Chinese Business Review, ISSN 1537-1506
July 2011, Vol. 10, No. 7, 532-541

Mapping and Its Importance to Supply Chains: A Case Study*

Susana Garrido Azevedo
University of Beira Interior, Covilhã, Portugal
Virgínia H. Machado, Ana P. Barroso, V. Cruz Machado
Universidade Nova de Lisboa, Caparica, Portugal

A strategic supply chain map will offer a basis for redesign or modification of the supply chain. It helps one to visualize the supply chain and identify areas for further analysis, or to reveal inefficiencies which are not as readily visible when one examines only a small segment of the supply chain. The main objective of this paper is to highlight the importance of mapping in the supply chain context while calling attention to the lack of universal symbols or conventions in the mapping procedure. Accordingly, a case study methodology is used in discussion of the Portuguese automotive supply chain. Based on this case study, it will be possible to conclude that there is an automotive industrial cluster located in two specific regions with an organisational agglomeration. Moreover, it has been possible to identify the main echoes which constitute the research supply chain as well as the dependent relationships which exist between different sectors in the Portuguese economy.

Keywords: mapping, supply chain, automotive industry, case study

Introduction

The mapping procedure can be found in many scientific areas, such as economic geography (Boschma & Frenken, 2003), industrial clusters (Porter, 1980), agglomeration economies, supply chain management and others. There is, however, a lack of consensus regarding the symbols and conventions which must be used as a universal language in drawing such maps. In fact, there are many phenomena which could appeal to this framework, but if a pattern or orientation exists in regards to the way they should be drawn, it will be easier to visually perceive the phenomena thus represented.

Given the context of a supply chain, it is important to use mapping to help visualize all the echoes involved as well as to identify problematic areas for further analysis which are not readily visible by examining only a small segment of the supply chain. With a good map, one can more easily rationalise the supply chain and thereby

* **Acknowledgment:** The authors would like to thank the Fundação para a Ciência e Tecnologia for its support (project PTDC/EME-GIN/68400/2006).

Susana Garrido Azevedo, Ph.D. in Management, NECE, Department of Management and Economics, University of Beira Interior.

Virgínia H. Machado, Ph.D. in Industrial Engineering, UNIDEMI, Department of Mechanical and Industrial Engineering, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

Ana P. Barroso, Ph.D. in Systems Engineering, UNIDEMI, Department of Mechanical and Industrial Engineering, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

V. Cruz Machado, Ph.D. in Industrial Engineering, UNIDEMI, Department of Mechanical and Industrial Engineering, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

Correspondence concerning this article should be addressed to Susana Garrido Azevedo, Department of Management and Economics, University of Beira Interior, Estrada do Sineiro, 6200-209 Covilhã, Portugal. Email: sazevedo@ubi.pt.

achieve an improved supply chain management procedure.

This research aims to highlight the importance of mapping in a supply chain context and to call attention to the lack of universal symbols or conventions in the mapping procedure. Methodologically, the data by which we developed in this study was obtained from the Portuguese Association of Automotive Suppliers (AFIA), the websites of the organizations in the Portuguese automotive supply chain, and from prior studies on the automotive industry in Portugal. Therefore, this paper is organized as follows: Section 2 presents a brief literature review with respect to mapping in general and in the supply chain; Section 3 describes a case study regarding the mapping in the Portuguese automotive supply chain. Finally, in section 4, the conclusions are drawn.

Background

The management of supply chains which operate in network environments can be quite complex. They are expected to provide the right products and services to the customer at the right time and place, with the required specifications. Consequently, supply chain management is critical in order for organizations to succeed, but these efforts may be assisted by visualisation approaches such as process mapping. A supply chain map is a representation of the linkages and entities of a supply chain (Gardner & Cooper, 2003).

A supply chain covers multiple processes across multiple organizations, while it calls for an integrated approach that adds value for stakeholders (Lambert, Cooper, & Pagh, 1998; Mentzer et al., 2001). Apparently, however, supply chain design is not sufficiently advanced to ensure optimised performance. To help organizations find an answer to this question, it is important to start with a spatial representation of all the entities involved in the supply chain, in which case one must draw a supply chain map.

