Improving Logistics Performance of SMEs in the Automotive Sector

Final Report

PROJECT PART-FINANCED BY THE EUROPEAN UNION

REGINS

North EAST South West INTERREG IIIC

PRINTED IN BERGAMO

NOVEMBER 2006

ISBN: 88-901162-3-4

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1. PROJECT DESCRIPTION

The lack of comparative and systematic studies on the current logistics practices in Small and Medium Enterprises (SMEs) have motivated three European research centres (from Lombardy Region, Baden-Württemberg and West Pannon) to carry out an initiative which in the long run aims at providing **companies operating in the automotive industry** with a **valuable service for self-assessing and comparing their logistics and production performance** with other SMEs- and industry-specific indicators.

More specifically, the expected outcome is the development of an inter-regional partnership among the companies joining the project in order to assess their current strengths and weaknesses and to look up a **structured catalogue of logistics practices**, which would support them in enhancing and sustaining their level of competitiveness.

In the automotive industry, where the transition to a global perspective, the evolution of socio-economical market factors, the innovation pressures coming out from a pervasive presence of ICT on products and processes are exerting dramatic changes in the inter-firm relationships, small-medium manufacturers – mostly second- or first-tier suppliers – have to bear the brunt of the intense competitive pressures triggered by their downstream tiers by trying to overcome the so-called “dilemma of opposites”: cutting internal costs, improving their level of services and guaranteeing high quality standards.

Most of the companies are not aware of the utmost opportunities which they could lever out from the adoption of a set of logistics and production practices which, if properly embedded in their processes, could provide the real “holy grail” for surviving in the market. It is also evident how these practices cannot be applied abruptly to a company neglecting at all its socio-cultural values, its mission, its main distinctive factors, which make it unique in the market. Some of them are endogenous to the company, but others are related to the local environment – in terms of political, infrastructural, social drivers – which can heavily enhance or inhibit their operations.

In this sense, the LOG4SMEs project aims also at understanding whether there are **regional factors which can affect the logistical performance of a company** in order to provide some recommendations to the local regional institutions for better addressing their industrial policies.

For a more fruitful and stable exploitation of its outcome, a possible fall-out of the LOG4SMEs project will be the **implementation of a web service** through the development of a unified database of logistical performance indicators and practices within the automotive industry, encompassing an interregional perspective.

The direct involvement of SMEs as well as the dissemination of the project results to local industrial Associations and industry clusters will allow a further fostering of relationships and a mutual collaboration between research and industrial entities.

2. THE STRATEGIC RELEVANCE OF THE AUTOMOTIVE INDUSTRY

General Context

Automotive is undoubtedly one of the most topical and important industries: its turnover in 2005 in Europe is estimated equivalent to 450 billion Euros (source: European Union). It contributes to around 8% of the EU 15 government revenues and it has a workforce ranging from 11 to 12 million directly or indirectly involved employees.
Given also its R&D volumes (amounting to 5,2% of the total turnover in 2001 in Europe), it also represents a pioneering industry, since it captures the major innovations in terms of design style, product quality and safety, process efficiency, environmental care. This trend is still on-going: as an example the **spreading of electronic components on board is expected to value up to 35% of the total car costs** in the upcoming 10 years, while **a noticeable increase of software incidence, rising up from 4% to 13%,** is foreseen in the same period.
Globalisation of markets has further contributed to an internationalisation of the strategic models of a company: this has been pursued also by leveraging on a high number of merger-acquisitions, joint-ventures and commercial alliances between companies, resulting in a high market concentration. As Table 2.1 shows, only by increasing its own scale a company is able to make up for an increasing cost trend line, due to the high impact of R&D costs, in opposition to a reduction in the average revenue per single car.

Year	Average cost increase	Average revenue per car
2000	100,0	100,0
2001	101,2	99,9
2002	104,3	101,2
2003	106,1	98,7

Table 2. 1 - Rate cuts and dispersal caused by increased delivery frequency
Source: European Car Transport of Interest (ECG) / KPMG (Lawson, 2004)

The saturation of mature markets, the achieved political and economic stability of most of developing countries (in Eastern Europe, Asia and South-America) as well as the persistent gap of labour costs if compared to western countries, have impressed in the 90's a quick and strong changeover and delocalization of production plants to most promising regions.

Outsourcing

In addition, the swift decrease of profitability, along with the growing financial requirements due to the heavy investments required, has induced carmakers to move towards a business model based on a "core competence" view: they have progressively focused on their brand image, design capability and market ownership, and, conversely, have systematically leveraged on outsourcing most of the engineering, manufacturing and assembly processes to their First-Tier Suppliers (FTSs).
As a consequence, **80% of the total car value is expected to be produced by external suppliers in the upcoming 10 years** and the market of components is estimated to increase up to 700 billion Euros worldwide by year 2015. In addition, the most evident measure of the diffusion of outsourcing lies on the gradual reduction of employment levels of automotive carmakers, in spite of the increase of the employment rate at suppliers level, where 3,3 million of new jobs worldwide are estimated in the next 10 years: the de-verticalisation process pursued by most carmakers undoubtedly contributes to the growth of their suppliers.
This current changeover of relations within the automotive supply chain has also a direct impact on suppliers operating at more upstream levels than the FTSs. **FTSs tend to spill over the stringent OEM requests to their own suppliers,** generally family run companies, which find difficulties in keeping the pace with the technological,

planning and organisational capabilities requested to them, because of their inherent financial vulnerability and unavailability of skilled workforce. The expected final outcome of this selection process will be the reduction of the number of suppliers at every tier level; as shown in a Mercer Management study (Figure 2.1), the number of automotive suppliers worldwide is foreseen to be halved to 2.800 by 2015 and the number of independent automakers is foreseen to decrease from the existing 12 to just 9 or 10.

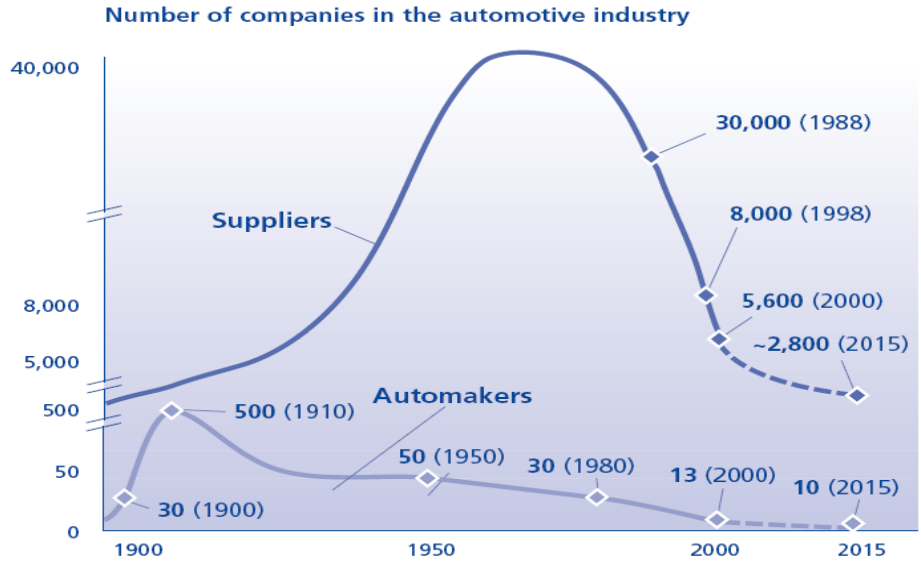


Figure 2.1 - Still room for consolidation

Source: Automobil produktion, University of London, Mercer analysis (2004)

In a highly competitive sector as automotive, all the initiatives able to guarantee enterprises to get profits are fundamental.
In the production and logistics areas, lean manufacturing concepts have been definitely acquired and implemented. As a consequences for acting as a world-class company, it becomes necessary to go beyond, by embracing other organisational and management concepts. As identified by a study conducted by Mercer Management consulting group (Mercer et al., 2004), several promising business designs, combined with forms of collaboration among the players, are gradually spreading out: systems and production cooperation projects (both among the suppliers and also with their customers), engineering service provision, spin-offs and private label productions, are only some examples of business solutions which could have, if well implemented, the potential to deliver significantly higher returns than those achieved through traditional relationships. **An extraordinary reorganisation in the automotive supply chain is currently occurring.**

3. COMPARING THE REGIONAL FACTORS OF THE THREE REGIONS

3.1. Positioning the three regions

A brief description of the three regions involved in the LOG4SMEs project and their automotive industry conditions is reported hereafter. The economical values refer to year 2005 (source: Eurostat).

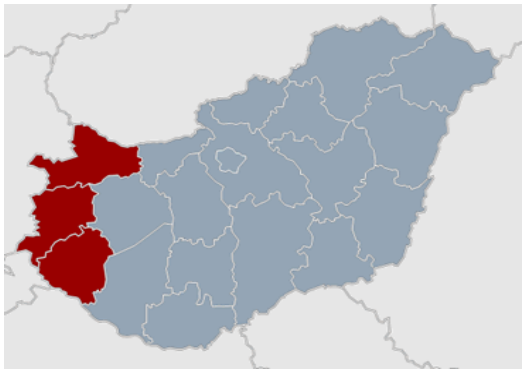
Baden-Württemberg (BW)

Baden-Württemberg is a German state in the south-western part of the country to the east of the Upper Rhine. The state capital is Stuttgart. The region surface area is **35.752 square kilometres** with **10,7 million inhabitants** and in Stuttgart, which is the largest city, the population amounts to about 600.000.
Almost half the surface area (47%) is used agriculturally, 38% is afforested, while settlements and transport account for 13%. The region has a Gross Domestic Product (GDP) of 330 billion Euros and a **GDP per inhabitant of 30.715 Euros**. With regard to the automotive industry, Baden-Württemberg generates more than a quarter of Germany's annual sales in this sector, with a high export rate of over 50%. Car companies are made up of a small number of global lead manufacturers surrounded by a large number of family-owned small and medium-sized suppliers.
The region hosts the premises of major car manufacturers (Audi, Mercedes-Benz, Porsche) and high value-added components manufacturers. Including manufacturers of special vehicles, distributors and indirect suppliers, Baden-Württemberg brings together more than 2.000 enterprises and engineering partners which are closely related to the automobile industry and accounts for sales more than 30 billion Euros.

Lombardy (L)

Lombardy is situated in the heart of Europe, in the northern part of Italy. The territory extends over a total surface area of **23.863 square kilometres**. It is the Italian region that has the highest concentration of people, businesses and wealth: it represents 15,6% of the overall national population with approximately **9,3 million inhabitants**. The Lombardy economy represents one-fifth of the Italian one, with a GDP of 270 billion Euros and a **GDP per inhabitant of 29.525 Euros**. The contribution made to the regional economy by the industry is almost 36%, while services represent approximately 62% and agriculture totals 2,1%. The number of companies operating in the region is 895.000 (140.000 manufacturers) and 83% of them are Small and Medium Enterprises. The geographical distribution of the firms in the Lombardy region is concentrated in 21 industrial districts which cover 30% of the regional territory, include 1/3 of the resident population and employ 30% of the work force. 97% of district enterprises have fewer than 20 employees, with an average of 5 employees per enterprise.

West Pannon (WP)



West Pannon is an Hungarian region that borders with four countries: on Austria in the west, on Slovenia and Croatia in the southwest and on Slovakia in the north. The territory of the region is **11.328 square kilometres**. About **1 million people** live in the region that is just 10% of the population of Hungary. West Pannon has a balanced economic structure (43% industry, 53% service) and a **GDP per inhabitant of 7.887 Euros**, which is one of the highest values in Hungary.
The automotive industry plays an important role for the economy of the West Pannon region. According to the TEÁOR 3400 classification, there are 44 automotive companies and 72,4% of them are Small and Medium Enterprises. The number of employees operating in this sector is around 9.500, that is the 3,1% of the total employees in the region.

3.2. A comparison of the regional factors

The LOG4SMEs survey aims at providing a comparison among the logistical practices adopted by the automotive companies involved in the project. These practices do not merely depend on companies' endogenous factors, but their effectiveness can be heavily affected also by the economical, logistical and social location factors of the regions where they are located. Hence, a list of regional factors which affect the logistical performance has been defined. Hereafter the most influent factors and their comparative values are reported. The source used to get these factors is mainly Eurostat. Istat has also been used for the Lombardy region and KSH for the West Pannon region; the values refer mostly to years 2004 and 2005.

Some ***General indicators*** have been defined in order to have an overall overview and an assessment of the companies position in each region. As previously outlined, the Lombardy (L) and the Baden-Württemberg (BW) regions are characterised by the biggest areas (23.863 Km^2 (L) and 35.752 Km^2 (BW)). They are also the most densely populated (inhabitants per Km^2: 408,8 (L), 299,4 (BW)) with the highest total and pro capite GDP (GDP per inhabitant: **29.525 Euros** (L) and **30.715 Euros** (BW)). Even if the values of West Pannon (WP) are promising, if compared with the other regions, they are still lower (GDP per inhabitant: **7.887 Euros**). This is mainly due to its past economical and political background.

Innovation

The ***Research intensity*** factor is one of the most important source of innovation and knowledge. In this context, human and financial resources, addressed to the knowledge creation, transfer and exploitation, are fundamental. As depicted by the selected indicators, Baden-Württemberg region invests more capitals and human resources than Lombardy and West Pannon in Research and Development activities.

	WP	L	BW
Total intramural R&D expenditure (% of GDP)	0,3%	1,2%	3,9%
Total R&D personnel (% of total employment)	0,5%	1,1%	2,6%

The ***Quality of the human resources*** analyses both quantitative and qualitative characteristics of the human resources operating in each region. The presence of personnel with a high-level instruction constitutes an important prerequisite for assuring future growth to companies operating in a *knowledge-based* economy. The

most significant indicators and the related values show that the highest level of human resources quality is in the Baden-Württemberg region.

	WP	L	BW
Compensation of employees (billion Euros)	3,3	112,9	170,0
Compensation of employees (thousand Euros per employee per year)	7,9	27,2	34,5
Population with University level of education attained	9%	8%	16%

The factor ***Education system*** identifies the breadth and the accessibility of the regional school system as well as the variety of structures offered in the territory; the proposed indicators show an equivalence regarding the development of the educational system in the three regions.

	WP	L	BW
Number of university centres/ million residence	18 [1]	2,89	6,4
Number of university students/ total population	2,8%	2,8%	2,3%

The level of ***Innovation spread*** analyses the intensity of innovation in the territory, in order to estimate the local importance of the high-tech activities. An important indicator is the *Patent applications to the European Patent Office (EPO)* by *priority year (per million inhabitants)*. It is 6,3 in West Pannon, 93,9 in Lombardy, and 313,5 in Baden-Württemberg. Also this indicator shows that the Baden-Württemberg region has a higher level of innovation than Lombardy and West Pannon.
The ***Internationalization*** factor aims at stimulating innovative processes and continuous renewal of competitive advantages. The indicator analysed is the *Level of integration with foreign countries (Export-Import/GDP)* which is -9,79% in Lombardy; +7,79% in Baden-Württemberg and -0,7% in all the Hungarian country.
The regions, where companies have set their headquarters, can ease their innovation attitude and network relationship through offering equipment and structural capabilities (both natural and artificial). The main indicators and their values mapped in the ***Localization and infrastructures area*** show that all the analysed regions are characterised by a discrete level of infrastructures, with the best performance in the Baden-Württemberg region:

	WP	L	BW
meters of high speed motorways/total area km^2	10	20	30
meters of roads/total area km^2	420	470	770
meters of railways/total area km^2	80	70	100
N° of airports	1	4	1

Enterprise Structure

The ***Enterprise characteristics*** is a structural factor which affects the potentiality of a company considering both company's size and the complexity of their organisational structure, even though they do not exhaust the range of variables of interest. These dimensions are directly associated to the company inclination to operate in international markets as well as to develop research activities. Moreover, the entrepreneurial dynamism, as a sign of the system vigour and ability to grow is also considered. The analysed indicators show a very high number of SMEs in the Lombardy region while the entrepreneurial development in Baden-Württemberg is

[1] Unlike the other regions, in Hungary there is a high fragmentation of faculties into more Universities and colleges.

quite dynamic. On the contrary, recent data on the level of development of enterprises in West Pannon show a worrying trend line.

