

SUSTAINABILITY IN THE BRAZILIAN AUTOMOTIVE PRODUCTIVE CHAIN: A MULTIPLE CASE STUDY

João Amato Neto
amato@usp.br

Escola Politécnica / Universidade de São Paulo / Brazil

Abstract

The term sustainability should be understood as a systemic concept, related with the continuity of the economic, social, cultural and environmental aspects of human society. Therefore, a sustainable development model should aim at satisfying the present needs of society, without, however, compromising the possibility of future generations satisfying their own needs. The sustainability notion has also permeated the companies normative ambit, as evidenced by the ISO 14000 Environmental Management Standards, the "green" stamp, ABNT 16001 Social Responsibility Norm, projects for cleaner Production (cleaner production) and the "3R strategies" - Reduce, Recycle and Reuse", besides many others. In the Brazilian context, this thematic is still at a quite incipient stage as compared to more developed countries of North America, Europe and Japan. The companies initiatives are localized and, on the other hand, there is little awareness and perception of such initiatives on the part of the great majority of the population.

The present work aims to investigate the degree of importance that the theme sustainability represents for the strategies of the great Brazilian automotive companies (automakers), trying to identify some manifestations of these strategies in the set of elements that compose the corporate governance of these companies. It is worth pointing out that this is an ongoing research and the results presented have a preliminary character.

Key words : sustainability, supply chain, Brazilian automotive industry.

Introduction

Day after day, the theme sustainability wins greater prominence in the entrepreneurial, governmental and academic spheres and in society in a general way. Specific issues, such as negative environmental impacts of industrial production, global heating, fairer work relationships, the fight against the exploitation of children's work, socially responsible investments (companies social responsibility), socio-environmental responsible consumption, besides others, stand out as issues of high importance, demanding urgent solutions. Specially, the growing social and environmental pressures for productive systems that do not generate negative impacts for society increase all over the world.

Successive international forums, that resulted in agreements signed by several countries along the last 2 decades (Eco-92/Agenda 21, Kyoto Protocol, 2002 Statement of Policies of the World Summit on Sustainable Development - Johannesburg, etc.) and organizations such as the World Business Council for Sustainable Development (WBCSD), World

Conservation Union (IUCN) and Earthwatch Europe have produced and disseminated a series of documents dedicated to the productive sector, aiming to enlighten the main actors about their responsibilities concerning sustainable development. In general, these movements fundamentally seek to reiterate the concern with redirecting the development models generated in the postwar period, which almost exclusively valued the economic dimension of development.

Actually, along practically the whole of the XX century, the industrialization process based on the Taylorist/Fordist paradigm prioritized, among several other aspects, wide scale production with excessive consumption of energy, water and raw materials, besides the intensive use of cheap labor. That model, with more recent variations, such as those deriving from the Japanese experience of Toyotism - of lean and flexible production - seems to present serious limitations, when its social and environmental undesirable impacts for society as a whole are questioned. Among these impacts, standing out are the environmental pollution of several orders (atmospheric, visual, sound), the excessive production of garbage as a consequence of massive consumption patterns linked to the traditional industrialization model, the precariousness of work conditions (especially in countries considered emergent or of late industrialization), among others.

In that sense, the term sustainability should be understood as a systemic concept, related with the continuity of the economic, social, cultural and environmental aspects of human society. Therefore, a sustainable development model should aim at satisfying the present needs of society, without, however, compromising the possibility of future generations satisfying their own needs.

The sustainability notion has also permeated the companies normative ambit, as evidenced by the ISO 14000 Environmental Management Standards, the "green" stamp, ABNT 16001 Social Responsibility Norm, projects for cleaner Production (cleaner production) and the "3R strategies" - Reduce, Recycle and Reuse", besides many others.

In the Brazilian context, this thematic is still at a quite incipient stage as compared to more developed countries of North America, Europe and Japan. The companies initiatives are localized and, on the other hand, there is little awareness and perception of such initiatives on the part of the great majority of the population.