The supply chain map will not only simplify the spatial relationships between organizations, but will also capture the essence of the business environment (Rouleau, 1993). Gardner and Cooper (2003) proved that a supply chain map can be useful as a means to enhance the strategic planning process, ease the distribution of key information, facilitate supply chain redesign or modification, clarify channel dynamics, provide a common perspective, enhance communications, facilitate the monitoring of supply chain strategy, and provide a basis for supply chain analysis. The mapping process may provide a tool with which to link corporate strategy to supply chain strategy: The right information should be collected, displayed and understood in order to promote integration between the two levels.

Supply chain mapping focuses on how goods, information, and money flow in both the upstream and downstream directions and through an organization. All processes may be included (Schroeder, 2000). Supply chain mapping also emphasizes high-level measures such as volume, cost, or lead time, taking an overall perspective of how processes work together between organizations (Lambert et al., 1998).

Additionally, process mapping or process flowchart analysis should include a comprehensive actual system description by means of flowcharts and efficiency measurements as well as the development of an improved process design. Process mapping may focus its attention upon a single operation or system within an organization, and it tends to break down a process into activities and steps. Each step includes information that helps one characterize the system being mapped. As an example, the SCOR model should be pointed out, as it provides a process mapping approach (Supply Chain Council, 2010).

Fine (1998) and Cooper, Douglas and Janus (1997) argue that a good map provides information about possible constraints in the system while allowing one, in a subsequent step, to develop further investigation and monitoring for supply chain bottlenecks. A good map is interpretable, recognizable, in a format which is easy to

disseminate. It should have standardized icons, and it should follow certain conventions such as the colour-coding or symbol-coding of business processes linked between organizations (Gardner & Cooper, 2003). However, there is not a convergence on the specific symbols for mapping. Some look like computer flowcharts, but many demonstrate eclecticism in the choice of symbols and presentations (van der Aalst, Desel, & Oberweis, 1998).

Rother and Shook (1999) propose a set of mapping symbols and conventions to help interpret supply chain maps. However, Gardner and Cooper (2003) criticize these symbols and conventions since, from their perspective, it includes neither the process information, which is very important in most supply chain mapping exercises, nor does it specify visual communication elements such as size, colour, shares, and pieces.

Even if the map does not provide complete, in-depth mapping, it should be able to identify the main constraints and identify non-value added activities for further analysis. With a good map, rationalizing the supply chain becomes easier so that one can achieve an improved supply chain management procedure. Channel dynamics can be displayed in a supply chain map, as can the relative importance of supply chain entities. The choice of what to represent and from what perspective can have an important effect on supply chain strategy (Gardner & Cooper, 2003). These authors consider that it is important to understand the targeted domain of supply chain map geometries, perspectives, and implementation issues, and therefore, the authors suggest a set of supply chain map attributes grouped into geometric, perspective, and implementation issues.

Supply chain maps can be generic examples for the user of a specific chain, doing so by naming the entities of the chain. User maps have been suggested for specific business problems (Rother & Shook, 1999). Value stream mapping, developed by the Lean Institute (Womack & Jones, 1996), emphasizes mapping the flow of materials on the production floor. The Supply Chain Council has developed the SCOR model for improving the buy-make-deliver operations of an organization, and has extended it beyond the single organization boundary.

Fine (1998) suggests three different kinds of maps. One should include organizations (e.g., focal organization), another would include technologies (e.g., engine valve, lifters), and the third would include capabilities (e.g., just in time delivery, chemical process control, assembly plant management, supply chain management). These types of user maps have low degrees of generalisation, are very detailed, and have a narrowly defined set of information specific to a situation.

The mapping issue could also be found in industrial clusters. Porter (1998) defined clusters as a geographically proximate group of interconnected organizations and associated institutions in a particular field, linked by commonalities and complementarities. However, Martin and Sunley (2003) criticized this definition as being ambiguous and vague in terms of geographical scale and internal socio-economic dynamics. There is still a lack of consensus regarding what defines a cluster, and there is scarce agreement about the need for spatial proximity among organizations.

