to be better understood, and resolved meaningfully (Singh et al., 2005). This implies that the holistic approach taken while consolidating the practices of the leading countries in this sector can contribute to the better comprehension of the current issues in the industry. "Furthermore, since the automotive industry is global to a large extent, it would be particularly interesting to investigate on an internationally comparative basis […] in terms of their impacts on company competitiveness" (Triebswetter & Wackerbauer, 2008, p. 42).

4. Conclusions.

Technology denotes the primordial force for firms and organizations in guaranteeing long-term competitiveness (Sköld & Karlsson, 2012). On one hand, technology has allowed for the improvement of time and integration; on the other hand, technology has also become a driver of product changes (Townsend & Calantone, 2014). Undoubtedly, innovation has experienced major changes, whereas it still involves being productive in R&D, improving management practices and delivery of new quality products and processes to the market, innovation today is not a linear process and is uniquely dependent on the discovery of scientific knowledge or formal R&D activities. (van Geenhuizen & Soetanto, 2013). Furthermore, developing activities and learning through research, fine-tuning and improvement of what already exists and utilizing new processes are crucial factors for the firm's survival (Moreno-Luzon et al., 2014). Currently, there has been increasing connection between economic growth and competitiveness of national economies and innovative processes as measured by the Global Competitiveness Report published by the World Economic Forum, together with Harvard University, as well as the World Competitiveness Yearbook published by IMD' in Switzerland. Innovation performance of the economy is usually evaluated by using input and output parameters such as the European Innovation Scoreboard (Kraft & Kraftova, 2012, p). On another branch, Basile (2012) showed that entrepreneurs and managers should be aware of the importance of R&D networking focused on specific agreements as the motor of firms' competitiveness. Also, it has been noted that "in order to effectively analyse and compare the industries of this century, investigating the design attributes of our artefacts, including their architecture, and the organizational attributes of design–production sites, including their manufacturing capability" (Fujimoto, 2014, p.15). Competitiveness is a crucial strategic feature for the automotive industry as part of the determination to remain in the top Category sector. Even though the competitiveness concept is fairly well understood, it has not become a common practice to measure the degree of competitiveness of a company (Lucato et al., 2012).

Throughout the development of this research, -the preliminary literature review, the systematic literature review, and the achievement of the specific objectives guided by the research justification, problem and hypothesis- the leading countries within the automotive industry were defined on the basis of their competitiveness on a macro and a microeconomic level (in alignment with Michael Porter's ideas) to further create a regional analysis on innovative capability reflected by the amount of available scientific research (constrained by the methodology parameters) and by their regional quality level analysis (based on the SCIMAGO ranking) to further narrow the investigation into the relevant and trustworthy sources that could provide the best knowledge to understand the dimensions of innovation

that affect proportionally (whether directly or inversely) to the manufacturing competitiveness of the automotive industry. After all this data was gathered and exposed, it can be said that the hypothesis is proven effectively: innovation has a positive impact in the manufacturing competitiveness of the leading countries in the automotive industry and that it can be further categorized in different interlinked dimensions such as product and process innovation, regional innovation, open innovation, knowledge transfer, government and consumer trends and behaviours and finally, management and organisational culture.

References

Ahmadinia, H., & Karima, M. (2016). Competitive intelligence: A case study on Qoros automotive manufacturing. *Journal of Intelligence Studies in Business, 6*(2), 52-65.

AnišIć, Z., Freund, R., & Suzic, N. (2013). Mass customization and personalization in Southeast Europe. *2013 DAAAM International Scientific Book.* 389-416. doi:10.2507/daaam.scibook.2013.20

Basile, A. (2012). Evaluating R&D networking to revitalize SMEs innovative performances: a management perspective. *Business: Theory & Practice*, 13(3), 217-227. doi:10.3846/btp.2012.23

Bhamra, R., Dani, S., & Bhamra, T. (2011). Competence understanding and use in SMEs: a UK manufacturing perspective. *International Journal Of Production Research*, 49(10), 2729-2743. doi: 10.1080/00207541003738873

Buerger, M., Broekel, T., & Coad, A. (2012). Regional dynamics of innovation: investigating the co-evolution of patents, research and development (R&D), and employment. *Regional Studies*, 46(5), 565-582. doi:10.1080/00343404.2010.520693