The present work aims to investigate the degree of importance that the theme sustainability represents for the strategies of the great Brazilian automotive companies (automakers), trying to identify some manifestations of these strategies in the set of elements that compose the corporate governance of these companies. It is worth pointing out that this is an ongoing research and the results presented have a preliminary character.

The development of the Brazilian automotive industry

The Brazilian automotive industry was established in the 1950s through a planned governmental action which aimed to develop the Brazilian industry and update the society way of life according to the United States and European countries standards. The development of this industry occurred in steps (Amato Neto and D'Angelo, 2000). The first step was in the 1950s, when many international automotive companies (such as Volkswagen and Mercedes Benz) built factories in Brazil. Other companies, such as General Motors and Ford, which started their activities in Brazil in the beginning of the century, expanded their activities. These investments were based on official incentives and protection against foreign competitors (Addis, 1997).

The second step was between 1958 and 1962, when there was a fast increase in production and sales. The next step is between 1963 and 1968, when a strong recession was responsible for a very small annual increase in automotive production. After that, a new period of development (up to 1974) and a new stagnation period (from 1974 to 1980). This last period was called “the lost decade”, because the production level in the end was almost the same as that of the beginning and there were practically no changes in the models produced.

In the beginning of 1990s, two important facts occurred. On the one hand, the creation of the *popular cars* concept, with reduced tax for cars priced around US\$ 7,000.00. On the other hand, the Brazilian market was opened to foreign vehicles and auto parts. This fact closed the protection Brazilians companies had enjoyed for almost thirty years and that caused technological, organisational and quality backlog between these companies and their original units in the United States, Japan and Europe. At a second moment (1994, with *Real Plan*), the end of high inflation levels eliminated the financial profit of the companies. After that, they started to seek profit in their core business (Silva, 2002).

The modernisation Process

The movement of globalisation in the modern capitalist world imposed deep changes on the organisational structure of the enterprises in order to get more competitive advantages. The opening to international markets put Brazilian auto parts companies face to face with international players and costs (Fleury, 1997). This situation forced these companies to make great efforts to attain international levels of quality and productivity (Silva, 1998). Automotive companies daily improved the quality requirements of products that they were buying. Certifications according to quality standards such as ISO 9000, QS 9000, EAQF 94, VDA 6.1, AVSQ 1994 and, more recently, ISO/TS 16949 became essential for all suppliers (D’Angelo, 2001). For some automakers, to have a quality system certification is not enough any more. The target is zero defect and preventive and corrective actions have strict monitoring by automotive companies (Amato Neto, 1993). Defective parts are no longer acceptable and parts must be delivered directly to the assembly line, without any inspections by the automotive company.

With the option to import auto parts and vehicles, the automotive industry, which established the principle of buying the world wide best price, forced auto parts companies to achieve international prices. This means that auto parts companies need to improve their productivity and most of them are doing this through *lean production* principles.

Nowadays, the Brazilian automotive industry has achieved international cost and quality level. Some Brazilian units have become so competitive that workers in the original country of the company have made protests and strikes against Brazilian exportations of cars and trucks. Another international point which influences Brazilian automotive and auto parts industry is the relationship with Mercosul partners, mostly with Argentina. The other partners, Uruguay and Paraguay, have a secondary role due to the small size of their economy. With an industrialisation process similar to the Brazilian one, Argentina automotive and auto parts industries faced a big crisis in the 1980s (worse than the Brazilian crisis). This crisis resulted in a technological stalemate. Besides, the Argentinean population is smaller than the Brazilian one and, therefore, the market is smaller, too. The last, but not the least point, is the exchange rate. The Argentinean government maintained the parity between the Peso and the Dollar. These conditions made Argentina automotive

and auto parts industries a “satellite” of the Brazilian complex. The original idea was to maintain the balance between two partners, with free circulation of auto parts and vehicles. Nevertheless, a lot of Argentinean auto parts companies were bought by Brazilians ones. Most of the Automotive companies established their headquarters and main factories in Brazil. Some automotive companies defined that Brazilian factories produce small cars (low price, high volume) and Argentinean factories are in charge of medium-sized cars. After the Argentinean bankruptcy, in 2001 and 2002, the automotive industry almost stopped its activities, as nearly all industrial sectors as well. The internal market practically disappeared and exportation to Brazil was the only possible destination for Argentinean cars and auto parts. In 2003, the Argentinean internal market was revived, at a very low scale. This situation places the Argentinean automotive market in a secondary position to the Brazilian automotive and auto parts companies (Amato Neto & D’Angelo, 2007).