The issue of spatial proximity has been of increasing importance in the cluster literature since Czamanski and Ablas (1979) made a distinction between industrial complexes and industrial clusters, particularly with respect to spatial co-agglomeration. The spatial proximity of interlinked industry activities is regarded as influencing the performance of these sectors, and regional clusters in both the short and long term (Maskell, 2001). While the short-term focus points out the temporal and qualitative availability of key inputs and services (Feser & Bergman, 2000), the long-term perspective stresses the necessity of interaction with other regional agents (buyers, suppliers, and institutions) as sources of competitive advantages through innovation, knowledge spillover and interactive learning (Lucas, 1988; Feldman, 1999).

Larsson (2002), as well as Frigant and Lung (2002) assert that new production concepts such as just in time

or modular production (presented in many supply chains) focus on reliability so much that temporal and spatial proximity becomes strategically important.

A promising field of application is the spatial evolution of industries. Boschma and Frenken (2003) have described about how evolutionary economics can contribute to a new, more dynamic understanding of an industry's location. In evolutionary economic geography, the basic starting point is to understand an organization's behaviour in space as being guided by routines. The key question, then, concerns the mechanisms through which these routines diffuse and cluster spatially when a new industry emerges and grows. In the literature, two such mechanisms have drawn special attention, namely spinoff dynamics and agglomeration economies.

In the literature of industrial clusters and economic geography, the issue of mapping is also presented. One can find the spatial representation of a set of organizations which constitute a cluster in Wennberg and Lindqvist (2008). The clusters represented in a map are pharmaceuticals, telecommunications, financial services, information technology and medical equipment. In this research, the absolute size of a cluster (number of employees) is represented by black dots. The level of specialisation of each cluster in the region is represented by shaded areas in which a darker shade is a higher degree of specialisation (location quotient of plants). The mapping of these clusters makes possible a better visualisation of the geographical dispersion of the organizations belonging to a specific cluster, as well as the dimension of a cluster and the degree of specialisation each one has. The same mapping approach was followed by Capó-Vicedo, Expósito-Langa and Molina-Morales (2008), in the Spanish context by Moreira, Carneiro and Selada (2008) in the northern region of Portugal, and also by Titze, Brachert and Kubis (2008) in Germany.

As can be seen in the literature review, mapping is presented in different areas of knowledge as a framework for a better understanding of many phenomena.

Case Study—Portuguese Automotive Supply Chain

The Portuguese automotive industry produced, in 2009, approximately 126 thousand vehicles. The industry consists of five automakers/manufacturers (Autoeuropa, Mitsubishi Fuso Truck Europe, PSA Peugeot/Citroen, Toyota Caetano, and V. N. Automóveis), about 170 truck, trailer and semi-trailer producers, and about 230 component producers (AFIA, 2009).

The Portuguese Automotive Industry Profile

The automotive component industry in Portugal generated, in 2009, approximately 3.7 billion euros, and employed more than 38 thousand workers (AFIA, 2009). With about 80% of vehicle production sold to other European countries, the automotive industry is Portugal's biggest export sector, playing a strategic role in the economy and representing 2.2% of the country's gross domestic product (AFIA, 2009).

The Portuguese automobile industry started at the end of the 1970s, and at the beginning of the 1990s, it entered a new phase with the installation of the Ford/VW Autoeuropa project, in the Setúbal region. Nevertheless, the international organisational strategies of the automobile sector aren't limited to this case. General Motors (GM) was one of the first Trans-National Enterprises (TNEs) to be installed in Portugal, for the assembly of vehicles (Opel Azambuja), but the plant closed in 2006. The GM network also integrates the electronics sector (cables, ignitions and sensors) and rubber accessories. Organizations such as Cablesa, Delco Remy or Inlan are the best-known cases from the perspective of intersection points of regional subcontracting networks (Moniz, 1994). Toyota was established in the early 1970s in Ovar, and the PSA Peugeot/Citroën in Mangualde. Others, like FIAT or União Metalo-Mecânica (UMM), stopped their assembly activities in the mid-1990s.