Cann, O. (2016, September 27). What is competitiveness? Retrieved January 29, 2017, from https://www.weforum.org/agenda/2016/09/what-is-competitiveness/

Colovic, A., & Mayrhofer, U. (2011). Optimizing the location of R&D and production activities: Trends in the automotive industry. *European Planning Studies, 19*(8), 1481-1498. doi:10.1080/09654313.2011.586175

Cornell University. (2016). Steps in the Systematic Review Process. Cornell University Press. http://guides.library.cornell.edu/c.php?g=459012&p=3142201

Dangayach, G. S., & Deshmukh, S. G. (2001). Practice of manufacturing strategy: Evidence from select Indian automobile companies. *International Journal of Production Research, 39*(11), 2353-2393. doi: 10.1080/00207540110040448

Delgado, M., Ketels, C., Porter, M. E., & Stern, S. (2012). The Determinants of National Innovative Capacity. National Bureau of Economic Research, NBER Working Paper Series, 18249th ser., 1-48. Retrieved January 29, 2017.

Dietl, H., Royer, S., & Stratmann, U. (2009). Value creation architectures and competitive advantage: Lessons from the European automobile industry. *California Management Review, 51*(3), 24-48. doi: 10.2307/41166492

Espitia, F. f., Sánchez, J. j., & Galvis, E. e. (2016). Systematic Literature Review of the Implementation of Knowledge Codification Process. Proceedings of The European Conference On Knowledge Management, 1111-1119

European Automobile Manufacturers' Association. (2014, June 13). A Manifesto for a Competitive European Automobile Industry. Retrieved January 29, 2017, from http://www.acea.be/publications/article/a-manifesto-for-a-competitive-european-automobile-industry

European Automobile Manufacturers' Association. (2014, June 12). Driving Innovation. Retrieved January 29, 2017, from http://www.acea.be/news/article/driving-innovation

European Commission. (2017). Innovation in Manufacturing. Retrieved March 07, 2017, from http://ec.europa.eu/research/industrial_technologies/innovation-in-manufacturing_en.html

Franke, V., & Wrede, S. (2014, April). How man and machine learn from each other. Harting Technology Newsletter, (26), 12-13. Retrieved February 17, 2017

Fujimoto, T. (2014). The long tail of the auto industry life cycle. *Journal Of Product Innovation Management*, 31(1), 8-16. doi:10.1111/jpim.12076

Gerken, J. M., Moehrle, M. G., & Walter, L. (2015). One year ahead! Investigating the time lag between patent publication and market launch: insights from a longitudinal study in the automotive industry. R*&D Management*, 45(3), 287-303.

Ghobakhloo, M., & Hong, T. S. (2014). IT investments and business performance improvement: the mediating role of lean manufacturing implementation. *International Journal Of Production Research*, 52(18), 5367-5384. doi:10.1080/00207543.2014.906761

Giffi, C. (2016). 2016 Global Manufacturing Competitiveness Index. Retrieved January 29, 2017, from:https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html

Gobble, M. M., & Gwynne, P. (2011). Can the U.S. Ride Out The Gathering Storm? *Research Technology Managemen*t, 54(2), 3-5.

Godlewska-Majkowska, H., & Komor, A. (2017). Regional strategic groups as a tool of enterprises localization analysis on automotive industry in the European Union. *Engineering Economics*, 28(1), 35-46. doi:10.5755/j01.ee.28.1.7799

Golinska, P., Fertsch, M., & Pawlewski, P. (2011). Production flow control in the automotive industry – Quick scan approach. *International Journal of Production Research, 49*(14), 4335-4351. doi:10.1080/00207543.2010.536180

Hemphill, T. A. (2014). Policy debate: The US advanced manufacturing initiative: Will it be implemented as an innovation - or industrial - policy? *Innovation: Management, Policy & Practice*, 16(1), 67-70. doi:10.5172/impp.2014.16.1.67

Henriksen, B., & Rolstadås, A. (2010). Knowledge and manufacturing strategy – How different manufacturing paradigms have different requirements to knowledge. Examples from the automotive industry. *International Journal of Production Research, 48*(8), 2413-2430. doi: 10.1080/00207540902744792