Currently, the auto industry in Brazil offers the best economic performance throughout its history. Altogether, the 16 car manufacturers (10 being car manufacturers and the others manufacturing light vehicles, trucks and buses) produce about 2,600 vehicles (54% more than in 2000), export about 12 thousand units (almost 4 times more than in 2000), with 106 thousand employees, or only 8% more than in 2000 (ANFAVEA, 2006).

Methodology

The methodological approach is based on a multiple case study. According to Yin (1998), the main characteristic of this case study method lies in the fact of its being generalized to theoretical propositions, and not to populations and universes. The generalization to theoretical proposition is exactly the subject intended by this work, which makes of the case study the ideal instrument to attain the objective.

In this sense, 4 great Brazilian automakers were selected, due to their outstanding importance in the Brazilian economy in terms of income and employment generation as well as exchange value (export). Besides, this industry has been considered a paradigm for the whole industrialization process of the country since the mid XX century. A semi-structured questionnaire was elaborated and applied to the main executives of the industrial area of the companies.

The main issues guiding the present research are:

- 1.) How does the company understand the term sustainability?
- 2.) Is there any strategic reorientation for the company based on sustainable development?
- 3.) What social and environmental practices are now being developed by the company?
- 4.) Are these practices an initiative of the unit (plant) in Brazil, or are they defined by the head office?
- 5.) Is there any initiative to disseminate these practices in the companies that compose the supply chain of the mother company? In case of a positive answer, what are they?

Sustainability in the productive chains: Main concepts

In general terms, it could be said that sustainability is something difficult to define. At the same time it is too big an operational concept to measure. Its concept embraces multiple objectives, involving four critical components: growth component, distribution component, environmental component and institutional component. The growth component is tied up to the creation of productive capacity, being fundamental for the economic growth of each country, positively impacting the physical middle, human, natural and social capital. In a broad sense, sustainability can be understood through some dimensions. The first one is the socioeconomic dimension. This dimension involves mainly the following aspects:

- International Cooperation to accelerate sustainable development
- Related internal policies
- Actions against poverty
- New consumption modality
- Actions for protection and for fostering human health
- Demographic dynamics and sustainability Fostering the sustainable development of human resources
- Integration of the environment and development in decision making

The second one is the environmental dimension. This involves mainly the following aspects:

- Fostering agriculture and of sustainable rural development
- Ecological management of biotechnology
- Planning of actions for Biodiversity conservation
- Protection of the quality of water resources
- Ecologically rational management of toxic chemical products
- Ecologically rational management of dangerous wastes
- Ecologically rational management of solid wastes

The third dimension refers to cultural aspects, such as: Values, diversity, knowledge, languages, world visions associated to culture and education for sustainable development.

Moreover, a new organizational approach should consider a strategic reorientation of the companies based on sustainable development. This implies, among other actions, the creation of a relationship and supply chain management net according to well defined approaches of sustainability.

Specifically in relation to the new conceptions of productive systems based on these new approaches Cleaner Production stands out, and its main principles and applications are:

- Strategic management based on Clean Production and Eco-efficiency for forming the total cost of goods and services
- Tools and methods of production management focused on strategic management for sustainable development.
- Products and processes abiding by the Cleaner Production requirements

Hill and Bowen (1997) pose a question: What exploration capacity maintains sustainable bases and respects the ecosystems? In agreement with Wilkinson et al. (2001) the concept of sustainable development should be concerned about maintenance, renewal and recovery of natural resources, but it should mainly include an ethical dimension of integrity, to provide a balance between the current economic pressures and the future environmental needs.