Most of the Portuguese automotive component suppliers, who produce small parts such as engine components, moulds, tools, electronics, plastic parts, seats, and climate control systems, are located at the lower levels of the supply chain. Different business sectors and clusters within the automotive industry, mainly those pertaining to textiles, metals, electronic components, and moulds and plastics, constitute the essential path which leads to the development and consolidation of the competitiveness of this sector.

The main global car automakers have plants in Portugal (see Figure 1). These larger automakers of the automotive industry choose Portugal to install their plants because they can profit from specialized knowledge and experience in this sector (or cluster, according to Porter) in the country's main industrialized regions (Aveiro and Setúbal, which are close to Porto and Lisboa, respectively) (Moniz, 1994).

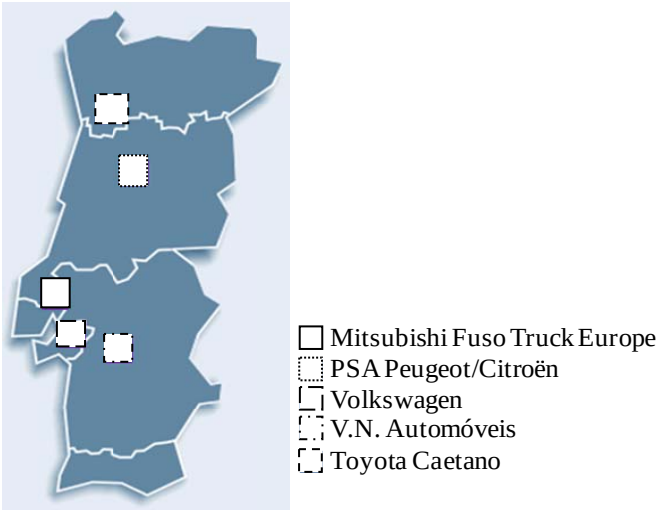

Figure 1. Distribution of car manufacturers in Portugal.

The Portuguese organizations in the automotive industry are nearly all small and medium enterprises (SMEs) (AFIA, 2009). However, the big enterprises (with more than 250 workers) also have an important presence, since they represent nearly 30% of the total of organizations in this sector (see Figure 2).

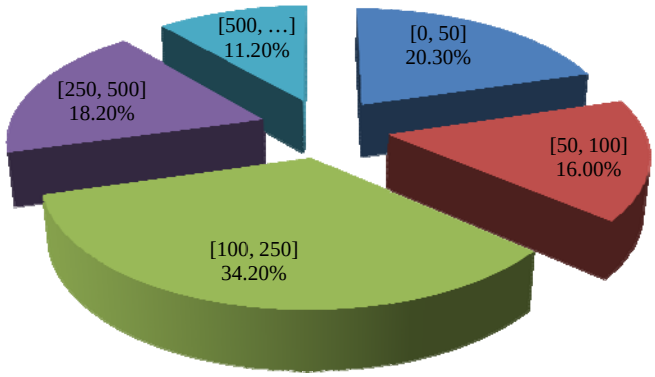

Figure 2. Portuguese automotive sector characterization. Source: AFIA (2009).

The entities with more representation on the supply chain of the Portuguese automotive industry are the 1st tier suppliers (with 51.1% revenue), followed by the second tier suppliers (26.2%) and the aftermarket organizations (11.2%) (see Figure 3).

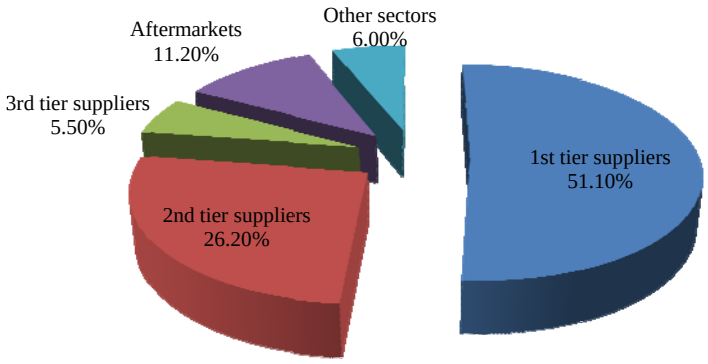

Figure 3. Portuguese automotive supply chain representation. Source: AFIA (2009).