	WP	L	BW
Number of enterprises between 10 and 50 employees and turnover between 2 million Euros and 10 million Euros	1.420[2]	37.000	39.326
Number of enterprises between 50 and 250 employees and turnover between 10 million Euros and 40 million Euros	483	9.000	9.107
Rate of entrepreneurial development (New enterprises - Bankrupted enterprises) / Enterprises registered the previous year)	-4,83%	7,34%	4,91%

Finally, the ***Automotive specific regional factors*** identify the relevance and the structure of the regional automotive sector.

	WP	L	BW
Number of local units referred to Manufacture of motor vehicles, trailers and semi-trailers	61 *	447 *	369 *
Number of automotive enterprises/ total enterprises	0,05%	0,06% *	4,30%
People working in the automotive sector/ total employees	3,1%	N.A.	20,1%
Number of Small automotive enterprises / total automotive enterprises	72,4 % **	39,1% *	27%
Number of Medium automotive enterprises / total automotive enterprises		13,2% *	43%

(*) (NACE DM- 34)[3]
(**) (TEÁOR 3400 classification)[4]

A comparative analysis

From a comprehensive comparative analysis of the regional factors there are three main remarks which can be clearly highlighted:

Size does matter – As also resulting from other regional and national research studies (Fillea, 2003 www.lomb.cgil.it) and from the internationalisation factors, which summarise the regional capabilities to produce **added value** products and goods, a high infrastructural gap among Lombardy, Baden-Württemberg and West Pannon exists. In particular, the negative trade balance in the Lombardy region (-9,79%), which is constituted by a high number of Small and Medium enterprises, shows that high fragmented industrial systems, which are potentially more flexible than others, present a higher risk to lack on competitiveness, due to the companies' lower capability to invest in innovation and new technologies.

Human capital intensity boosts up innovativeness – It is evident how the more a region bets on its human capital empowerment, the more it is rewarded with a better attitude of its companies to innovate their products and processes. As the radar chart in Figure 3.1 shows, Baden-Württemberg is undoubtedly best performing in terms of innovativeness (whose proxy measure is related to the number of registered patents), as a results of its major sensitivity to educating and training its future and current workforce and to its higher expenditure of R&D.

[2] Only industrial related companies are treated (total is 7552)
[3] For any details, please refer to chapter 5.
[4] According to the TEÁOR 3400 classification, there are 44 automotive companies.

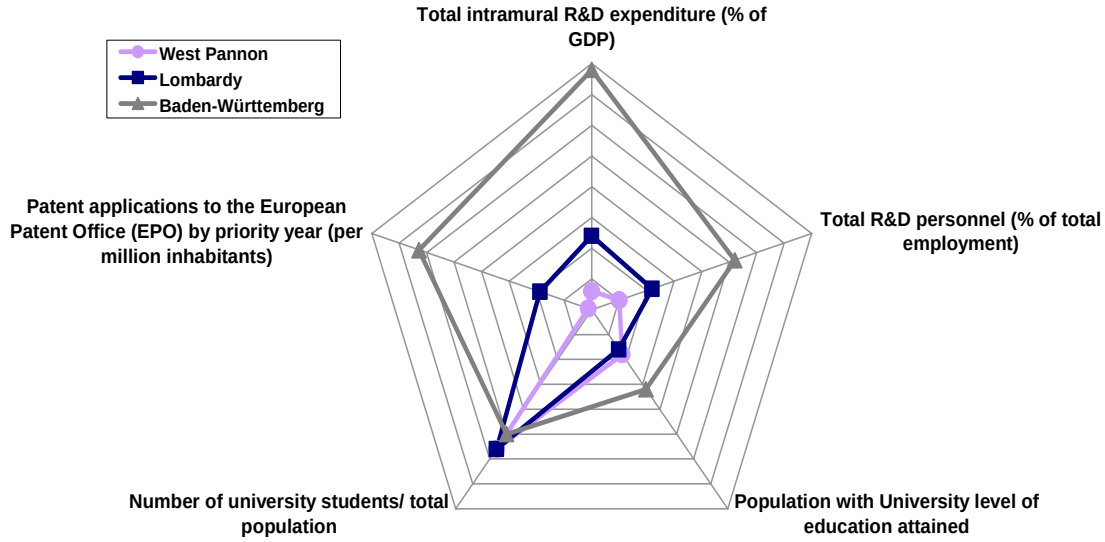


Figure 3.1 – Better trained and more innovative

The role of automotive industry in the regional economy – It is plain how the Baden-Württemberg economy relies heavily on the car making industry in terms of number of automotive enterprises and workforce employed. The maturity of the industry in this region is also represented by the highest incidence of Medium enterprises, while in Lombardy and West Pannon most of the companies are of small size (quite consistent with the dwarfish size of enterprises in this regions). In particular, West Pannon is characterised by the presence of young small suppliers which have mushroomed in the last decade as a response to the increasing demand of components resulting from the establishment in that region of new production sites by some big car players as, for example, Audi, Opel and Suzuki.

4. THE SURVEY: QUESTIONS ADDRESSED AND THE DATA MODEL

Questions

The comparative survey conducted along the three regions has been carried out with the primary objective to answer to the following questions:

- How to **assess the complexity of the logistic processes** managed in a company?
- How does **a company manage its own complexity**?
- Does **Information and Communication Technology properly support the logistics practices** adopted by automotive companies?
- Are all the **adopted practices properly measured and monitored**?

Hence, the results of the survey should hopefully:

a) **enable a company to self-assess its current capability to manage the complexity of the market** (and, in general, of the environment where it operates);

b) **verify whether the managerial practices and policies and the underlying ICT infrastructure are properly enhancing this capability** or, conversely, need to be better fostered.

The data model

The survey has been carried out through a questionnaire, whose structure and content has been designed and developed according to a theoretical data interpretative model, based on the integration of the de-facto standard SCOR (Supply Chain Operations Reference) and the IPA-Fraunhofer Supply Chain Management SCM-ITC reference models. More details on these models are reported in Appendix A.
As shown in Figure 4.1, the model underlying the questionnaire is designed considering three nested levels of analysis:

level 1. assessment of the level of complexity of a company, the managerial practices adopted and the ICT tools and performance measures implemented;

level 2. identification of the drivers which better describe the factors assessed at level 1;

level 3. definition of the questions to be inserted into the questionnaire in order to understand the position of a company in relation to the drivers identified at level 2.

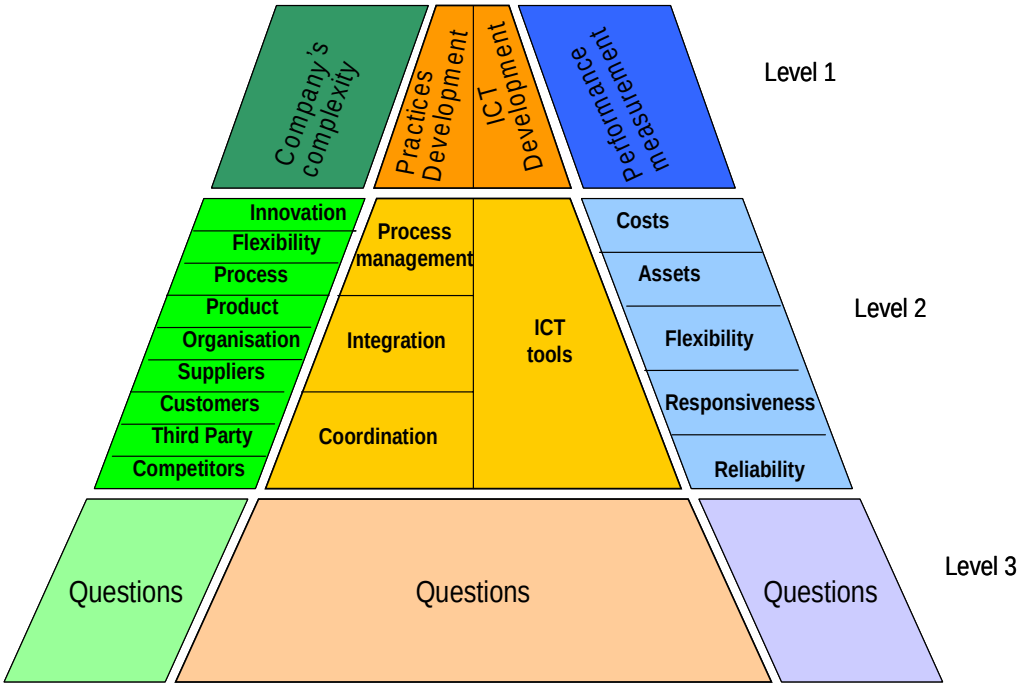


Figure 4. 1 – Rationale behind the design of the questionnaire

Crossing the structure of the questionnaire, the following sections can be highlighted (Fig. 4.2):

Level of complexity

Level of complexity – A complex system is defined as "*a system which has a large number of parts, whose relationships are not simple*" (Lawrence et al., 2003). The complexity is closely connected to the variety which exists within a company's boundaries and its supply chain. It refers to all the variables that an enterprise has to manage to satisfy customers needs assuring an appropriate service level. Complexity refers to both the socio-economical environment where a company operates (influenced by the behaviour of suppliers, suppliers of the suppliers, customers, third-party operators, competitors) and the internal company's factors, characterising both its organisation and management macro-processes.
In the survey, the following drivers have been selected to describe the complexity of a company: **suppliers and customers characteristics**, **third-party and competitors structures**, **product class and innovation, process organisation** (procurement, production, logistics and sales) as well as level of **flexibility of its production and logistic processes**.
Since complex systems are made up by single elements which have intimate connections, counterintuitive and non linear links, they present self emerging and chaotic behaviours (Forrester, 1961). In this condition, understanding the functioning of each single factor affecting the complexity does not imply the understanding of the whole system. In addition, the interaction among the variables does not allow to manage them separately (Perona and Miragliotta, 2002).

Managerial practices

Managerial practices – They include policies, methodologies and procedures that are adopted by an enterprise to manage, coordinate and integrate its operations processes. Three main typologies of practices have been considered in this survey (Figure 4.2):

- *Managing internal operations functions*: it refers to those practices usually adopted by a company to manage a single function - primarily procurement, production, logistics and sales - directly or indirectly involved in its operations and logistics activities; in an evolutionary path of a company, they could be considered

as the “must” practices a company normally is supposed to adopt for ensuring the basic operability of its production operations.

- *Integration*: it captures the forward step a company carries out in the consciousness to integrate its internal functions in a more process-like fashion (e.g., new product development process, order fulfilment, demand planning,..); usually, the adoption of these practices comes after the implementation of ERP or management systems which ensure, through a common data warehouse, the proper share of information and consistency of decisions adopted throughout the company.
- *Coordination*: also termed as collaboration, it identifies a further level of development in the managerial growth of a company, in the view to achieve not only an integration of its internal functions, but also to strive for an external synchronisation with the upstream and downstream actors (i.e. suppliers and customers) involved in its logistics chain. Examples of collaborative practices, whose level of adoption in the analysed sample will be also discussed in section 5, are Vendor Managed Inventory, Distribution Requirement Planning, Collaborative Planning and Forecasting.

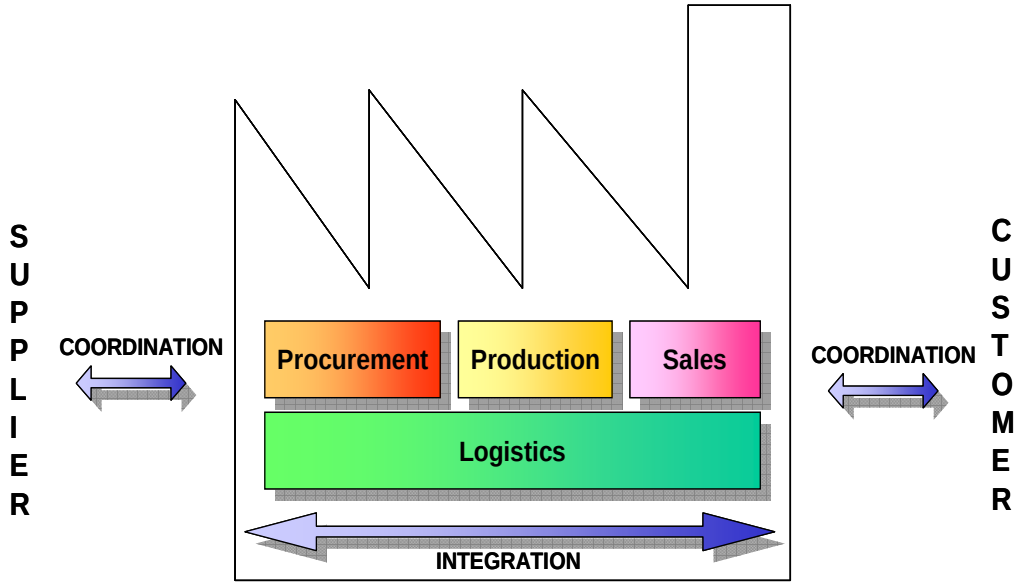


Figure 4. 2 - Managerial practices structure

ICT Tools

ICT tools – They refer to hardware and software technologies implemented in a company in order to support and enable the management of its practices at each level of development (i.e. functional practices, integration practices, collaborative practices). The survey aims to evaluate whether the practices, once adopted in a company, are properly supported by specific ICT tools.

Performance Measurement

Performance measurement – A set of metrics is mandatory in a company in order to allow for target setting, performance monitoring and identification of corrective actions during the ordinary management of its operations practices. In the survey, the main objective is to evaluate whether a company adopts proper Key Performance Indicators (KPIs) and operative metrics in relation to the adopted practices at each level of development. Performance metrics have been categorised in reliability, responsiveness, flexibility, costs and asset management metrics, in strict accordance with the SCOR framework (see Appendix A).

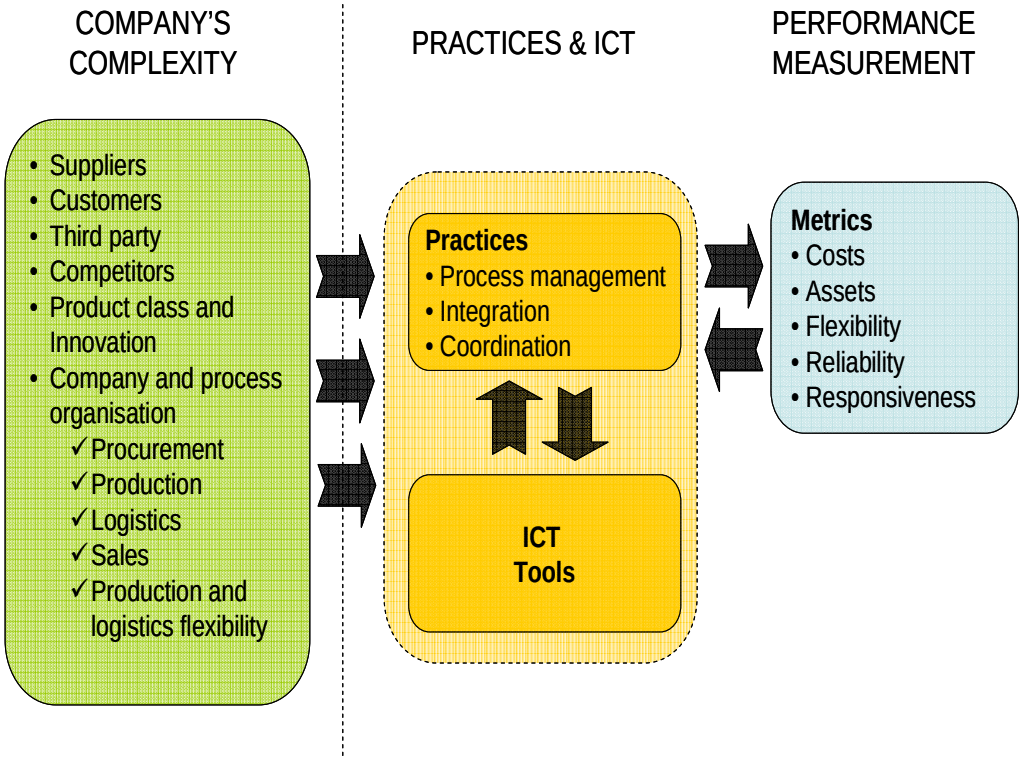


Figure 4. 3 - Data interpretative model - Level 2

The statistical methodology

A statistical approach has been carried out to analyse the data collected in the survey. The methodology has been provided in two steps:

i) *an exploratory data analysis* - used to describe data and their statistical correlation; plots which provide information on mistakes, outliers, distributions and relationships among variables, and numerical summaries which provide a statistical synopsis of the data in a tabular format, have been used.

ii) *adoption of statistical models* - in order to express a response variable as a function of a set of one or more predictor variables; the development of statistical models is data dependent; the choice of the modelling technique depends both on data type and structure as well as on what the model has to test or explain.