According to Veenan and Polytilo (2003), sustainability is difficult to define, to be made operational and too great to measure, Its concept comprehends multiple goals, involving four critical components: growth component, distribution component, environmental component and institutional component. The growth component is linked to productive capacity, being fundamental for each country economic growth, positively affecting the physical environment, human, natural and social capital.

Sustainable Engineering

Sustainability is a task which cannot be addressed only by individuals, single companies or single countries. Sustainability is rather an all-embracing, cross-sectional task including aspects of each engineering discipline, which has to be addressed on a global scale. From this point of view, the idea of sustainability has been interpreted with respect to engineering science within the Collaborative Research Center 281 on Disassembly Factories for the Recovery of Resources in Product and Material Cycles funded by the German National Science Foundation (DFG) at the Technical University of Berlin (TUB).

Sustainable Engineering can be defined as the application of scientific and technical knowledge to satisfy human needs in different societal frames without compromising the ability of future generations to meet their own needs. To achieve this goal, scientists and engineers cooperate in international and multidisciplinary groups and organizations. They use their imagination, judgment and take initiatives to apply science, technologies and practical experience to shape competitive processes and products. Management guides the creation, application and evaluation of science, technology, processes, and products, as well as the dissemination of knowledge.(Seliger, Kernbaum and Zettl, 2006)

Resource productivity

In order to achieve the ambitious goals of sustainability, a paradigm change in applying engineering has to be performed. Hereby, increasing the use of resources productivity has to be investigated in order to satisfy human needs of the current and future generations without exceeding the ecological boundaries of the planet. As mentioned before, the term sustainability should be understood as a systemic concept, related with the continuity of the economic, social, cultural and environmental aspects of human society. Therefore, a sustainable development model should aim at satisfying the present needs of society, without, however, compromising the possibility of future generations satisfying their own needs.

Remanufacturing vs. Recycling

To investigate the relative environmental emissions associated to recycling vs. remanufacturing, a Life Cycle Assessment (LCA) was exemplarily conducted by a mobile telephone company. The results of the investigation showed, as expected, that mobile telephone production accounts for almost all of the non-energy related emissions in the life

cycle. It was also found that the integrated circuits, display modules and main printed circuit boards accounted for nearly three-quarters of the energy consumed in the production phase. Not including integrated circuits manufacturing, the production stage itself consumed approximately 250 MJ of energy, which was over two times the estimated amount of energy consumed by the normal use of the mobile telephone over two years (Guenther et al., 2003).

Efficient remanufacturing processes

Remanufacturing is already a profitable business field. In fact, companies in Europe and North America are making significant profits by selling remanufactured products and components, e.g. mobile telephones and automobile components, mainly in markets of emerging countries (Skerlos et al., 2004). However, the potential of remanufacturing is not yet fully exploited. Complex and manual processes, various product models, missing product information, high spare-part costs, quality problems as well as technological and stylistic obsolescence are making the remanufacturing of many products unprofitable. An analysis of cost structures in the remanufacturing industry quickly revealed the major cost drivers: acquisition of cosmetic parts, manual sorting, disassembly and reassembly, as well as manual testing of functionality (Seliger et al., 2003).

Case study

Automaker A

This company is one of the largest of the automotive industry and is also the oldest assembler to settle in Brazil. Currently, it produces about 766 thousand vehicles per year at its 5 plants, exports a significant portion (about 45% of its total production), and has about 22 thousand employees.

The sustainability initiatives of the company (Automaker A) are relatively recent in the country. The focus is mainly on the issue of environmental responsibility and still restricted to some of its 5 plants operating in Brazil. In 2001, the company began the implementation of its environmental management system (EMS), the main goals prioritizing measures to reduce emissions.

In one of its largest plants (which produces 200 thousand units of light vehicles per year, with 4 thousand employees) the company reduced the carbon dioxide emission by 13.4% in its manufacturing process, in the last five years.