Data Collection

The data used to develop this case study came mostly from three sources: The Portuguese Association of Automotive Suppliers (AFIA), the websites of the organization's AFIA members, and prior studies on the automotive industry in Portugal. From the AFIA, we get the 2009 report with the main features related to this industry. Once the players in this supply chain were identified, the next step was to explore their websites in order to obtain data about its geographic location.

The Portuguese Automotive Supply Chain Mapping

Concerning the location of the automotive suppliers, nearly of them are situated in the Porto region, more precisely in the Porto, Aveiro, and Braga districts (51.9%), followed by the Lisboa region, which includes the Lisboa, Setúbal, and Santarém districts (21.9%) (see Figure 4). The spatial proximity of the Portuguese automotive players in these two regions could help to improve the performance of this sector, according to Maskell (2001). This spatial proximity enables one to make use of a set of manufacturing philosophies and approaches as a way of improve the responsiveness and decrease the waste that occurs alongside the supply chain. Some of these philosophies and approaches are: just in time, lean thinking, agility, and quick response.

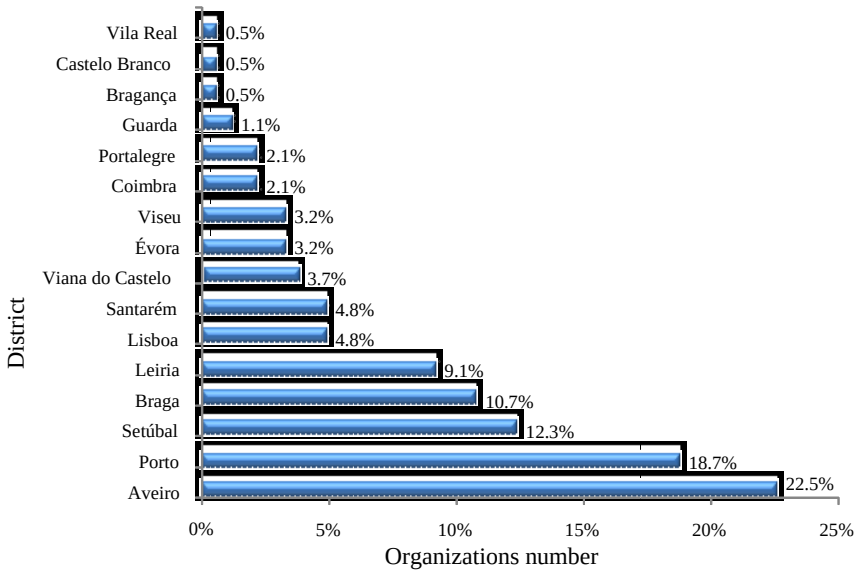

Figure 4. Geographic distribution of the Portuguese automotive players. Source: AFIA (2009).

As can be seen in Figure 4, there are two districts (Porto and Aveiro) where the automotive suppliers are more concentrated on. As a means to obtain a better visualisation of this geographical concentration, the mapping of automotive supply chain is illustrated in Figure 5.

There are some concentrations of the automotive supply chain in two specific regions of Portugal (see Figure 5). One region of concentration is around Porto and includes the Porto, Aveiro, and Braga districts, while the other is around Lisboa and includes the Lisboa, Setúbal, and Santarém districts. This concentration may be explained by the proximity of the automakers which exist in Portugal. The automakers Toyota and PSA Peugeot/Citroen are installed in the Porto region. Lisboa region are installed the other two automakers: Mitsubishi and Autoeuropa.

This spatial map facilitates a better visualisation of the main organizations which make up part of the Portuguese automotive supply chain. This will help in the understanding of a set of phenomena which could influence the choice of such locations, as well as the cluster industry. To ensure a better image in regards to the mapping of the Portuguese automotive supply chain, we chose to follow the model proposed by Fine (1998) and to identify the different entities comprised within it (see Figure 6).