More details on the methodology adopted in the survey are reported in Appendix B.

5. RESULTS: A DESCRIPTIVE ANALYSIS

The survey has been carried out considering automotive Small and Medium Enterprises (manufacturers and assemblers)[5] belonging to the following NACE codes[6].

*Sub Section **DL** : Manufacture of electrical and optical equipment*

31 : Manufacture of electrical machinery and apparatus n.e.c.[1]

- **31.6** : Manufacture of electrical equipment n.e.c.
  - **31.61** : Manufacture of electrical equipment for engines and vehicles n.e.c.

*Sub Section **DM** : Manufacture of transport equipment*

34 : Manufacture of motor vehicles, trailers and semi-trailers

- **34.1** : Manufacture of motor vehicles
  - **34.10** : Manufacture of motor vehicles
- **34.2** : Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semitrailers
  - **34.20** : Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semitrailers
- **34.3** : Manufacture of parts and accessories for motor vehicles and their engines
  - **34.30** : Manufacture of parts and accessories for motor vehicles and their engines

The sample

The sample analysed for the survey is made up of **48 companies** which operate in the automotive industry, within the regions involved in the project. **28 companies are from Lombardy Region, 13 from West Pannon** and **7 from Baden-Württemberg**. The sample is composed of **24 Small, 18 Medium** and **6 Large Enterprises**. Hence, though the survey is mainly addressed to SMEs, a small sample of larger enterprises, mainly from Lombardy, has also been included in order to provide a possible upper bound benchmark on the way practices, ICT tools and performance measures are carried out.

5 The category of micro, Small and Medium-sized Enterprises (SMEs) is made up of enterprises which employ less than 250 people and which have an annual turnover not exceeding 50 million Euros, and/or an annual balance sheet total not exceeding 43 million Euros. Within the SME category, a small enterprise is defined as an enterprise which employs fewer than 50 people and whose annual turnover and/or annual balance sheet total does not exceed 10 million Euros. Within the SME category, a micro enterprise is defined as an enterprise which employs fewer than 10 people and whose annual turnover and/or annual balance sheet total does not exceed 2 million Euros. Micro enterprises have not been considered in this survey.

6 NACE stands for "Nomenclature générale des activités économiques dans les Communautés Européennes", which is the standard for classification of economic activities in the EU. Details of these can be found in Council Regulation No: 3037/90 (as amended by Regulation No 761/93 and 29/2002), NACE Rev 1. Under the previous regulation, the scheme was open to the industrial sector covering only NACE codes from 10 to 40. Now that EMAS II allows participation of organisations from all economic sectors, the whole range of NACE codes is applicable. This list enumerates NACE codes with a maximum of two decimals after the comma, however, there are NACE lists that go much deeper into detail with up to five decimals after the comma.

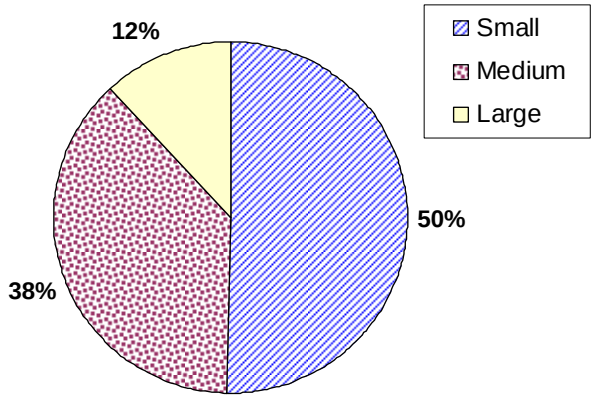


Figure 5. 1 - Sample breakdown

A **descriptive analysis** about the data collected is hereafter summarized considering three clusters of information:

1) **General information** refers to companies' structure, organisation, people as well as to product features.
2) **Customer/supplier information** reports the main findings on the position of a company within its automotive supply chain as well as on its relations with its suppliers and customers.
3) The third section provides an insight on the **Practices** adopted by companies to manage, integrate and eventually outsource their internal processes and to coordinate with the other actors involved in the supply chain (i.e. suppliers and customers).

In Appendix C a legend of the acronyms and terms used in the following sections is reported.

General information

Companies' size

Companies have been classified according to their turnover and number of employees, consistently with the European classification. As reported in table 5.1, the sample is mainly made up of Small and Medium Enterprises. Companies claiming a turnover lower than 10 million Euros but with an overall number of employees higher than 50 units have been classified as Small enterprises. Most of these companies operate in West Pannon: the relative lower labour costs allows them to count on average on more employees than their homologous from the other two regions.

	Lombardy	Baden-Württemberg	West Pannon
Small	39%	29%	85%
Medium	39%	71%	15%
Large	22%	0%	0%

Table 5. 1 - Companies' size classification

Legal form

With regard to the enterprises' legal form, 53% of them are limited companies, 27% are limited liability companies, 8% are limited partnership companies, 6% are public companies, 4% are general partnership companies and 2% are of other types. 57% of the sample is constituted by family run companies and 43% by managerial ones (Figure 5.2). 63% of them are independent while 37% belong to a group.

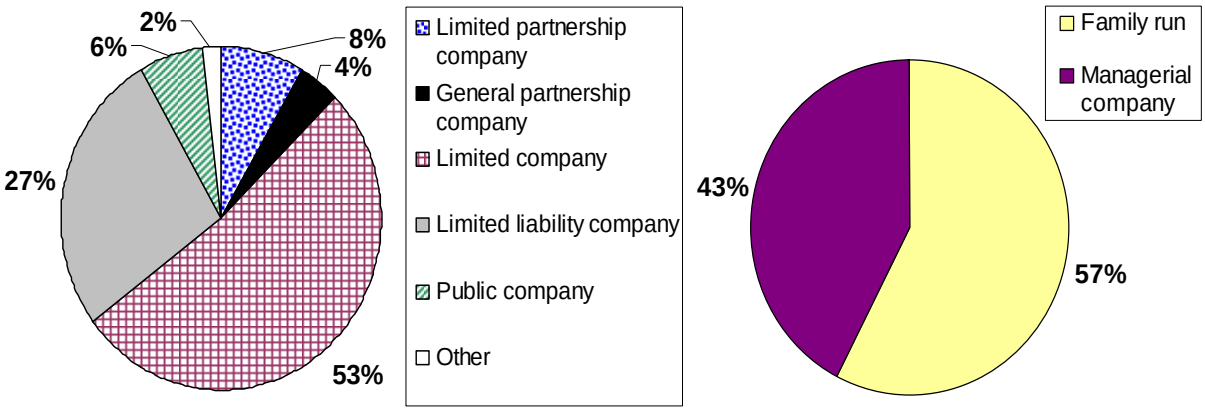


Figure 5. 2 - Companies' legal form and managerial structure

Employees' Education Level

A comparison among the three regions has been done in order to understand how **employees with a high education degree** are recruited according to the companies' size. It results that Lombardy has a lower number of employees with a high education degree than Baden-Württemberg and West Pannon. 81% of companies in Lombardy have a fair low number of employees with a high education degree (0% - 15%), while in the remaining 19% their quota ranges between 15% and 30% of the overall workforce. These figures are significantly better in West Pannon and Baden-Württemberg. In the latter region, 17% of the companies (100% of small ones) declare that the number of their employees with a high education degree is between 15% and 30%, while for the 16% of the companies it values up to between 30% and 50% of the overall workforce. In West Pannon 18% of the companies have around 15 - 30% high educated employees and far beyond 27% of the companies declare to have more than 50% of employees with a high education degree.
As predictable, the larger a company is, **the higher the number of educated people is expected**. Considering Medium enterprises, this trend is remarkable: the rate of companies with the lowest range of high skilled employees is exiguous.

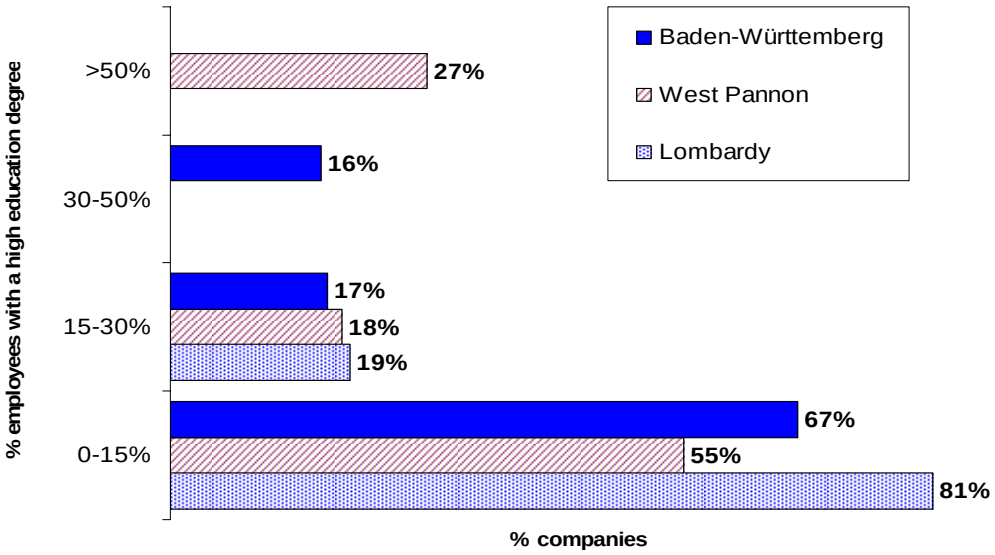


Figure 5. 3 - Percentage of employees with a high education degree

Geographical distribution

Referring to the companies position and geographical distribution along the automotive supply chain, it results that **the analysed sample is mainly constituted by local components and parts suppliers**.
As shown in Figure 5.4 it turns out that 65% of the companies are limited to a regional area since they have just regional manufacturing sites, 20% have also some national sites and only 15% have some manufacturing locations in other countries.

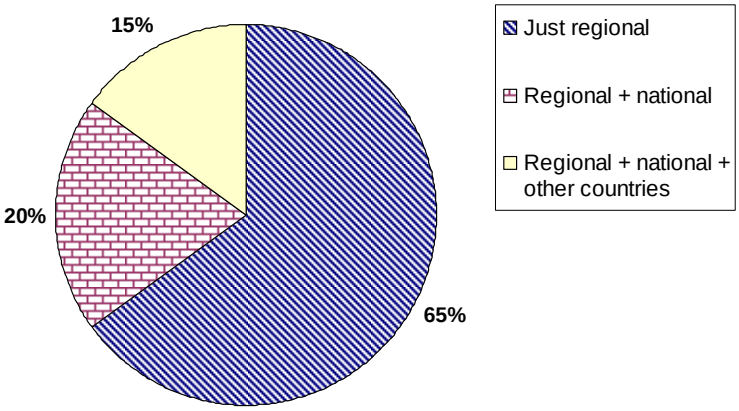
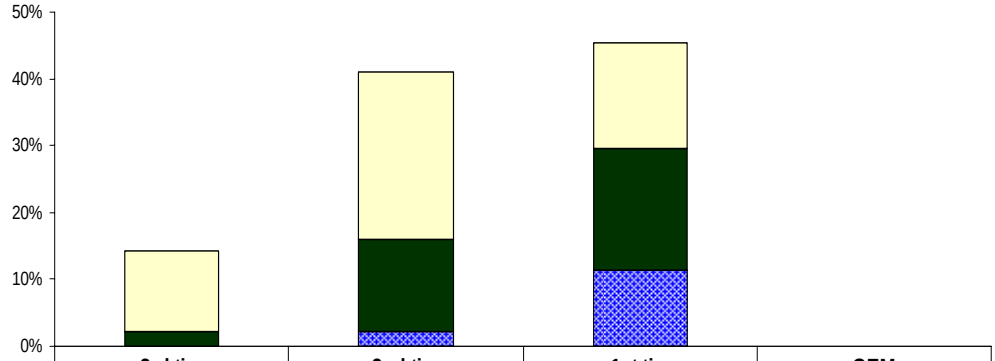


Figure 5. 4 - Companies' geographic location

Position in the automotive network

The position of the surveyed companies along the automotive network is mainly of 1st tier. As reported in the chart, 45% are 1st tier, 41% are 2nd tier, 14% are 3rd tier (Figure 5.5). There are not OEMs in the analysed sample. An evident consideration can be inferred from a cross analysis between the companies' size and their position along the network: **the nearer a company is to the OEM position, the larger its size is.** Even if the Large companies are not the focus of this work, it is noticeable that they also follow this trend.



	3rd tier	2nd tier	1st tier	OEM
Small	12%	25%	16%	0%
Medium	2%	14%	18%	0%
Large	0%	2%	11%	0%

Figure 5. 5 - Position along the automotive supply chain

Different activities and, as a consequence, different organisation and companies structures are needed at each level of the automotive supply chain. The OEM's increasing request at developing with their suppliers co-design practices, wide assortment of products and services as well as having a global presence wherever they have industrial plants is forcing first-tier suppliers (FTSs) to merge with or acquire other brands and companies, so that they are expected to get bigger and fewer, taking

on module and systems development (Lung, 2004, Accenture, 2002). As already discussed in section 2, the on-going consolidation at this level of the automotive supply chain has a direct impact on suppliers operating at the upper stream tiers, which are expected to have a dimension sufficiently large to invest in production efficiency and product innovation according to their industrial customers recommendations.

Product Portfolio

Concerning the ***product portfolio,*** as Figure 5.6 shows, their assortment is quite broad. It comes out that 19% of the products are engine systems, 17% other components, which are usually produced by third tier companies for all the companies along the supply chain, 16% power train components, 14% interior parts,13% electrics and electronics items, 9% body parts, 7% undercarriage and 5% exterior parts. About the finished products range, it has been noticed that the analysed companies have mainly less than 500 items of finished products (58%). Few companies have more than 500 items in their portfolio.
From the survey it results also that the **percentage of new products introduced in the market every year** (a good measure of a company's attitude to innovation) is 41%, being equally distributed by products engineered by the customer and those ones internally engineered.