Hermann, M., Pentek, T., & Otto, B. (2016). Design Principles for Industrie 4.0 Scenarios. 2016 49th Hawaii International Conference on System Sciences (HICSS). doi:10.1109/hicss.2016.488

Hilger, C. (2014, April). Orchestrating services. Harting's Technology Newsletter, (26), 6-7. Retrieved February 17, 2017, from http://www.harting.com/fileadmin/harting/documents/lg/hartingtechnologygroup/news/tec-news/tec-news26/EN_tecNews26.pdf

Industrial Research Institute Inc. (2014). 2014 R&D Trends Forecast. *Research Technology Management*, 57(1), 32-41. doi: 10.5437/08956308X5701009

Institute for Strategy & Competitiveness. (2017). Drivers of Competitiveness. Retrieved January 29, 2017, from http://www.isc.hbs.edu/competitiveness-economic-development/frameworks-and-key-concepts/Pages/drivers-of-competitiveness.aspx

Institute for Strategy & Competitiveness. (2017). Innovation & Innovative Capacity. Retrieved January 29, 2017, from http://www.isc.hbs.edu/research-areas/Pages/innovation-and-innovative-capacity.aspx

Isac, N. (2009). Competitiveness and strategy for automobile industry in Europe. *Annals of the University of Petroşani, Economics, 9*(2), 51-56.

Jacob, M. (2016, July 22). French Manufacturing Competitiveness Radar 2015/2016. Retrieved March 07, 2017, from https://www.rolandberger.com/en/Publications/ pub_french_ manufacturing_2015.html. Publisher: Roland Berger

Jean, R., Sinkovics, R. R., & Hiebaum, T. P. (2014). The effects of supplier involvement and knowledge protection on product innovation in customer-supplier relationships: A study of global automotive suppliers in China. *Journal of Product Innovation Management, 31*(1), 98-113. doi:10.1111/jpim.12082

Jonnaert, E. (2016). ACEA Pocket Guide. The Automobile Industry Pocket Guide 2016 - 2017, 1-78. Retrieved January 29th, 2017 from: http://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2016_2017.pdf

Katerinich, D. (2016). Innovative approaches to increasing the competitiveness of production in mechanical engineering. *Problems Of Economic Transition*, 58(6), 533-538. doi:10.1080/10611991.2016.1222207

Kato, T., Nunes, B., & Dey, P. K. (2016). Is keiretsu really a source of competitive advantage for Japanese automotive suppliers*? Journal of Manufacturing Technology Management, 27*(1), 62-81. doi: 10.1108/jmtm-06-2014-0077

Kerr, C. I., Roy, R., & Sackett, P. J. (2006). Requirements management: An enabler for concurrent engineering in the automotive industry. *International Journal of Production Research, 44*(9), 1703-1717. doi: 10.1080/00207540500445263

Kraft, J., & Kraftova, I. (2012). Innovation -- Globalization -- Growth (Selected Relations). *Engineering Economics*, 23(4), 395-405.

Kumar, R. (2011). Research methodology: A step-by-step guide for beginners (3rd ed.). London: SAGE Publications Ltd.

Lacka, I. (2013). Technological cooperation between scientific and research institutions and companies as a condition of the growth of innovativeness and competitiveness of polish economy. *Economics & Management*, 18(2), 275-285. doi:10.5755/j01.em.18.2.4467

Lee, J., Lapira, E., Bagheri, B., & Kao, H. (2013). Recent advances and trends in predictive manufacturing systems in big data environment. Manufacturing Letters, 1(1), 38-41. doi:10.1016/j.mfglet.2013.09.005

Lee, J. (2014, April). Industry 4.0 – Factory in Big Data Environment. Harting Technology Newsletter, (26), 8-9. Retrieved February 17, 2017, from http://www.harting.com/fileadmin/harting/documents/lg/hartingtechnologygroup/news/tec-news/tec-news26/EN_tecNews26.pdf

Lee, J., Bagheri, B. & Kao, H.-A. (2014). Recent Advances and Trends of Cyber-Physical Systems and Big Data Analytics in Industrial Informatics. Keynote given at the 12th IEEE International Conference on Industrial Informatics (INDIN 2014), Porto Alegre, Brazil.