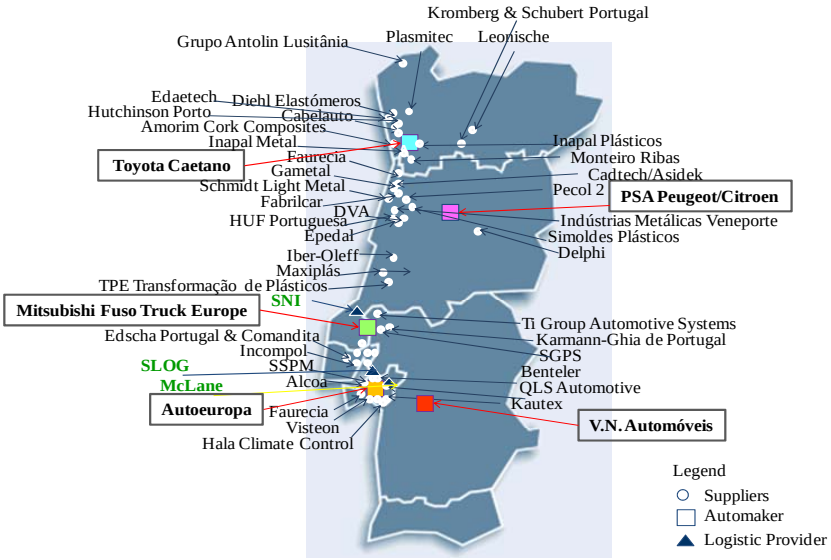

Figure 5. Spatial mapping of the Portuguese automotive supply chain.

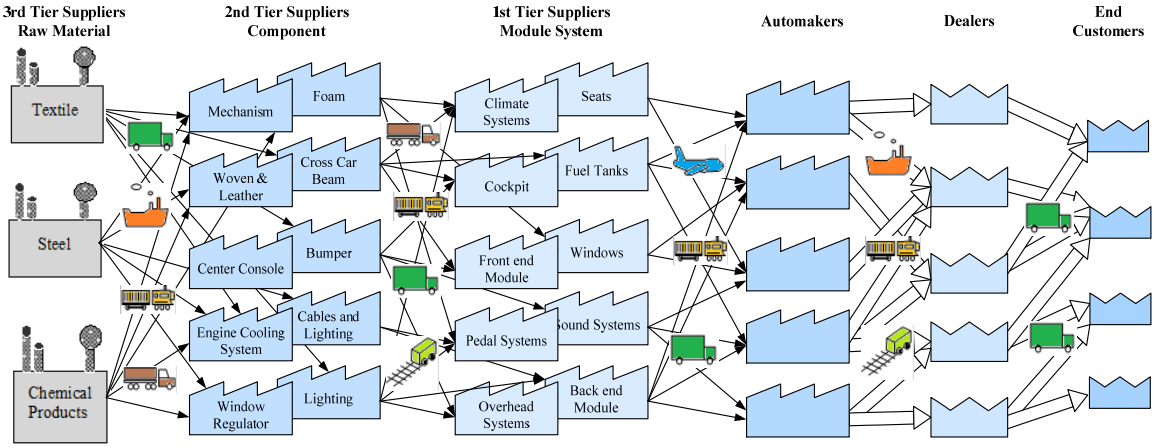

Figure 6. Mapping of the Portuguese automotive supply chain by entity type.

The Portuguese automotive supply chain follows the pattern of any one elsewhere in the world. The automakers design and assemble the vehicles. The supply chain is organized in tiers:

- The first tier suppliers manufacture components and supply them directly to the automakers. These suppliers are capable of designing and integrating components, subassemblies, and systems into modules which are shipped or placed directly to the automakers' assembly plants;
- The second tier suppliers design and manufacture specific components or subsystems for a given vehicle or platform. Some of them have process specialists which produce some of the simpler individual parts for inclusion in components manufactured in the first tier;
- The third tier suppliers generally provide raw materials to the automakers or their suppliers. This includes products ranging from steel coils or blanks to aluminium ingots or polymer pellets;

The automotive logistics providers help the organizations to place the final product (the vehicle) in the market as well as to reach their competitive priorities, which are a decrease in the order lead time (the time between final order and delivery at the customer) and also on-time delivery. This helps organizations to obtain better performance in terms of customer satisfaction. The logistics providers will be in touch with dealers and retailers in order to continuously replenish the products and components, to avoid product stockout, and satisfy customer requirements.