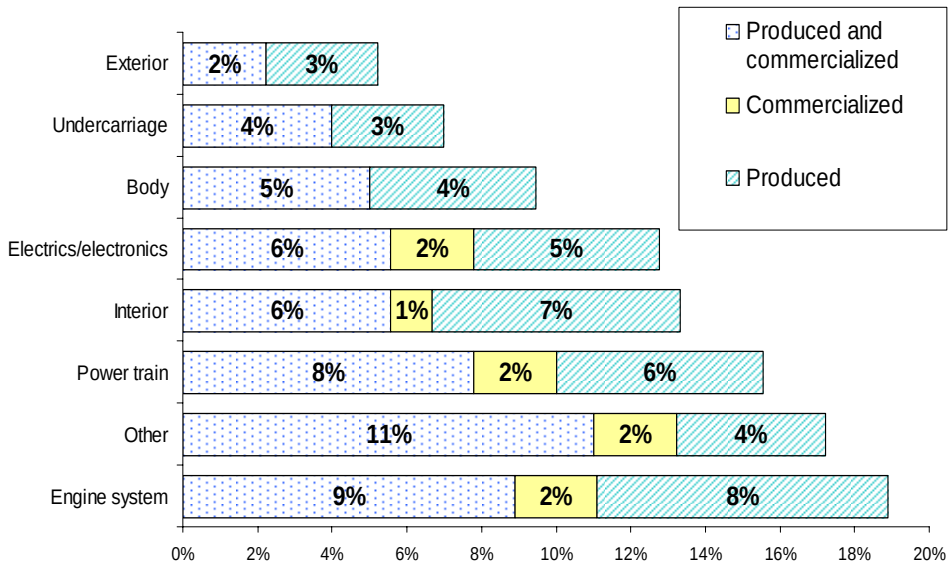


Figure 5. 6 - Manufactured and commercialised products

Relations with customers and suppliers

Suppliers

The analysis on the supply chain structure has mainly focused on the networks relations with suppliers and customers. First of all a cross analysis has been carried out in order to identify a relation between the position that the companies have along the network and the number of their suppliers. As reported in the chart (Figure 5.7), 3rd tier companies have less suppliers than the 1st tier: this is quite obvious since the former usually produces plain items characterised by few components while the products of 1st tier manufacturers are generally results of more complex assembly groups.

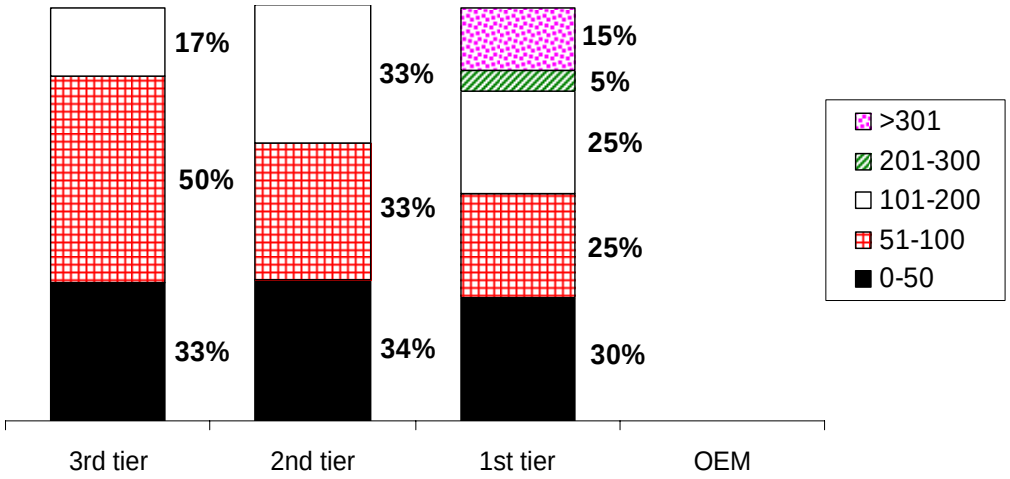


Figure 5. 7 - Numbers of suppliers along the automotive supply chain

Customers

With regard to the customers, it is worthwhile to analyse the relation between the position of a company along the network and its commercial channels. As Figure 5.8 shows, the main customer of 1st tier companies is the OEM, while 2nd and 3rd tier companies mainly produce and commercialise their products for other suppliers. Wholesalers and resellers as customers show a growing homogeneous trend for all the positions while just 3% of 1st tier companies distribute their products to fast fit networks. These figures point out how **it is rather difficult for suppliers to address directly the lower streams of the automotive supply chain,** in particular the after market segment which is actually becoming the most valuable source of profits in this industry.

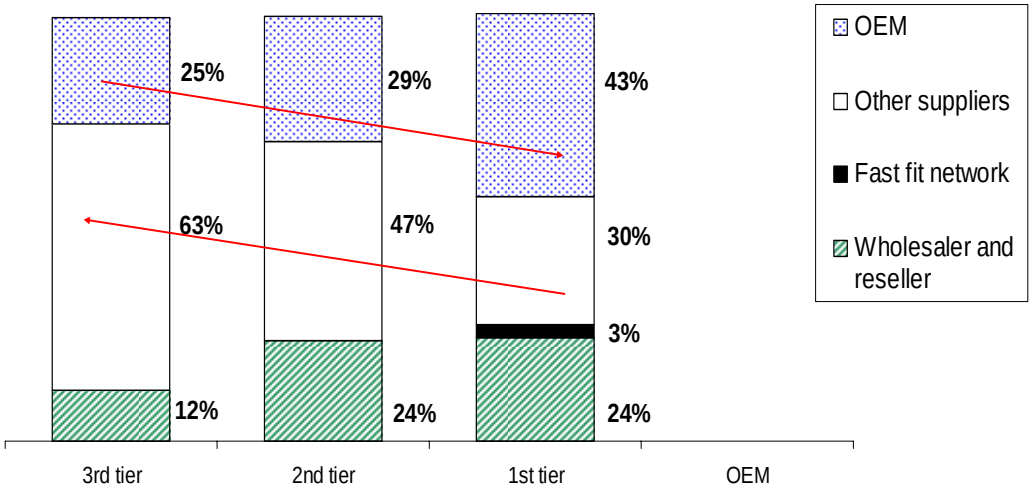


Figure 5. 8 - Type of customer along the automotive supply chain

Managerial Practices

In accordance with the classification adopted in chapter 4 (see Figure 4.2), the main findings from the survey conducted are broken down in relation to the breadth of coverage of the practices they adopt for managing their production and logistic activities.

Management of Process Practices

Referring in particular on ***internal operations function***, as Figure 5.9 evidences, the practices which have been included in the questionnaire appear not so widely implemented in the surveyed sample. On average, half of the companies claim the absence of these practices within their organisation.

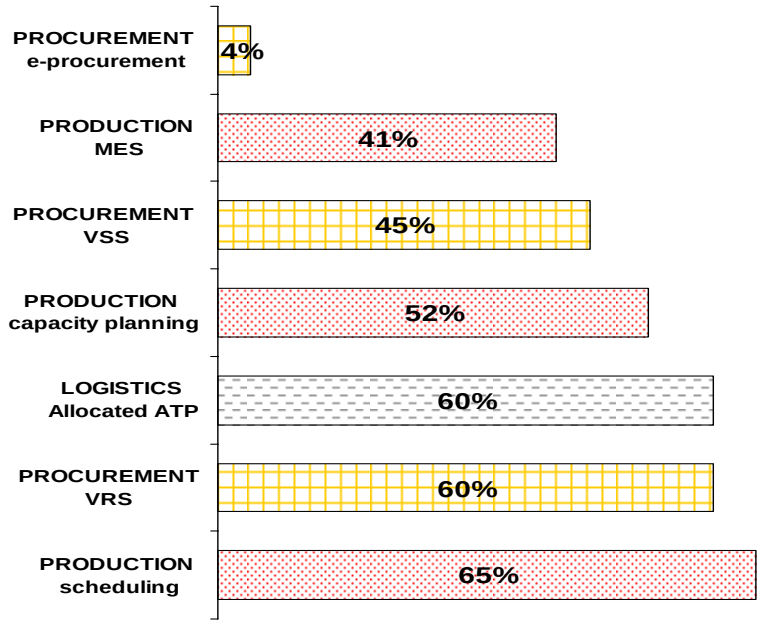


Figure 5. 9 - Level of adopted management process practices

Integration Practices

Concerning ***integration practices***, adopted by companies to integrate their internal functional units and activities, even though quality tools and CAD/CAM systems are applied by a great number of companies, the majority of the sample is far behind. This is confirmed by the fact that Master Production Schedule, Material Requirements Planning or Forecasting systems are implemented on the average by half of the companies. The same percentage applies to companies that have introduced ERP systems (Figure 5.10).

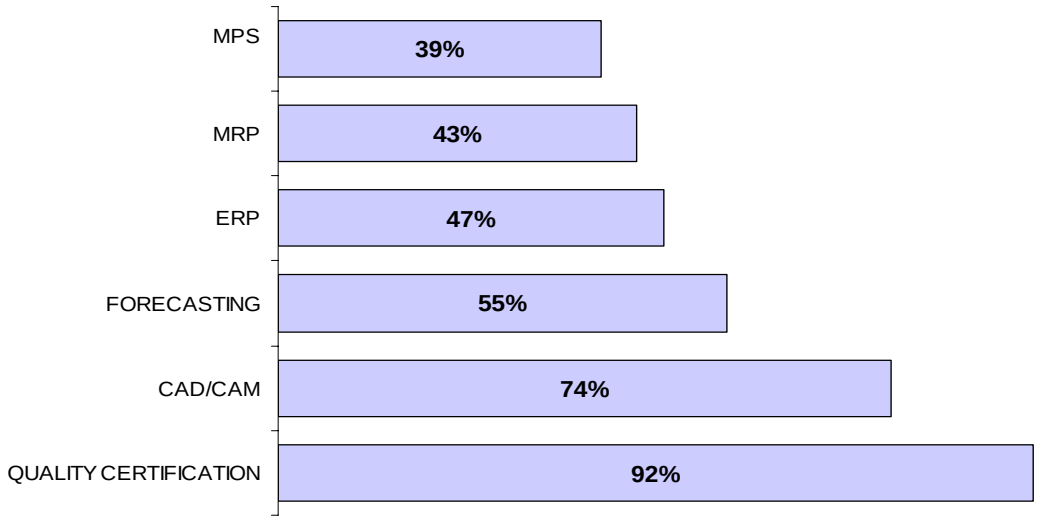


Figure 5. 10 - Adopted integration practices

Coordination Practices

Finally analysing ***coordination practices*** for enabling collaboration with the upstream and downstream counterparts, from the survey it appears not symmetric on both sides. It is evident how, throughout the chain, collaboration practices are more used towards the downstream side, due to the higher requirements from the lower tiers, than towards the upper stream level. Frequent deliveries are quite widespread, since 58% of the companies claim to have already implemented them with their customers (Figure 5.11).

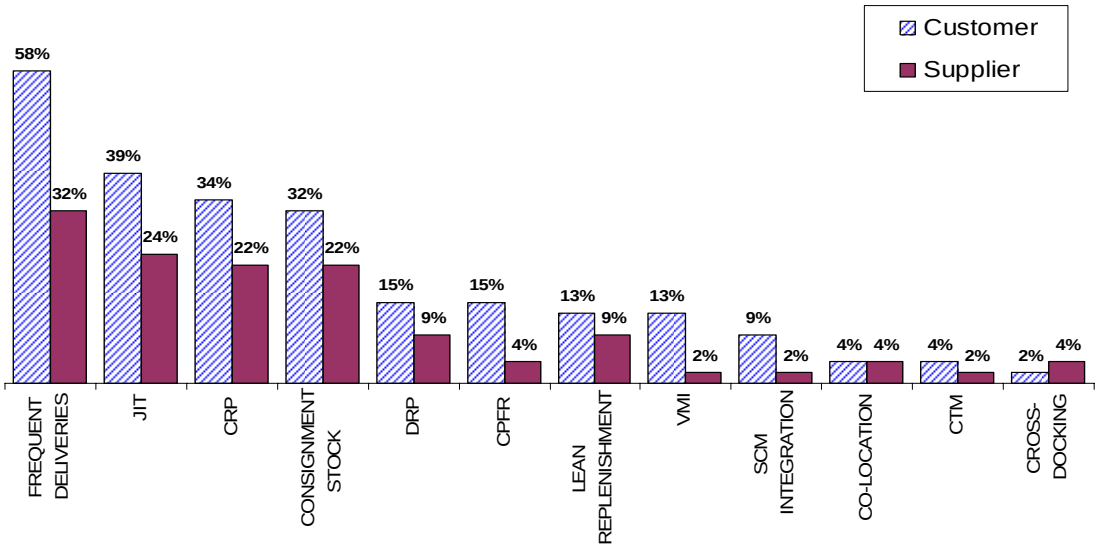


Figure 5. 11 - Coordination practices

Outsourcing

Finally, an insight on the **attitude of companies to outsource their internal processes**. As shown in Figure 5.12, almost all the activities are internally managed by the companies: just a limited quota of production, sales, logistics, R&D, marketing, financial accounting and human resources is outsourced. On the contrary the legal function is generally externalised (89%). It is curious to observe how in 23% of the

sample marketing and R&D functions are not even present: this is mainly the case of Small enterprises operating as third party producers at the upper levels of the automotive supply chain.

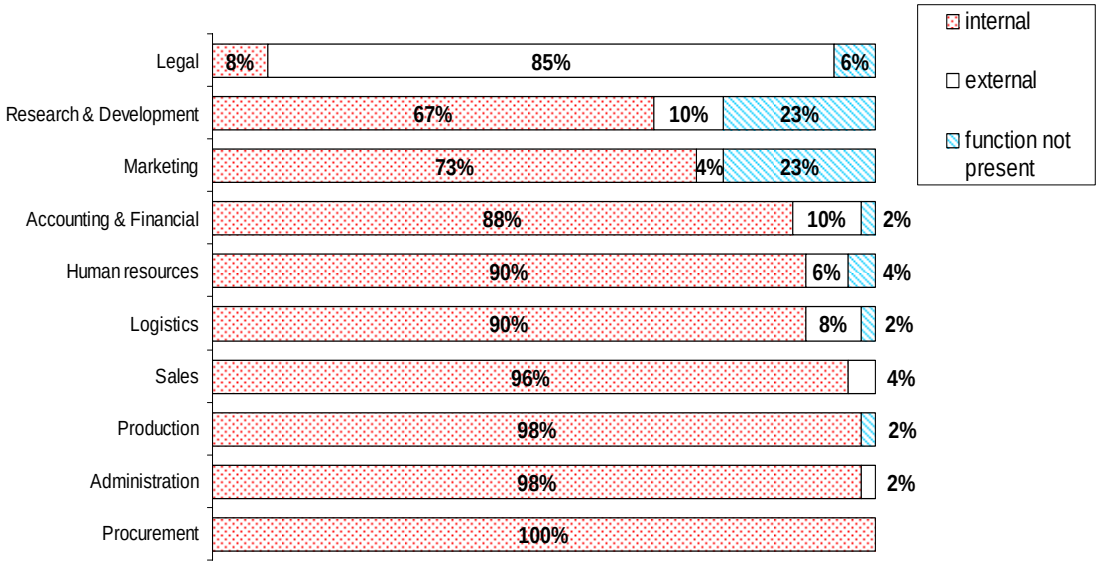


Figure 5. 12 - Internal vs. external functions

About the percentage of the outsourced activities, it results that companies operating in Baden-Württemberg are more inclined to outsource than in the other regions. In 2005, Italian companies outsourced 20% of their activities, the Hungarian ones 14% while the German ones 28%. It has been also found that in Baden-Württemberg the outsourcing trend has increased a lot in the last three years, since 71% of the interviewed companies have experimented an outsourcing growth. In the other regions, even if this trend is present, the impact is less hard: in West Pannon just 42% of the companies have resorted to the outsourcing while in Lombardy 48%. Regarding the logistics activities, it turns out that the most outsourced ones are transportation (14%) and customs clearance (8%) (Figure 5.13).