Lucato, W. C., Júnior, M. V., Vanalle, R. M., & Salles, J. A. (2012). Model to measure the degree of competitiveness for auto parts manufacturing companies. International Journal of Production Research, 50(19), 5508-5522. doi:10.1080/00207543.2011.643252

Matthews, C. (2016, March 31). The U.S. Will Surpass China As the No. 1 Country for Manufacturing by 2020. Fortune. Retrieved February 17, 2017, from http://fortune.com/2016/03/31/united-states-manufacturing-china/

Min, Z. (2005). Five competitive forces in China's automobile industry. *Journal of American Academy of Business, 7*(1), 99-105. Retrieved December 19, 2016.

Moreno-Luzon, M. D., Gil-Marques, M., & Arteaga, F. (2014). Driving organisational ambidexterity through process management. The key role of cultural change. *Total Quality Management & Business Excellence,* 25(9/10), 1026-1038. doi:10.1080/14783363.2013.776768

Navickas, V., Sujeta, L., & Vojtovich, S. (2011). Logistics systems as a factor of country's competitiveness. *Economics & Management*, 16231-237.

Neumann, M., Riel, A., & Brissaud, D. (2013). IT-supported innovation management in the automotive supplier industry to drive idea generation and leverage innovation. *Journal of Software: Evolution and Process, 25*(4), 329-339. doi:10.1002/smr.578

Ong, M. H., West, A. A., Lee, S. M., & Harrison, R. (2006). A structured approach to evaluating the impact of implementing a component-based system in the automotive engine manufacturing domain. *International Journal of Production Research, 44*(13), 2645-2670. doi: 10.1080/00207540500358490

Organisation Internationale des Constructeurs d'Automobiles. (2017). Economic Contributions. Retrieved January 29, 2017, from http://www.oica.net/category/economic-contributions/

Organisation Internationale des Constructeurs d'Automobiles. (2017). 2016 Production Statistics. Retrieved March 05, 2017, from http://www.oica.net/category/ production-statistics/

Organisation Internationale des Constructeurs d'Automobiles. (2017). R&D. Retrieved January 29, 2017, from http://www.oica.net/category/economic-contributions/rd/

Piper, R. J. (2013). How to write a systematic literature review: a guide for medical students. University of Edinburgh. p. 2.

Petrovic, V., Gonzalez, J. V., Ferrando, O. J., Gordillo, J. D., Puchades, J. R., & Griñan, L. P. (2011). Additive layered manufacturing: Sectors of industrial application shown through case studies. *International Journal of Production Research, 49*(4), 1061-1079. doi: 10.1080/00207540903479786

Porter, M. (2017). Competitiveness & Economic Development. Retrieved January 29, 2017, from the site: http://www.isc.hbs.edu/competitiveness-economic-development/ Pages/default.aspx

Roland Berger. (2015, November). French plants going digital? Paris: Roland Berger's manufacturing Competitiveness Radar

Schulze, A., Brojerdi, G., & Krogh, G. V. (2013). Those who know, do. Those who understand, teach. Disseminative capability and knowledge transfer in the automotive industry. *Journal of Product Innovation Management, 31*(1), 79-97. doi:10.1111/jpim.12081

Singh, P. J., Smith, A., & Sohal, A. S. (2005). Strategic supply chain management issues in the automotive industry: An Australian perspective. *International Journal of Production Research, 43*(16), 3375-3399. doi: 10.1080/00207540500095738

Sköld, M., & Karlsson, C. (2012). Technology sharing in manufacturing business groups. *Journal Of Product Innovation Management*, 29(1), 113-124. doi:10.1111/j.1540-5885.2011.00882.x

Talay, M. B., Calantone, R. J., & Voorhees, C. M. (2013). Coevolutionary dynamics of automotive competition: Product innovation, change, and marketplace survival. *Journal of Product Innovation Management, 31*(1), 61-78. doi:10.1111/jpim.12080

Townsend, J. D., & Calantone, R. J. (2014). Evolution and transformation of innovation in the global automotive industry. *Journal Of Product Innovation Management*, 31(1), 4-7. doi:10.1111/jpim.12075

Triebswetter, U., & Wackerbauer, J. (2008). Integrated environmental product innovation and impacts on company competitiveness: A case study of the automotive industry in the region of Munich. *Environmental Policy and Governance, 18*(1), 30-44. doi:10.1002/eet.475

van Geenhuizen, M., & Soetanto, D. P. (2013). Benefitting from learning networks in "open innovation": spin-off firms in contrasting city regions. *European Planning Studies*, 21(5), 666-682. doi:10.1080/09654313.2013.733504

Vavra, J., Munzarova, S., Bednarikova, M., & Ehlova, Z. (2011). Sustainable aspects of innovations. *Economics & Management*, 16621-627.