Conclusions

The issue of mapping has been presented in many scientific areas as a framework to a better understanding of the diversity of phenomena. We can find it in economics, agglomeration economies, industrial clusters, supply chains and so on, as a way of representing links and relationships between different players in a specific context.

However, there is no consensus regarding the kinds of symbols or conventions one should use for the better, faster interpretation of these maps. We can find maps which use only geometric shapes and lines to represent organizations' networks in a tree representation (Lewis & Talalayevsky, 1997; Lambert et al., 1998; Mariotti, 1999; Blumberg, 1999), icons to illustrate the different kinds of players which make up part of a supply chain (Zubrod, 1998; Rother & Shook, 1999), we can find flowcharts to illustrate a set of processes in a supply chain or individual organization (La Londe & Pohlen, 1996; Stallkamp, 1998; Fine, 1998), and we can find a spatial representation of a specific phenomenon (Juga, 1995; Guedes, Saw, & Waller, 1995).

This study is intended to call attention to the lack of uniformity in the way maps are drawn, as well as to point out some of the confusion which persists in this area. In an attempt to clarify this issue, a literature review about mapping was developed and two different mapping approaches were proposed with respect to the Portuguese automotive supply chain.

The mapping of the Portuguese automotive supply chain allows us to highlight a set of questions. First, the spatial representation of the focused supply chain is a good framework for the identification of some economic phenomena which could arise from the spatial concentration of a specific kind of organization. In this case, it is acceptable to conclude that there is an automotive industrial cluster located in the two regions with more concentration of organizations, meaning in the Porto/Aveiro region and in Lisboa/Setúbal region. This could also be explained from different perspectives and scientific areas such as the kind of manufacturing systems used, and so on. The other map developed according to Fine (1998), in which we have used icons to illustrate the different types of players involved in the automotive supply chain, allows us to identify the extend of the supply chain the echoes which constitute it as well as the dependent relationships which exist among different sectors in a specific economy.

Independently from the kind of map used to illustrate a supply chain, there are always advantages associated with it. It is, however, important to express it in a universal language which is easily understandable by anyone.

As a future course of research, we propose to use the same mapping approaches in the Portuguese automotive supply chain but to have as reference one focal organization, which could be one of the automakers that have chosen to install plants in this country.

References

AFIA. (2009). *Portuguese auto components industry: Statistics 2009*. Retrieved November 3, 2010, from http://www.afia.pt/images/stories/afia_estatisticas_2009_pt.pdf

Blumberg, D. (1999). Strategic examination of reverse logistics and repair service requirements, needs, market size, and opportunities. *Journal of Business Logistics, 20*(2), 141-160.

Boschma, R., & Frenken, K. (2003). Evolutionary economics and industry location. *International Review for Regional Research, 23,* 183-200.

Capó-Vicedo, J., Expósito-Langa, M., & Molina-Morales, F. (2008). Improving SME competitiveness reinforcing interorganisational networks in industrial clusters. *International Entrepreneurship Management Journal, 4,* 147-169.

Cooper, M., Douglas, L., & Janus, P. (1997). Supply chain management: More than a new name for logistics. *International Journal of Logistics Management, 8*(1), 1-4.

Czamanski, S., & Ablas, L. (1979). Identification of industrial clusters and complexes: A comparison of methods and findings. *Urban Studies, 16,* 61-80.

Feldman, M. (1999). The new economies of innovation, spillovers and agglomeration: A review of empirical studies. *Economics of Innovation and New Technology, 8,* 5-25.

Feser, E., & Bergman, E. (2000). National Industry Cluster Templates: A framework for applied regional cluster analysis. *Regional Studies, 34,* 1-20.