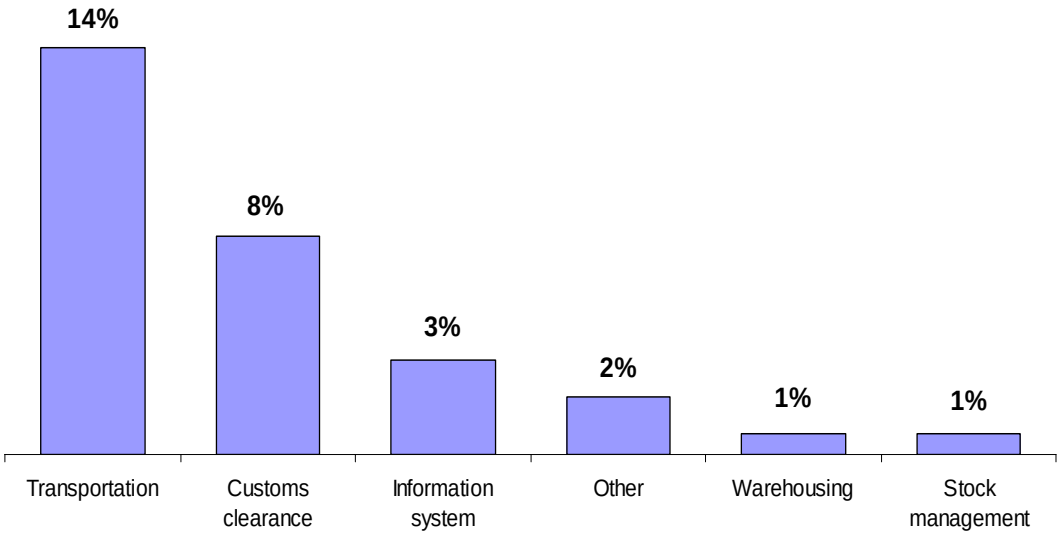


Figure 5.13 - Percentage of outsourced logistics activities

6. HOW COMPANIES MANAGE THEIR COMPLEXITY

After having reported the main statistics on the surveyed companies, this section is devoted to the provision of some answers and considerations regarding those questions which have been already addressed at the beginning of section 4. They will be hereafter discussed one by one.

6.1. Assessing the complexity of the logistic processes

For a better understanding of the level of complexity of a company, the following drivers have been considered in the study (see also previous Figure 4.3):

- characteristics of suppliers and customers;
- relations with third-parties and level of competition;
- product class and innovation attitude;
- process organisation (i.e. management of procurement, production, logistics and sales processes);
- level of flexibility of production and logistic processes.

From the data gathered through the submission of the questionnaire, it has been possible to extrapolate those variables which statistically more affect, and hence explain, the level of complexity of a company. **The independent variables *Product* and *Process Organisation* show a bigger impact on the dependent variable *Complexity***, given their highly positive correlation.

Moreover, from the analysis conducted, there is an interesting outcome: if we refer to the variable outsourcing, it comes out that **no relevant relation can be inferred between the level of complexity of a company and its declared degree of outsourcing**. The statement "*the more complex a company is, the more it needs to focus on its core processes*" does not find any confirmation on the surveyed sample. Outsourcing processes does not reduce the complexity of a company, since the inherent know-how (in particular in terms of human resources) needs to be preserved within the company in order to proper monitor and control the level of quality of the services ensured by the provider.

Complexity cluster

According to their level of complexity, it has been carried out a cluster analysis in order to find possible commonalities among the surveyed companies. Table 6.1 provides a clearer explanation of the main evident features of these clusters.

- ***Light weight*** - It is made up of Small and Medium-sized, second-tier enterprises; these companies usually operate as **sub-suppliers** or **third party companies**.
- ***Medium weight*** - It is mainly composed by Medium-sized, second-tier companies, mainly **producers of interiors** supplied to other industrial companies (OEMs or Other Suppliers).
- ***Heavy weight*** – It groups companies with the highest level of complexity, mainly composed by Medium-sized, first-tier companies; these companies normally produce and commercialize their products, mainly **engine systems** and **power trains**; their customers are both OEMs and wholesalers, addressing the independent market.

Cluster	% of the Sample	Size	Position in the Supply Chain	Type of Products	Consumers Profile	Operations Features
Light	48%	Small: 50% Medium: 50%	Mainly 2nd-tier (43%), a low percentage of 1st-tier (38%) and 3rd-tier (19%)	Simple components	Mainly other suppliers: 45%	One manufacturing site located in the regional area Mainly MTO
Medium	31%	Small: 53% Medium: 47%	Mainly 2nd-tier (54%), a low percentage of 1st-tier (31%) and 3rd-tier (15%)	Car Interiors	OEMs: 30% Other Suppliers: 42%	One manufacturing site located in the regional area Mainly MTO and MTS
Heavy	21%	All Medium-sized companies	Mainly 1st-tier (80%), and a low percentage of 2nd-tier (20%), no 3rd-tier	Engine Systems and Power Trains	OEMs: 50% Wholesalers: 28%	On average 2 manufacturing sites located in the regional area, and 1 national or international manufacturing site Mainly MTO, MTS and ATO

Table 6.1 – Main features of the three clusters of companies according to their level of complexity

A more in-depth analysis, which is not possible to describe in detail in the present report, allows also to **highlight a peer-to-peer likeness among companies, though operating in different regions or producing diverse products and addressing different commercial channels**. This could be functional for conducting possible further comparative studies, as for example an industrial benchmarking among the interviewed companies. As an example, Figure 6.1 shows a hierarchical clustering dendrogram with many U-shaped lines connecting nodes (each representing a company); the height of each U represents the distance between the two nodes being connected and, hence, how two companies are similar to each other in terms of complexity.
For confidentiality reasons, the names of the companies have been coded with their country code (e.g. IT for Italy, HU for Hungary and DE for Germany) and a progressive number.

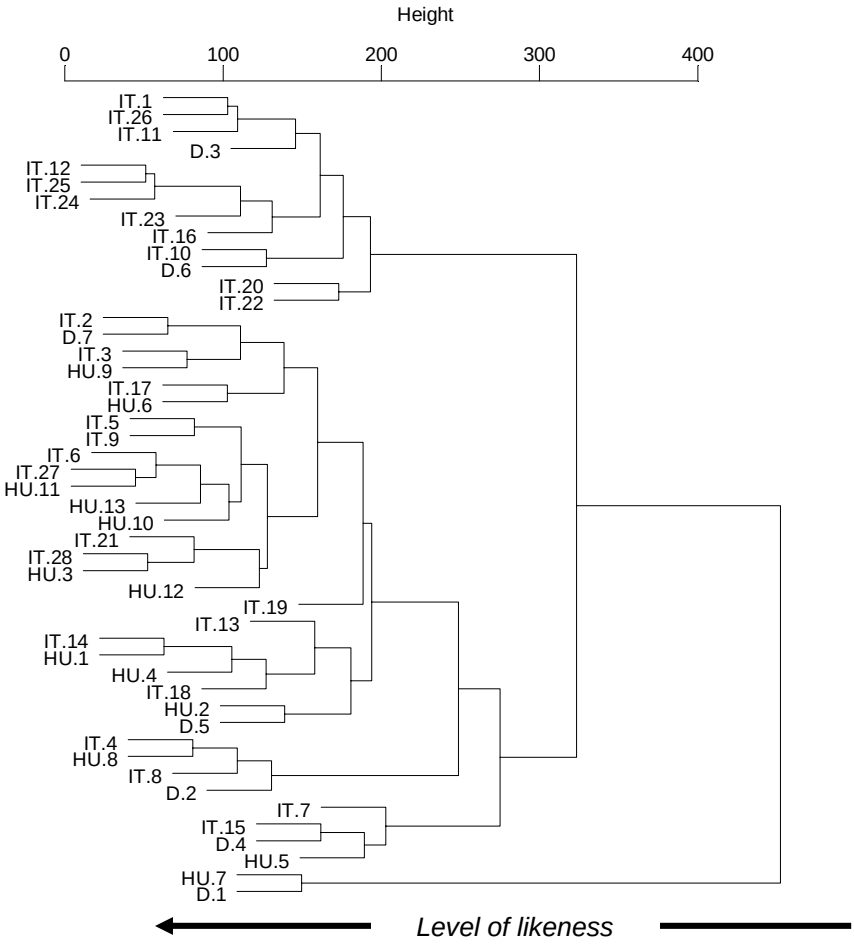


Figure 6.1 – Tree-diagram of likeness of companies with regard to their level of complexity

6.2. Managing the complexity

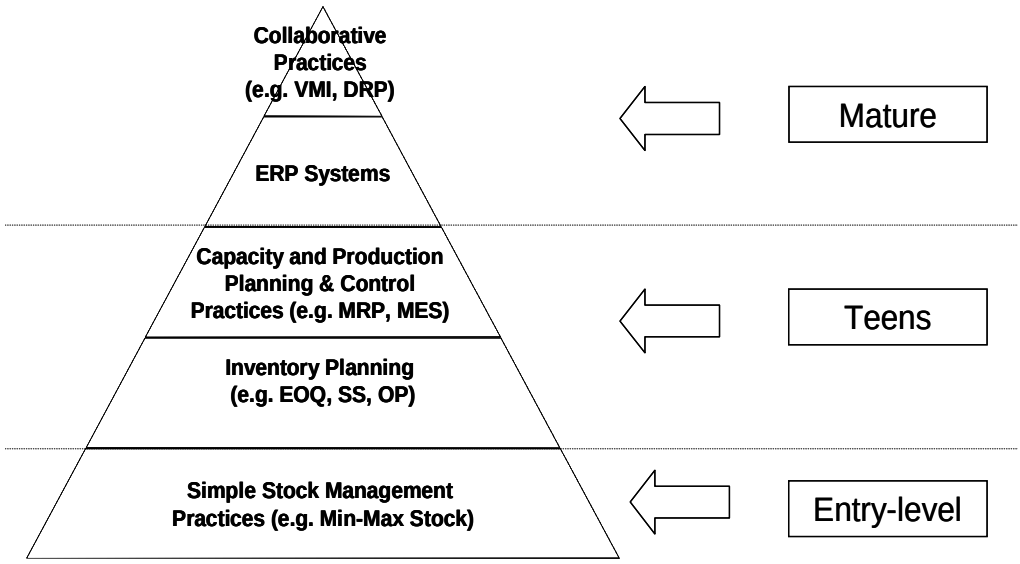
How do companies manage their complexity? Once assessed the level of complexity of their organisation, a company needs to endow itself with a consistent toolset of managerial practices. Along with the classification provided in section 4 (according to which practices can be categorised into *internal operations functions*, *integration, and collaborative practices)*, from the statistical analysis conducted on the surveyed sample **three main clusters of enterprises** have been identified:

Practices cluster

Entry-level – It represents the 27% of the overall surveyed sample; they are normally positioned on the 3rd tier of the automotive chain. On average, they adopt **plain stock management practices and completely neglect any production planning and control practice**. In addition, these companies are usually characterised by simple production processes (foundries or third-parties suppliers of plain components) or with high percentage of products being commercialised rather than internally produced.

***Teens* –** It represents the 50% of the overall surveyed sample; they are usually Medium-size companies, positioned on the 2nd and 1st tier, and their customers are usually other suppliers. They manage their internal operations functions, using Inventory Planning techniques and have made some experiences on the implementation of production planning and control practices.

Mature **–** It represents the 23% of the overall surveyed sample; they are usually positioned on the 1st tier of the automotive chain, generally Medium companies which produce components for the OEM channel. They have **fully achieved the integration of internal operations** (mainly through the implementation of ERP systems) and **are looking outwards to strengthen collaborative relations with their downstream and upstream partners**. Usually the adoption of coordination practices is triggered by the high requirements demanded by their customers, mainly big car manufacturers.



Cluster	% of the Sample	Internal Operations Practices	Level of Integration	Level of Coordination
Entry level	27%	Simple Stock Management Practices (e.g. Min-Max Stock)	No integration practices adopted	No coordination practices adopted
Teens	50%	Inventory Planning (e.g. IR or EOQ, SS, OP-Order Point)	Production and Control Practices (e.g. MRP, MES)	No coordination practices adopted
Mature	23%	Inventory Planning (e.g. IR or EOQ, SS, OP-Order Point)	ERP systems	Collaborative practices (e.g. VMI, DRP, CRP)

Figure 6.2 – Level of adoption of managerial operations practices

Complexity vs. Practices

Do companies appear to properly manage their complexity? Comparing the two groups of clusters, respectively the *complexity cluster* (i.e. light-, medium- and heavy-weight) and the *practice cluster* (i.e. *entry-level*, *teens* and *mature*), it is evident that not all the companies align their complexity of adopted operations practices with their inherent complexity. Figure 6.3 shows that **70% of the companies are *lined-up*,** while just **10% of the companies**, even if they are characterised by a low level of complexity, **can be considered as *forerunners*,** since they are keener to adopt advanced practices. More worrying seems the condition of **20% of the surveyed companies which are in an entry-level position even if they have been classified as heavy-weight.** Going into more detail on the latter category, there is a partial justification for the counterintuitive position of some companies, since in some cases they are mainly commercial subsidiaries. It is also meaningful the case of a company, which justifies the lack of integration practices thanks to its solid niche position that prevents potential competitors from affecting its current market share and competitive advantage. In the longer term, this situation could turn out to be a myopic vision.

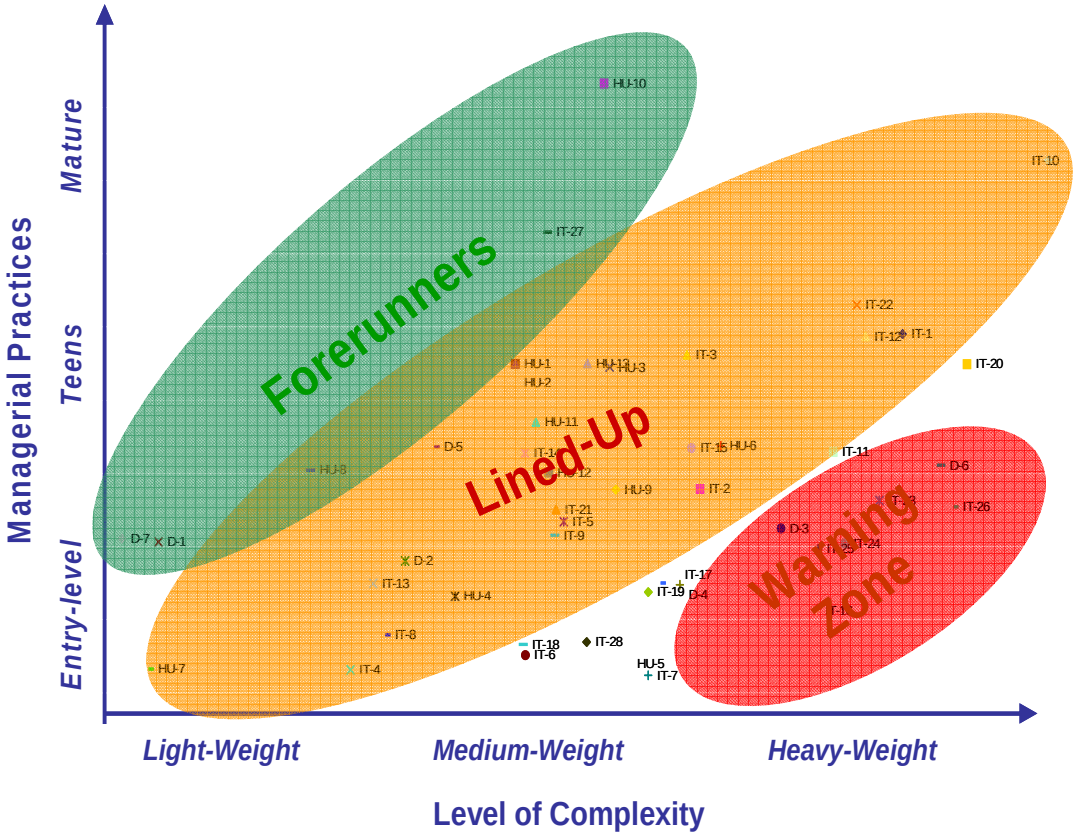


Figure 6.3 – Consistency between level of complexity and adopted practices

6.3. How do Information and Communication Technologies properly support logistics practices?

The third step of the analysis is devoted to the understanding on the way **companies envision ICT tools as enablers and enhancers of the way they manage their own operations**.

In particular, the assumption to prove is whether *"companies provide a consistent coverage of their practices with the implementation of specific software"*.

From the surveyed sample it comes out that there is a good correlation between set of practices adopted and ICT tools implemented. This means that in most of the cases the decision on adopting specific managerial practices is made jointly with the development of an ICT project. This is quite evident for *Teens* and *Mature* companies where the implementation of functional- or enterprise-wide systems is instrumental for embedding new ways of managing and integrating their internal operations processes. It becomes mandatory when collaborative practices (as for example Collaborative Planning Forecasting Replenishment or Vendor Managed Inventory policies) are developed in order to interconnect more enterprises along the chain.