Vanichchinchai, A., & Igel, B. (2011). *International Journal of Production Research, 49*(11), 3405-3424. doi:10.1080/00207543.2010.492805

Watkins, M. D. (2014, July 23). Demystifying Strategy: The What, Who, How, and Why. Harvard Business Review. Retrieved February 03, 2017, from https://hbr.org/2007/09/demystifying-strategy-the-what

World Economic Forum. (2017). The Global Competitiveness Index Historical Dataset © 2007-2016 World Economic Forum [XLSX]. N/A: World Economic Forum.

World Economic Forum & Deloitte Global. (2012). The Future of Manufacturing: Opportunities to drive economic growth (pp. 1-84, Publication). Geneva: World Economic forum.

Wright, A. (2011). Automotive Autonomy. *Communications Of The ACM*, 54(7), 16-18.

Xu, H. Q., Besant, C. B., & Ristic, M. (2003). System for enhancing supply chain agility through exception handling. *International Journal of Production Research, 41*(6), 1099-1114. doi: 10.1080/0020754021000049826

Zühlke, D. (2014, April). Harting Technology Newsletter, (26), 10-11. Retrieved February 17, 2017, from http://www.harting.com/fileadmin/harting/documents/lg/hartingtechnologygroup/news/tec-news/tec-news26/EN_tecNews26.pdf

Biography

Rolando Rodríguez Alanis is an Industrial and Systems Engineer graduate from the Universidad de Monterrey and who has acquired the degree of Masters in Management at the *Ecole Supérieure des Sciences Commerciales d'Angers*, in France. Currently working as process engineer and optimization expert at the *Ravago Group* in its headquarters in Belgium, he is a certified internal auditor from ISO who also participated in the American Society for Quality student chapter as logistics coordinator. He is part of the first generation of the *Universidad de Monterrey's* signature social service and leadership program: *Formar para Transformar* and has strong interests in social welfare as well as research and development of new technologies and entrepreneurship.

Luz María Valdez de la Rosa is currently a Director of Engineering Management Bachelor Academic Program in the University of Monterrey, in the state of Nuevo Leon, Mexico. She earned B.S. in Industrial Engineering and Systems and Masters in Quality Management at University of Monterrey, Mexico, and she is currently studying the Ph. D. in Administration Sciences from the Autonomous University of the State of Nuevo Leon, Mexico. She has 18 years of experience in the Quality field and 11 years as a higher education teacher. She has participated as consultant for the manufacturing and services in the quality field, and participated as ASQ and IISE member.

Fernando Gonzalez Aleu is an Associate Professor at the Universidad de Monterrey (UDEM) in Mexico. He received a BS in Mechanical and Management Engineering at UDEM, an MS at ITESM in 1999, and both an MS and PhD in Industrial and Systems Engineering from Virginia Tech in 2015 and 2016, respectively. His research focuses on the applications of continuous improvement projects. Prior industry experience includes 15 years implementing quality systems, environmental systems, and management systems. He is member of the Institute of Industrial and Systems Engineers, the American Society for Engineering Management, and the American Society for Quality.

Teresa Verduzco-Garza is a Researcher Professor at the Industrial and Systems Engineering School in University of Monterrey (UDEM) in Mexico. She received a BS in Industrial and Systems Engineering in 1998, an MS in Business Administration in 2005, and a MS in International Commerce in 2006 at UDEM. At the moment, she is a PhD Candidate in Management focused on logistics and supply chain operations at the Autonomous University of Nuevo León (UANL) in Mexico. Her expertise focuses on Logistics clusters for competitiveness, Operations Management, Supply Chain Operations, and Soft Systems Management. Prior industry experience includes 12 years improving enterprises performance though project management and strategic planning. She is an active member of the American Production and Inventory Control Society (APICS) and The Competitiveness Institute (TCI). She has published and presented her work at international forums like IISE World Conferences, TCI Global Conferences, SISE World Conferences and other regional conferences.