Fine, C. (1998). *Clockspeed: Winning industry control in the age of temporary advantage*. Reading, MA: Perseus Books.

Frigant, V., & Lung, Y. (2002). Geographical proximity and supplying relationships in modular production. *International Journal of Urban and Regional Research, 26,* 742-775.

Gardner, J., & Cooper, M. (2003). Strategic supply chain mapping approaches. *Journal of Business Logistics, 24*(2), 37-64.

Guedes, P., Saw, R., & Waller, A. (1995). Logistics strategy planning: Modeling and decision support techniques for the 1990s. *The International Journal of Logistics Management, 6*(1), 37-50.

Juga, J. (1995). Redesigning logistics to improve performance. *The International Journal of Logistics Management, 6*(1), 75-84.

La Londe, B., & Pohlen, T. (1996). Issues in supply chain costing. *The International Journal of Logistics Management, 7*(1), 1-12.

Lambert, D., Cooper, M., & Pagh, J. (1998). Supply chain management: Implementation issues and research opportunities. *The International Journal of Logistics Management, 9*(2), 1-19.

Larsson, A. (2002). The development and regional significance of the automotive industry: Supplier parks in Western Europe. *International Journal of Urban and Regional Research, 26,* 767-784.

Lewis, I., & Talalayevsky, A. (1997). Logistics and information technology: A coordination perspective. *Journal of Business Logistics, 18*(1), 141-157.

Lucas, R. (1988). On the mechanics of development planning. *Journal of Monetary Economics, 22,* 3-42.

Mariotti, J. (1999). The trust factor in supply chain management. *Supply Chain Management Review, 3*(1), 70-77.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: Chaotic concept or policy panacea? *Journal of Economic Geography, 3,* 5-35.

Maskell, P. (2001). Towards a knowledge-based theory of the geographical cluster. *Industrial and Corporate Change, 10,* 921-943.

Mentzer, J., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, S., & Zacharia, Z. (2001). Defining supply chain management. *Journal of Business Logistics, 22*(2), 1-25.

Moniz, A. (1994, July). *The automobile sector and the organisation of the industrial space: The case of Setúbal region (Portugal).* (MPRA paper 7503, University Library of Munich, Germany).

Moreira, A., Carneiro, L., & Selada, C. (2008). Defining the regional innovation strategy for the year 2015: The case of the ITCE clusters in the north of Portugal. *International Journal of Innovation and Regional Development, 1*(1), 66-89.

Porter, M. (1980). *Competitive strategy*. New York: Free Press.

Porter, M. (1998). *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press: New York.

Rother, M., & Shook, J. (1999). *Learning to see*. Boston: Lean Enterprise Institute.

Rouleau, B. (1993). Theory of cartographic expressions and design. In R. Anson, & F. Ormeling (Eds.), *Basic cartography for students and technicians*. London: New York: Elsevier Applied Science Publishers, Distributed by Pergamon Press, 1, 65-91.

Schroeder, R. (2000). *Operations management: Contemporary concepts and cases*. Boston: Irwin McGraw-Hill, 109-111.

Stallkamp, T. (1998). Chrysler's leap of faith: Redefining the supplier relationship. *Supply Chain Management Review, 2*(2), 16-23.

Supply Chain Council. (2010). Retrieved 3 November, 2010, from http://supply-chain.org

Titze, M., Brachert, M., & Kubis, A. (2008). The identification of regional industrial clusters using qualitative input—Output analysis (Halle Institute for Economic Research, IWH-Discussion Papers, No. 13)

Van der Aalst, W., Desel, J., & Oberweis, A. (1998). *Business process management: Models, techniques, and empirical studies*. New York: Springer Verlag.

Wennberg, K., & Lindqvist, G. (2008). How do entrepreneurs in clusters contribute to economic growth? SSE/EFI Working paper series in Business Administration No. 2008, 3.

Womack, J., & Jones, D. (1996). *Lean thinking*. New York: Simon and Schuster.

Zubrod, J. (1998). Competing successfully in Asia: Or how to be an also-ran. *Supply Chain Management Review, 2*(2), 11-14.