Level of coverage of ICT systems

However, there are **some companies which show some inconsistencies between the amount of practices they declare to have adopted and the coverage of their ICT tools**. Other interviewed companies have also carried out some integration efforts without having heavily invested in ERP systems. We have classified these companies as *sceptical* about the possible enhancement coming out from this kind of ICT systems.

Finally, there are still some companies, mainly belonging to the *entry-level* cluster, which claim having not implemented any kind of ICT tools in order to manage their operations. They merely use phone, fax (in some cases e-mails) for receiving and emitting orders, while internal production planning and control is carried out using spreadsheets or even on paper.

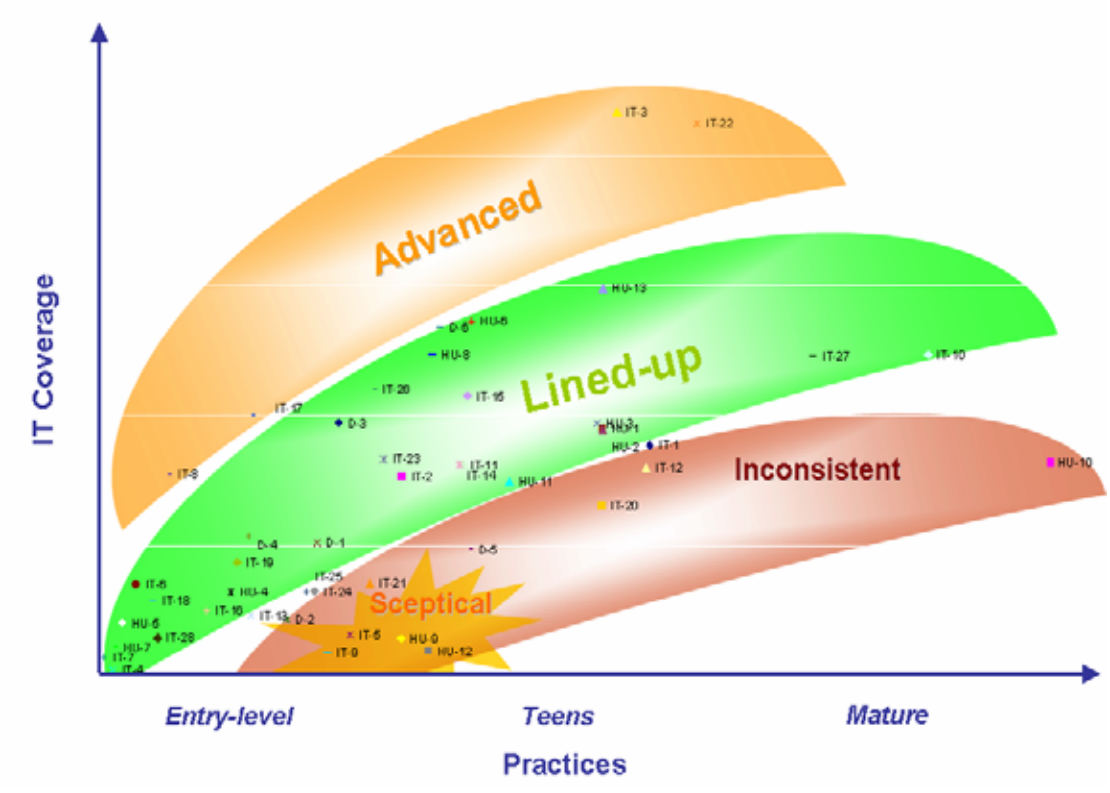


Figure 6.4 – Consistency between ICT coverage and adopted practices

6.4. Measuring and monitoring practices

The last step of the statistical analysis deals with the evaluation of the level of development of performance measurement systems for monitoring and supporting the control of their operations activities. From the survey, it comes out, quite worryingly, that, on average, **even the most "mature" companies appear not so eager to monitor the performance of their operations.** There are of course some virtuous exceptions in those enterprises which fully exploit the capabilities of their ICT solutions by using properly the dashboards provided thereby.

Main performance indicators

Figure 6.5 explains the main performance indicators being used within the surveyed companies. As reported in the histogram graph, the most monitored performance are related to the shop-floor (as percentage of waste of production, production lead time and inventory turnover) and control of suppliers' performance (e.g. supply average delay or average supply delivery time). Only one-third of the companies measure their logistics costs, delivery time to customers and stock-out frequency (for those ones working in Make-To-Stock).

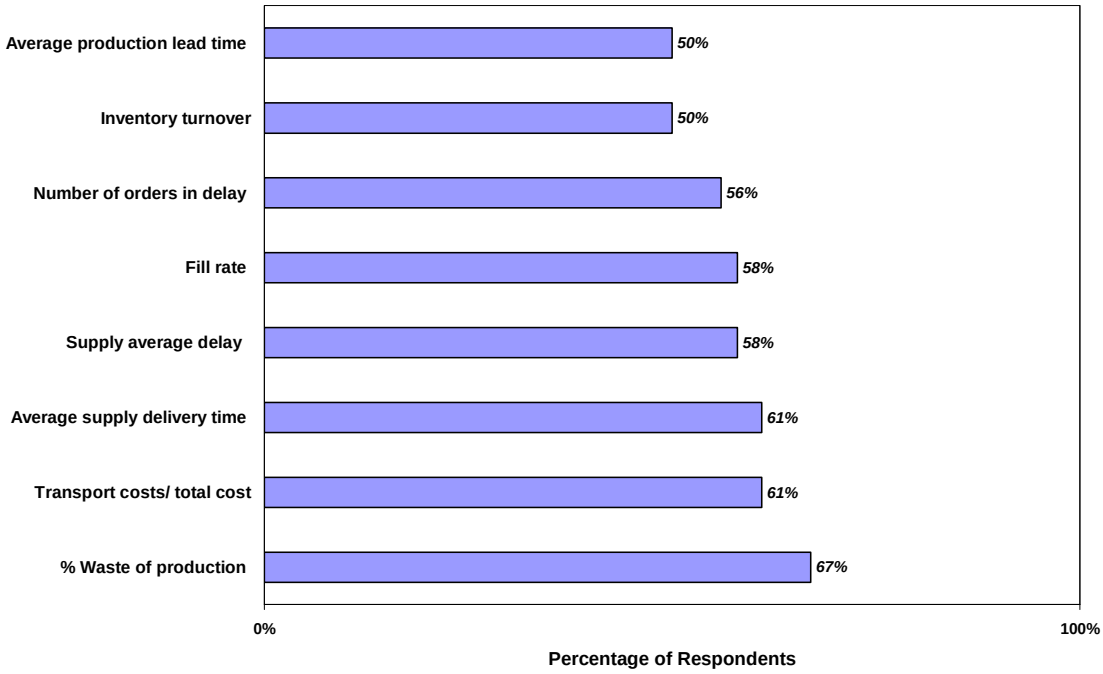


Figure 6.5 – Main performance indicators adopted within the surveyed companies

7. CONCLUSIONS

By elaborating the data gathered through the submission of a questionnaire to 48 automotive companies distributed in three European regions, this report has tried to provide some answers to the following questions:

- How regional factors can affect the logistical performance of a company?
- How to assess the complexity of the logistic processes managed in a company?
- How does a company manage its own complexity?
- Does Information and Communication Technology properly support the logistics practices adopted by automotive companies?
- Are all the adopted practices properly measured and monitored?

The proposition of an interpretative model, depicted in Figure 4.1 has allowed the authors of the report at first to design the questionnaire and subsequently to carry out a descriptive and statistical analysis which has been discussed in the previous sections.
The main findings of these sections can be wrapped up in the following points:

Regional Factors - A high infrastructural gap among Lombardy, Baden-Württemberg and West Pannon does exist. The negative trade balance in the Lombardy region, which is constituted by a high number of Small and Medium Enterprises, shows that high fragmented industrial systems, which are potentially more flexible than others, present a higher risk to lack on competitiveness, due to the companies' lower capability to invest in innovation and new technologies. Moreover, Baden-Württemberg is undoubtedly best performing in terms of innovativeness, as a results of its major sensitivity to educating and training its future and current workforce and to its higher expenditure of R&D. The economy of the same region relies heavily on the car making industry in terms of number of automotive enterprises and workforce employed. The maturity of the industry in this region is also represented by the highest incidence of Medium Enterprises, while in Lombardy and West Pannon most of the companies are of small size. In particular, West Pannon is characterised by the presence of young small suppliers.

Structure of the Companies - The surveyed sample is mainly made up of Small and Medium Enterprises, being their size dependent also on their position in the automotive chain: the nearer a company is to the OEM position, the larger its size is. Concerning the product portfolio***,*** their assortment is quite broad with mainly less than 500 items of finished products. One of the most relevant outcome, which is consistent with the findings from the analysis of the regional factors, regards the share of employees with a high education degree: Lombardy has a lower number of employees with a high education degree than Baden-Württemberg and West Pannon. Moreover, the larger a company is, the higher the number of educated people is.

Relations with suppliers and customers - The position of the surveyed companies along the automotive network is mainly of 1st tier. 3rd tier companies have less suppliers than the 1st tier: this is quite obvious since the former produces normally plain items characterised by few components, while the products of 1st tier manufacturers are generally results of more complex assembly groups. Moreover, it is rather difficult for a component supplier to address directly the lower streams of the automotive supply chain, in particular the after market segment which is actually becoming the most valuable source of profits in this industry

Level of complexity - For assessing the level of complexity of companies, the following drivers have been used: suppliers and customers characteristics, third-party and competitors structures, product class and innovation, process organisation (procurement, production, logistics and sales) as well as the level of flexibility of its

production and logistic process. Three main clusters of companies have been identified (light-, medium- and heavy-weight) according to their claimed position on this multi-criteria driver. Half of the sample is made up of Small and Medium-sized, second-tier enterprises which usually operate as sub-suppliers or third party companies and present a light organisational structure. Only 20% of the sample is positioned in the highest rank of complexity: they are medium-sized, first-tier companies, which usually produce and commercialize engine systems and power trains; their customers are both OEMs and wholesalers, addressing the independent market.

Management of practices - Once assessed the level of complexity of their organisation, a company needs to endow itself with a consistent toolset of managerial practices. Three main clusters of enterprises have been identified:

- *Entry-level*, representing a quarter of the overall surveyed sample, normally positioned on the 3rd-tier of the automotive chain, which adopt plain stock management practices and completely neglect any production planning and control practice;
- *Teens*, representing half of the sample, usually medium-size companies, positioned on the 2nd and 1st tier; they manage their internal operations function, using Inventory Planning techniques and have made some experiences on the implementation of production planning and control practices.
- *Mature*, representing the last quarter of the sample, which have fully achieved the integration of internal operations (mainly through the implementation of ERP systems) and are looking outwards to strengthen collaborative relations with their downstream and upstream partners.

Comparing the two groups of clusters, respectively the *complexity cluster* (i.e. light-, medium- and heavy-weight) and the *practice cluster* (i.e. low-entry, teens and mature), it is evident how not all the companies align their complexity of adopted operations practices with their inherent complexity. There is 20% of the companies which, though being classified as heavy-weight, appear to be in an entry-level position.

Role of ICT tools - It comes out that there is a good correlation between the set of practices adopted and ICT tools implemented. This means that in most of the cases the decision on adopting specific managerial practices is made jointly with the development of an ICT project. This is quite evident for *Teens* and *Mature* companies where the implementation of functional- or enterprise-wide systems is instrumental for embedding new ways of managing and integrating their internal operations processes. It becomes mandatory when collaborative practices are developed in order to interconnect more enterprises along the automotive chain

Performance Measures - The last step of the statistical analysis has dealt with the evaluation of the level of development of performance measurement systems for monitoring and supporting the control of their operations activities. From the survey, it comes out, quite worryingly, that on average even the most mature companies appear not so eager to monitor the performance of their operations. There are of course some virtuous exceptions in those enterprises which fully exploit the capabilities of their ICT solutions by using properly the dashboards provided thereby.

Due to the short term horizon of the project, which in overall lasted 11 months, the sample of surveyed companies has not been adequately balanced in order to provide a cross-regional comparison between companies operating in the different regions. In fact, most of the companies are from Lombardy region (58% of the sample), while 27% are from West Pannon and an exiguous 15% from Baden-Württemberg. Quite surprisingly, there has been more reluctance by German companies to be interviewed, while the Italian ones have demonstrated more curiosity and willingness to open themselves in a mutual comparison with other enterprises.

The follow-up of the LOG4SMEs project will mainly operate on two directions:

- the **implementation of a web service** through the development of a unified database of logistical performance indicators and practices within the automotive industry, encompassing an interregional perspective: this service should enable a company to self-assess its current capability to manage the complexity of the environment where it operates and verify whether the managerial practices and policies and the underlying ICT infrastructure are properly enhancing this capability or, conversely, need to be better fostered;

- a **peer-to-peer benchmarking between companies**: in this sense, clustering techniques, as the tree diagram reported in Figure 6.1, appear as valid tools for identifying those companies which can be mutually benchmarked, though operating in different regions or producing diverse products and addressing different commercial channels.

APPENDIX A: REFERENCE MODELS

An overview of the SCOR model

The Supply Chain Operations Reference-model (SCOR) is the product of the Supply-Chain Council (SCC), an independent, not-for-profit, global corporation with membership open to all companies and organizations interested in applying and advancing the state-of-the-art in supply-chain management systems and practices. While much of the underlying content of the model has been used by practitioners for many years, the SCOR-model provides a unique framework that links business process, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities.
The model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return:

- PLAN: activities which balance, in the long term perspective, forecast with offer and define the optimal solution for procurement, production and delivery activities;
- SOURCE: set of activities which create goods and services necessary for satisfying real demand;
- MAKE: set of activities responsible about product manufacturing and include physical and chemical processes;
- DELIVER: set of activities related to deliver products and services required by customers;
- RETURN: set of activities linked to the reverse logistics both for goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.

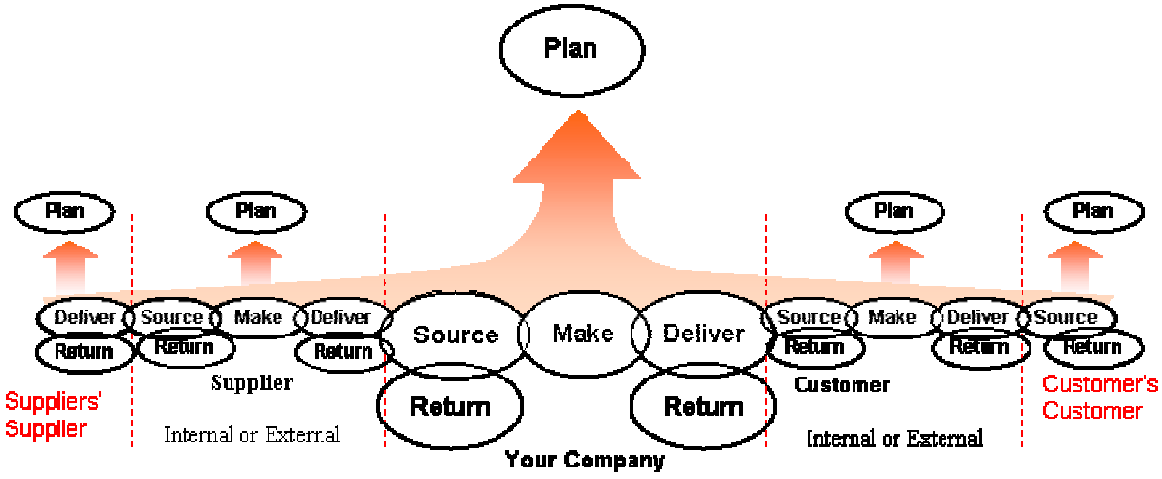


Figure A. 1 - SCOR is organized around five major management processes

By describing supply chains using these process building blocks, the model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain. The model has been able to successfully

describe and provide a basis for supply chain improvement for global projects as well as site-specific projects.
It spans: all customer interactions (order entry through paid invoice), all physical material transactions (supplier's supplier to customer's customer, including equipment, supplies, spare parts, bulk product, software, etc.) and all market interactions (from the understanding of aggregate demand to the fulfilment of each order). It does not attempt to describe every business process or activity. Specifically, the model does not address: sales and marketing (demand generation), product development, research and development, and some elements of post-delivery customer support.

As shown in Figure A.1, the model is designed and maintained to support supply chains of various complexities and across multiple industries. The Council has focused on three process levels and does not attempt to prescribe how a particular organisation should conduct its business or tailor its systems / information flow. Every organisation that implements supply chain improvements using the SCOR-model will need to extend the model, at least to Level 4, using organisation-specific processes, systems and practice.
Each macro-activity from the support and operative process can be disaggregated according to the SCOR (Supply Chain Council, 2005). Generally SCOR is divided in three levels:

1. At level 1 the five core management processes (*Plan, Source, Make, Deliver and Return*) are determined as above mentioned (see Figure A.1)
2. At level 2 each process element included in one of the SCOR processes can be further described by 3 process types:
    - Planning: planning element is a process that aligns expected resources to meet expected demand requirements. Planning processes balance aggregated demand across a consistent planning horizon. Planning processes generally occur at regular intervals and can contribute to supply chain response time.
    - Execution: Execution processes are triggered by planned or actual demand that changes the state of products. They include scheduling and sequencing, transforming materials and services, and moving product.
    - Enable: Enable processes prepare, maintain, and manage information or relationships upon which planning and execution processes rely.
3. At level 3 process flow, inputs and their source, outputs and their destinations are captured.

Every organisation that implements supply chain improvements using the SCOR-model will need to extend the model, at least to Level 4, using organisation-specific processes, systems and practice.

Plan, Source, Make, Deliver, and Return sections are organized with a standard structure. At the beginning of each section, there are graphics that provide a visual representation of the process elements, their relationships to each other, and the inputs and outputs that are germane to each process element. Following the graphics are text tables that identify: 1) the standard name for the process element, 2) the notation for the process element, 3) SCC's "standard" definition for the process element, 4) performance attributes that are associated with the process element, 5) metrics that are associated with the performance attributes, 6) best practices that are associated with the process (candidates, not necessarily an exhaustive list), and features (generally technologically related) that can contribute to heightened performance of the process.

Within the Source, Make and Deliver process elements, a common internal structure has been agreed upon. The model focuses on three environments, Make-to-Stock, Make-to-Order, and Engineer-to-Order. As a result, S1 becomes Source Make-to-

Stock Product, S2 becomes Source Make-to-Order Product and S3 becomes Source Engineer-to-Order Product. This same convention is used for Make, i.e. M1 – Make-to-Stock, and Deliver, i.e. D2 – Deliver Make-to-Order Product. This convention was extended to Return in Version 5.0. R1 is the Return of Defective Product, R2 is the Return of Maintenance, Repair or Overhaul (MRO) Product, and R3 is the Return of Excess Product.

Performance Attribute	Performance Attribute Definition	Level 1 Metric
Supply Chain Delivery Reliability	The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Delivery Performance
		Fill Rates
		Perfect Order Fulfillment
Supply Chain Responsiveness	The velocity at which a supply chain provides products to the customer.	Order Fulfillment Lead Times
Supply Chain Flexibility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Supply Chain Response Time
		Production Flexibility
Supply Chain Costs	The costs associated with operating the supply chain.	Cost of Goods Sold
		Total Supply Chain Management Costs
		Value-Added Productivity
		Warranty/Returns Processing Costs
Supply Chain Asset Management Efficiency	The effectiveness of an organisation in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-Cash Cycle Time
		Inventory Days of Supply
		Asset Turns

Table A. 1 - Definitions for SCOR Performance Attributes and which Level 1 metrics are associated with each attribute

It is important to note, that like the process elements themselves, the metrics are intended to be hierarchical. Although not explicit in the model, Level 1 metrics are typically “assigned” to P1 (Plan Supply Chain) and are decomposed (Level 2 and diagnostic metrics) to the respective planning, execution and enable elements. As shown in Table A.1, the metrics are used in conjunction with performance attributes. In the last version of SCOR model, there are five performance attributes defined in Table A.1 (Supply Chain Reliability, Supply Chain Responsiveness, Supply Chain Flexibility, Supply Chain Costs, and Supply Chain Asset Management).

General structure of the SCM reference model

SCM Task Reference Model can support the identification of requirements concerning ICT support for an efficient network management. The reference model subdivides the planning tasks in supply chain management in that it summarises the formation of various industry sectors. Thus, the result is a description of the structure of the planning tasks. It examines the logistics network structures of various industry sectors and the positions of organisations in the value chain.

Figure A. 2- General Structure of the SCM Reference Model

The reference model concentrates on the viewpoints of production-orientated organisations in logistics networks.
The scm-CTC reference model provides a detailed description with regard to the software functionalities; this is done to refine the SCOR model that only describes / standardises the supply chain operations and supply chain Key Performance Indicators (KPI) on a broad level without describes the ICT practices.
SCM software is generally made up of numerous components, which support different task spectrums and functionalities.
The comparison of the software solutions is a complex process due to the before mentioned statement. In addition to this, the software vendors use different descriptions for the same functionality, which leads to ambiguity when having to select a software solution. A standardised and vendor independent reference model should provide help with regard to the task spectrum of SCM functionalities.
The essential idea of the SCM Task Reference Model is to describe trans corporate logistics by means of tasks and Functions. The model can be divided into three main sections that have their specific tasks which correlate to the operational, tactical and strategic level:

- strategic design;
- supply chain planning;
- supply chain execution.

Order management and supply chain event management can be considered as cross sectional tasks, which are directly linked with other planning and execution tasks.

The reference model summary and its general structure is presented as follows:

Strategic design task
This describes the applicable long-term planning tasks that are needed for the development of logistics networks. This is a question of strategy in the areas of: logistics, production, information technology, and selection of suppliers and customers. Site decisions regarding the construction of production and logistic systems form part of strategy while many other aspects do not form part of the operative processes.

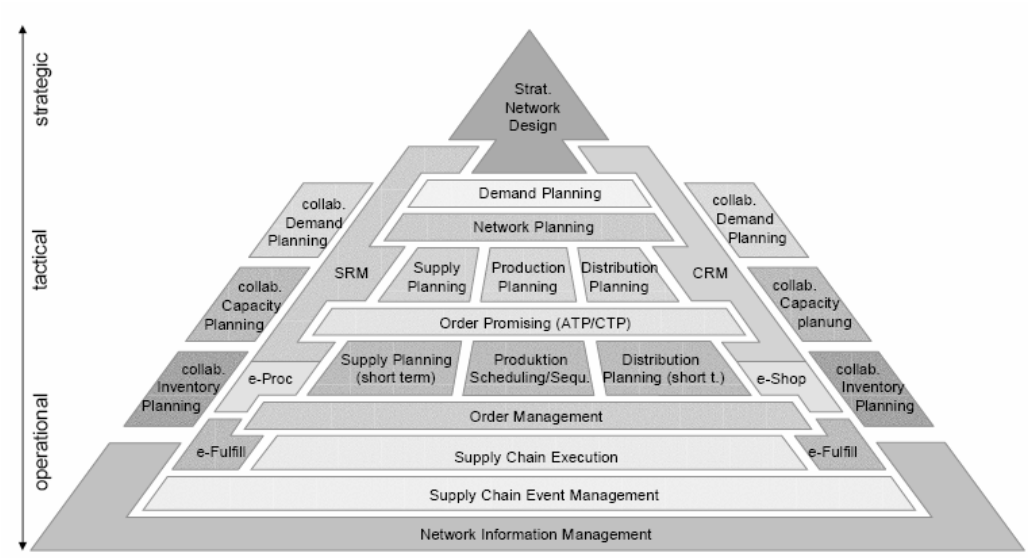


Figure A. 3 – SCM Task Reference Model (source scm-CTC)

Strategic Network

It is concerned with the cost-effective design of the whole logistics network and can be seen as a stand-alone task. The objective of this task is long-term and strategic planning with regards to logistics strategy, selection of trading partners, supplier relations, site location and other general questions. Strategic network design is responsible for the basic considerations and decisions, which are given to the other planning tasks in the reference model.

Planning tasks

The planning tasks listed in this section are concerned with a given network in which long-, medium- and short-term demand, inventory and capacity is planned.
Order fulfilment is achieved through the planning and allocation of capacity along the logistics chain. Different time horizons and the examination of the parts in the logistics chain provide the distinguishing feature for the functions.
The planning area is divided into the following sections:

1. *Demand Planning*

   The main objective of this task is to forecast and to plan the long-, medium-, and short-term demand along the logistics chain. In addition to that the task gives transparency for the future demand.
   Demand planning plays a major role in the implementation of SCM software systems.

2. *Network Planning*

   The network planning task is the comprehensive coordination of all partners in a value chain or in a production network. Network planning can occur within an enterprise or even between several enterprises in a supply chain.

3. *Supply Planning*

   The objective of this task is to optimise the planning of the material supply, production as well as in some cases the planning of a multi-level supply chain, based on the results of the demand and network planning. Thus, supply planning aims to satisfy the production demand with the right materials at the right time and the right place, while keeping the inventory levels at a minimum.

4. *Production Planning*
This task is responsible for the creation of an optimised production plan for each production site of the supply chain. Thus, the objective is to ensure the correct customer service level and the delivery reliability, while optimising the capacity utilisation and minimising the inventory costs simultaneously.

5. *Production Scheduling*
Production scheduling is concerned with the medium- and short-term planning of an organisation´s production. It focuses specifically on a short-term plan, which can be implemented for a single production area within the factory, whereas production planning focuses on a production plan that can be implemented throughout the whole factory; in other words it provides a general production plan on a factory level.

6. *Distribution Planning*
This task encompasses the planning of optimised inventory levels in the distribution chain and the planning of the product distribution to the final consumer. Similar to supply planning, distribution planning focuses on a multilevel distribution structure, which concerns the distribution of finished goods in a distribution channel or network to the customer.

7. *Short-Term Distribution Planning*
Short-term distribution planning focuses on the optimisation of transport modes, transport routes, and the loading of trucks for on-time delivery.. The objective is to reduce delivery lead time and to increase delivery reliability, while reducing costs.

8. *Order Promising (ATP / CTP)*
Order promising concerns the feasibility check of customer orders or enquiries, which is also known as “available to promise (ATP)“ and in an extended version as “capable to promise (CTP)“. Order promising is one of the main tasks in Supply Chain Management and it is an interface between the planning and execution tasks of anonymous and associated customer orders. Making use of the order promising function can improve the customer orientation and the customer benefit.

These tasks are currently mainly supported in isolation by each partner’s traditional enterprise resource planning (ERP) system. The output is generated on a network level for each network entity, and will then serve as input for the local corporate operational level.

Tasks with cross-functional characteristics in the reference model
The SCM Task Reference Model is enhanced by tasks on the supplier side (SRM, e-Procurement, e-Fulfillment) as well as on the customer side (CRM, e-Shop, e-Fulfillment). All SCM tasks can be supported by a supply chain event management (which includes e.g. monitoring and alert management) and a network information management. To emphasize the network aspects within the model ‘collaborative’ tasks have been added.

1. *Order Management*
The order management task encompasses controlling and monitoring of customer orders and their related production-, supply-, and distribution orders.
Order management forms an interface between a manufacturing enterprise and its distribution channels, resellers, and customers. Thus, this task possesses all the relevant information relating to the customer orders and their processes. The objective here is to ensure a high level of customer satisfaction.

2. *Customer Relationship Management (CRM)*
CRM systems represent one of the most important connections to the SCM planning modules. They support organisations’ business processes, while possessing the vital customer contacts. These CRM systems have been in

constant development over the past few years and they cover a wide range of application areas to date.
Its objective is to increase customer loyalty, to identify prospective segments, and to secure a long-term market.

3. *Supplier Relationship Management (SRM)*

This function encompasses all the activities that range from the strategic supplier selection process, supplier development process, right up to the supplier integration process. Exchanging information as well as collaboration between manufacturers and suppliers allows the automation or the optimisation of inter-enterprise workflows.

4. *Supply Chain Event Management (SCEM)*

SCEM encompasses the active monitoring of the material supply or the material flow along a value chain. This allows the manufacturer to monitor the material flows together with his suppliers and customers. Breakdowns can occur in the form of delays, breakdowns of trucks, and undersupply of minimum stock levels. The SCEM system identifies and communicates an unscheduled breakdown to all the affected locations in the chain and informs them about the incident, the reasons and the implications.

5. *Network Information Management*

Network information management includes the distribution and management of information. The general SCM concept requires that the local master and transaction data residing in ERP, PDM, BIW, and MIS systems must be extracted, and in some cases aggregated so that the SCM planning modules can be supplied with the respective data. This data is used for SCM planning and simulation purposes. Once the process has been completed, the network information management task ensures that all the results are sent back to the master and transaction systems. Thus, planning data needs to be exchanged on an accurate and timely basis when connecting numerous SCM systems within an organisation or between partners of a supply chain.

6. *Supply Chain Collaboration / Collaborative Planning*

Supply chain collaboration is a new concept and it forms the basis for the creation and development of new production networks. The tasks can be seen as a fundamental component in supply chain management. The concept assumes that the supply chain can only be in perfect harmony if inter organisational collaboration is guaranteed. This means that the synchronisation of market demand and the supply of parts have to be achieved. Profit and loss sharing as well as opportunity and risk sharing need to happen among the partners in a supply chain in order to create a win-win situation for everyone.

Supply Chain Execution

Supply chain execution is based on an operational level where all the required tasks are summarised in order to execute and control the production process within a supply chain. Thus, this task differs completely from the supply-planning task and it encompasses the execution of order processing, warehouse management, and transport management.

Supply chain controlling tasks

Its major objective is to assess the performance capability of every partner in the supply chain, such as logistics service providers, suppliers and production plants. It also aims to provide information on the proficiency of the total logistics network. All the partners need to define key performance indicators, which will be used in the assessment and these findings need to be presented in a tabular or graphical format. Transaction systems or business data warehouses provide the required information.

APPENDIX B: THE STATISTICAL METHODOLOGY

In this appendix the statistical methodology performed in this report is detailed. The adopted software to carry out the analysis is ***Splus***.
The *explanatory analysis* aims at:

1) identifying such indexes able to explain the company's complexity and its level of coordination, integration and ICT development. Moreover a quantitative variable analysis is performed in order to study the companies' Practices and ICT tools and if they are properly measured and monitored. For instance, to define an index that is able to soundly describe the company's complexity (considering aspects like innovation, flexibility, product, organisation and process), a correlation analysis and a Principal Component Analysis (PCA) are requested.

   The correlation analysis is the statistical tool used to describe the degree of linear relation between one variable and another; some examples are herewith proposed:

   - ✓ Is the (flexibility) *average number of order received per year* correlated to the *average number of purchase orders per year* (flexibility)?
   - ✓ Is the (flexibility) *average number of orders received per year* correlated to the organisation) *number of employees*?

   A Principal Component Analysis (PCA) is recommended for investigations that involve a large number of observed variables: it is useful to simplify the analysis since just a smaller number of linear combinations of the original variables is considered. For instance, the complexity of a company is composed of different variables with different variances, thus the PCA finds a set of standardized linear combinations, called the principal components, that taken together explain all the variance of the original data.

2) identifying company clusters (complexity vs. integration, complexity vs. coordination, complexity vs. ICT development) through a qualitative data analysis, which is performed with cluster analysis and classification/regression trees. The cluster analysis is a searching for groups (clusters) in the data, in such a way that objects belonging to the same cluster resemble each other, whereas objects in different clusters are dissimilar. The classification technique is adopted when the analysis refers to a factorial predictor while the regression trees is applied when the analysis refers to a continuous predictor. These tools are allow to study the structure of data and to create nodes or clusters of data with similar characteristics.

3) identifying variables correlated to integration, coordination and ICT using correlation coefficients.

The *models* implementation phase is made on the empirical data that come from the exploratory analysis. The main goals of this phase are:

1) to make comparison among the relevant companies variables. For example if a comparison among complexity of different companies along the automotive network is required, the statistical tools analysis of variance (ANOVA) technique and hypothesis tests are used.

2) to model the correlation among the monitored performance, the company's complexity, coordination, integration, ICT development and the model integration, coordination and ICT aspects. The adopted techniques are multiple linear regression analysis and logit models.

Both the two steps of the methodology adopted, the exploratory analysis and the models implementation, are completed with graph representations and plots.

APPENDIX C: GLOSSARY

Term	*Explanation*
1st tier	A first tier supplier is responsible for the actual physical delivery of material to customer. The 1st Tier supplier must ensure that deliveries are made on the specified dates and at the specified times of day to the nominated factory entry points, and that the goods delivered are physically arranged for use on the customer's production line in the order specified.
2nd tier	The second tier supplier is so called because it delivers to a nominated 1st tier supplier, which then makes the material ready in the prescribed manner and effects actual delivery.
3rd tier	The 3rd supplier is so called because it delivers to a nominated 2nd tier supplier
Advanced Planning and Scheduling (APS)	Software system designed to integrate with ERP and MRP systems to enhance the short term production planning and scheduling systems that are notoriously inadequate in MRP systems. APS systems have extensive programming logic that allows them to be more effective in dealing with rapidly changing customer demands.
Assemble To Order (ATO)	A manufacturing environment where the final product is assembled based on the receipt of a customer order (instead of to stock). The assembly is normally performed using standard components, modules and subassemblies that are already stocked based on forecasts developed from past usage history. An ATO environment allows each customer order to specify a custom combination of previously-defined standard options.
Available To Promise (ATP)	Available To Promise takes the simple availability calculation, adds time phasing and takes into account future scheduled receipts. Available to promise may be calculated for each day or broken down into larger time buckets. The first time period will take on-hand inventory and add any scheduled receipts for that period. It will then deduct any allocations scheduled prior to the next scheduled receipt (which may be several periods in the future). Subsequent periods without any scheduled receipts will have the same available to promise as the previous period. Subsequent periods with scheduled receipts will generally start with a fresh calculation, ignoring any remaining available to promise from previous periods. There are many variations on exactly how available to promise is calculated and it is also important to note that available to promise often works independently of allocation systems. This can sometimes create conflicts.
Average production lead time	Amount of time required for an item to be available for use from the time it is ordered. Lead time should include purchase order processing time, vendor processing time, in transit time, receiving, inspection, and any pre-pack times.
Computer Aided Design (CAD)	The use of software and computer hardware in developing engineering drawings and designs and accessing stored product and engineering data and history. CAD systems allow for multiple iterations, views and comparisons of proposed designs.
Computer Aided Manufacturing (CAM)	The use of computer systems to program, setup, control, monitor and generate reports for manufacturing equipment and processes.
Capacity planning	Assuring that needed resources (e.g., manufacturing capacity, distribution centre capacity, transportation vehicles, etc.) will be available at the right time and place to meet logistics and supply chain needs

Co - location	Co-location facilities offer customers a secure place to physically house their hardware and equipment (as opposed to keeping it in their offices or warehouse, where the potential for fire, theft, or vandalism is much greater).
Consignment stock	It is any stock that the supplier has placed in the warehouse without charge. It remains the property of the supplier until it is actually used (issued) and should not be included in the value of the stock on hand.
Collaborative Planning Forecasting Replenishment (CPFR)	Collaborative Planning Forecasting Replenishment is the sharing of forecasts and related business information among business partners in the supply chain to enable automatic product replenishment.
Customer Relationship Management (CRM)	The processes and systems that combine sales, marketing, contact management and support activities in managing customer interaction. They provide tools to analyze customer/product sales history and profitability, campaign tracking and management, contact and call centre management, order status information, and returns and service tracking.
Cross-Docking	The acquiring of commodities by a distribution centre using just-in-time scheduling, so that products can be moved from the receiving area through staging, and onto a transport vehicle without ever having to be put away.
Capacity Requirements Planning (CRP)	A process using demand from open production orders and MRP planned orders, and work centre / production line rate and capacity data to determine over or under capacity conditions. A short- term, detailed view of capacity that verifies the feasibility of firming up planned orders and releasing them to the floor. CRP systems normally function as a capacity status report, without generating exception messages that recommend order reschedules or moving production to alternate work centres or lines.
Collaborative Transportation Management (CTM)	Collaborative Transportation Management - is defined as a holistic process that brings together supply chain trading partners and service providers to drive inefficiencies out of the transport planning and execution process.
Customer Service Level	The minimum level of support deemed acceptable by the warehouse operations management. Includes the availability of stock items when required and in the quantity required.
Delivery Time	The time during the day and for the days of the week, during which the receiving unit will spot and unload trucks and rail cars.
Distribution Requirements Planning (DRP)	Distribution Requirements Planning - process for determining inventory requirements in a multiple plant/warehouse environment. DRP may be used for both distribution and manufacturing. In manufacturing, DRP will work directly with MRP. DRP may also be defined as Distribution Resource Planning which also includes determining labour, equipment, and warehouse space requirements.
Economic Order Quantity (EOQ)	A level of quantity or inventory indicating that a re-order to replenish should be made in order to maintain or control a safe inventory.
Electronic Data Interchange (EDI)	The electronic transfer of order and transfer information between trading partners on the same system, that uses a predefined, standard message format for order receipt, order release, advanced shipping notifications, invoices and other transactions.
e-procurement	E-procurement is the business-to-business purchase and sale of supplies and services through the Internet as well as other information and networking systems, such as electronic data interchange (EDI) and Enterprise Resource Planning (ERP).

Enterprise Resource Planning (ERP)	It describes software systems designed to manage most or all aspects of a manufacturing or distribution enterprise (an expanded version of MRP systems). ERP systems are usually broken down into modules such as Financials, Sales, Purchasing, Inventory Management, Manufacturing, MRP, and DRP. The modules are designed to work seamlessly with the rest of the system and should provide a consistent user interface between them. These systems usually have extensive set-up options that allow you to customize their functionality to your specific business needs. Unfortunately, in the real world, ERP systems rarely are sufficient to meet all business needs and a myriad of other software packages such as Customer Relationship Management (CRM), Manufacturing Execution Systems (MES), Advanced Planning and Scheduling (APS), Warehouse Management Systems (WMS) and Transportation Management Systems (TMS) are being sold to make up for these deficiencies.
Engineer To Order (ETO)	A manufacturing response to demand in which engineering analysis and design occurs for all materials and production activities designated for a specific customer order. ETO may involve the use of a few common raw materials, but requires constructing new bills of materials and routings to complete intermediate items and the end time required.
Family run	A family run firm is any enterprise in which more than one family member has significant participation in the operation or management decisions of the enterprise.
Fill rate	A customer order delivery performance measurement of the percentage of times line item shipments met requested dates and quantities. Whole order shipments may be used instead of individual line items for customers who require the entire order to be shipped complete.
Forecasting	The systematic development of an estimated future requirement determined from past experience, usage trends, technology advances, planned activity and any other factors deemed relevant.
Gross Domestic Product (GDP)	The GDP of a country is defined as the market value of all final goods and services produced within a country in a given period of time. It is also considered the sum of value added at every stage of production of all final goods and services produced within a country in a given period of time.
General partnership company	Allows two or more people to share profits and liabilities. A general partnership is similar to a sole proprietorship, except that two or more parties are involved. In a business partnership, the parties that join forces could be individuals, corporations, trusts, other partnerships, or a combination of all of the above.
Inventory turnover	An inventory investment and activity measure that compares inventory usage (as defined by the annual cost of goods sold) divided by the inventory investment (as defined as the average inventory level at standard cost). Higher values indicate a more efficient use of inventory; absolute targets can only be set based on relevant industry figures, as the turnover for grocery chains is vastly different than for capital goods manufacturers.
Item	Any unique manufactured or purchased part, material, intermediate, sub-assembly, or product.
Just In Time (JIT)	Term usually thought of as describing inventory arriving or being produced just in time for the shipment or next process. Actually, JIT is a process for optimizing manufacturing processes by eliminating all process waste including wasted steps, wasted material, excess inventory, etc.
Key Performance Indicators (KPIs)	Key Performance Indicators are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization. They will differ depending on the organization.

Lean replenishment	A overall methodology that seeks to minimize the resources required for production by eliminating waste (non-value added activities) that inflate costs, lead times and inventory requirements, and emphasizing the use of preventive maintenance , quality improvement programs, pull systems and flexible work forces and production facilities.
Limited liability company (LLC)	A separate legal entity, the LLC is a hybrid between a partnership and a corporation, combining the limited liability advantage of a corporation with the tax status of a sole proprietor or partnership. Owners of the LLC are called members.
Limited partnership company	A separate legal entity, this type of business includes a general partner and one or more limited partners who invest capital into the partnership, but do not take part in the daily operation or management of the business. The limited partners limit their amount of liability to the amount of capital invested in the partnership. The general partner shoulders the personal liability for the debts and obligations of the partnership. Business operations are governed, unless otherwise specified in a written agreement, by majority vote of voting partners.
Lumpy Demand	Demand that is uneven in terms of timing and quantity variations, and may require more investment in inventory or a longer response time than predictable, even demand.
Managerial company	A managerial company is any enterprise in which people who have significant participation in the operation or management decisions of the enterprise are manager.
Manufacturing Execution Systems (MES)	Programs and systems that participate in shop-floor control, including programmed logic controllers and process control computers for direct and supervisory control of manufacturing equipment; process information systems that gather historical performance information, then generate reports; graphical displays; and alarms that inform operations personnel what is going on in the plant currently and a short history into the past. Quality control information is also gathered - a laboratory information management system may be part of this configuration to tie process conditions to the quality data that are generated. Thereby, cause-and-effect relationships can be determined. The quality data at times affect the control parameters that are used to meet product specifications, either dynamically or offline.
Min - Max	Min - max - a simplistic inventory system in which a minimum quantity and maximum quantity are set for an item. When the quantity drops below Min you order up to the Max.
Master Production Schedule (MPS)	The schedule of manufactured items usually created to fill 'outside' demand from forecasts, customer orders and interplant orders that specifies the exact item numbers, dates and quantities for production but is not in itself a production order to be released to the floor. It considers the high-level production plan and rough cut capacity availability, and aligns with management targets for linearity and permissible level of changes. Once accepted, the MPS specifies the date and quantity requirements used by MRP to explode demand through the bill of materials. While most often for end items, variations of MPS allow planning critical lower levels such as major subassemblies based on a forecast that is then consumed by customer orders for finished goods that require those subassemblies. The MPS is the main driver for the rest of the planning and scheduling system, and the level of success in attaining a realistic MPS often indicates how well the other detailed parts of the system function.
Material Requirements Planning (MRP)	The Material Requirements Planning process is designed to take the Master Production Schedule replenishment quantities, "explode" through the bill of materials to create component requirements which are netted against on-hand and on-order, level by level. It is a time-phased process whereby the

	planned orders are driven by actual requirements by date.
Make To Order (MTO)	A manufacturing method in which commonly-used raw materials and components may be stocked based on previous demand history, but further processing into higher-level items is not done until receipt of a customer order. Variability in customer demand will not allow stocking upper-level assemblies and major subsystems or modules prior to receipt of an order, as done in assemble to order (ATO) environments.
Make To Stock (MTS)	A manufacturing method in which finished goods are produced and stocked prior to receipt of a customer order. It uses a forecast based on past demand history to initiate production of end items when inventory has fallen below desired levels, instead of waiting until a final quantity and configuration is described on a customer order.
Original Equipment Manufacturer (OEM)	A producer of equipment from components usually bought from other manufacturers.
Procurement	The business functions of procurement planning, purchasing, inventory control, traffic, receiving, incoming inspection, and salvage operations.
Productivity	A measure of resource utilization efficiency defined as the sum of the outputs divided by the sum of the inputs.
Public company	A company which has issued securities through an offering, and which are now traded on the open market. also called publicly held or publicly traded.
Raw materials	Crude or processed material that can be converted by manufacturing, processing, or a combination thereof into a new and useful product.
Safety Stock (SS)	The level of stock, over and above the expected usage between the time a replenishment order is processed and replenishment actually occurs, that is held in reserve to try to prevent stock-out, should there be a delay in delivery of stock by the vendor.
Supply Chain Management (SCM) integration	The coordinated set of techniques to plan and execute all steps in the global network used to acquire raw materials from vendors, transform them into finished goods, and deliver both goods and services to customers. It includes chain-wide information sharing, planning, resource synchronization and global performance measurement.
Simulation	Simulation is used in many contexts, including the modelling of natural systems, and human systems to gain insight into the operation of those systems; and simulation in technology and safety engineering where the goal is to test some real-world practical scenario. Simulation, using a simulator or otherwise experimenting with a fictitious situation can show the eventual real effects of some possible conditions.
Stationary	Stationary process (or strictly) stationary process) is a stochastic process in which the probability density function of some random variable X does not change over time or position. As a result, parameters such as the mean and variance also do not change over time or position.
Stock out frequency	Probability that a stock out will occur.
Stock out	Having no stock. During a stock out, demand for a product must either be turned away or, if the customer will agree, put on backorder.
Value-Added Productivity	It is defined as "sales revenue less the cost of purchased materials & services".

Vendor-Managed Inventory (VMI)	An inventory planning and fulfilment technique in which a supplier is responsible for monitoring and restocking customer inventory at the appropriate time to maintain predefined levels. The vendor is given access to current customer inventory, forecast and sales order information and initiates replenishment as required.
Vendor Rating System (VRS)	Vendor rating is the system of rating of vendors based on performance in respect of quality of supplies, deliveries and service.
Vendor Selection System (VSS)	Vendor selection is the system of selection of vendor.
Warranty	In legal parlance, an express or implied term in a contract which is not central to the contract's main purpose.
Work In Process (WIP)	generally describes inventory that is currently being processed in an operation, or inventory that has been processed through one operation and are awaiting another operation. WIP is actually an inventory account that represents the value of materials, labour, and overhead that has been issued to manufacturing but has not yet produced a stockable item. Depending on how your accounting and inventory systems are set up, it may also include components picked for production usage or finished products awaiting final inspection.

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CONTRIBUTORS AND AUTHORS OF THE REPORT

This report shows the results of the LOG4SMEs (*Improving the logistics performance of Small and Medium- sized enterprises in the automotive sector*) project.
LOG4SMEs, a Regins project (www.regins.org), was launched by partners from three European Union regions in January 2006. The project duration has been of eleven months.
Regins is a project within the European Community Initiative INTERREG III C, financed under the European Regional Development Fund (ERDF).
Approved as a Regional Framework Operation, the overall REGINS objectives are to enhance and support inter-regional and strategic co-operation between the participating partner regions from Austria, Germany, Italy and Hungary.

Contributors and authors of the report are:

University of Bergamo (Lombardy region)

- Sergio Cavalieri
- Paolo Gaiardelli
- Elena Legnani
- Giuditta Pezzotta

Fraunhofer Institute for Manufacturing Engineering and Automation, IPA (Baden-Württemberg region)

- Daniel Palm
- Jörg Kimmich
- Christian Morawetz

Széchenyi István University (West Pannon region)

- Imre Czinege
- Elisabeth Ilie-Zudor
- Pfeiffer András
- Ildikó Kóbor

For more information on the LOG4SMEs project please contact:
Ing. **Giuditta Pezzotta**
e-mail: giuditta.pezzotta@unibg.it
tel.: (+39) 035-2052.031
mail address: Dipartimento di Ingegneria Industriale, Università degli Studi di Bergamo, Viale Marconi, 5 - 24044 Dalmine (BG) - Italy

Official Web Site of LOG4SMEs Project

www.log4sme.sze.hu