According to the direction of the manufacturing unit, they stopped generating the equivalent to 13.5 kilograms of carbon dioxide (the gas is a major component in the potentiating of global warming) per car produced in the last six years. The total rate of recycling of waste generated by industrial process, such as steel barb, packaging and ink residue, reached 93.6%. A considerable feat, compared to the total volume, which reaches 2,714 tons.

In the last seven years, the environmental investments made by the factory add to more than \$ 22 million. This reduction in emissions was achieved after the replacement of diesel oil by natural gas as fuel in boilers and greenhouse gases of painting, in addition to activities directly linked to the workers' actions to fight energy waste.

Together with reducing emissions, the plant decreased the generation of particulate

material in painting by 33%. This derived from the replacement of conventional pistols by electrostatic guns, imported from the United States.

The company also has a 22% decrease in the use of solvents and other products such as primer and varnish. This action guaranteed a 25% reduction in volatile organic compounds. In all, in 2006, it stopped generating more than 44 tons of these gases and other 137 tons of waste in the painting process. The factory still managed to recycle 88.7% of the total volume of the surplus generated in this sector, which only last year reached the mark of 862.8 tons. The remains of automotive paint were reused for painting of viaducts, containers and vessels.

Automaker B

In Brazil, the company produces about 185 thousand vehicles per year in its 4 operational units, exporting a significant part of this total (130 thousand vehicles, approximately), and counting on about 9,800 employees (ANFAVEA, 2006).

This assembler, also one of the pioneers in Brazil, is one of the most active in the environmental issue worldwide. In early 2005, it created a committee called *Sustainable Business Strategies*, whose focus is the quest for sustainable alternatives in all fronts of operation of the company, from vehicles manufacturing to emissions of pollutants and working conditions in the countries where it operates. In the case of Brazil, in addition to the environmental concern, the company prioritizes various social actions in their approach to sustainability, choosing basic education as a priority area to be developed in their actions.

In its new plant installed in 2001 in the northeast region of Brazil, the company, which produces more than 900 vehicles daily, recycles 4 thousand tons of material per month, reuses 729 tons and drops only 281 tons per month in landfill (this unit is called "eco-factory" by the company). In a built area of 1.6 million m², this plant has natural ventilation and light in most areas and conducts heat treatment of the gases emitted in painting through the process of regenerative thermal-oxidation, which is the destruction of volatile organic compounds. Indeed, this plant operates as a large industrial condominium, in which 25 of the leading suppliers of the company are located in the production line, under the modular assembly system.

Among the various environmental actions in this plan, the following can be detached:

- All the water used in manufacturing vehicles is treated at special stations and much of it is collected from rain on specific lakes;
- Composting of organic waste, using the by-product for soil regeneration ;
- Recycling all the materials possible and discarding the waste that can not be recycled or reused for ecological disposal, with the help of partners specialized in this type of tasks.
- Investment in planting and regeneration of 4.6 million m² of the Atlantic Forest around the industrial complex and 2.4 million m² inside it, with native species from the region and reserving a 12km perimeter area in its surroundings, to avoid future congestion, for new plants to be installed in the outskirts of the complex.
- Investments in the search for new technologies and sustainable materials, prioritizing the use of local raw material and national suppliers, since they comply

with the environmental standards of quality required by the assembler.

In sum, this plant of assembler 2 is a world of reference for the company, in terms of innovation in vehicle manufacturing and environmental sustainability. In other operational units of the company in Brazil, located in São Bernardo do Campo (SP), Taubaté (SP) and Tatuí (SP), the company also uses state of the art technology for treating effluent and recycling materials, in addition to preserving forest areas and reforestation.

In the plant located in Taubaté (SP), for example, more than 60% of the discarded materials, such as blankets, lamps and waste from aluminum smelting, are recycled or reused.

Besides the recycling of waste in the factories, most of the vehicles produced by this automaker use recycled material. The plastic protectors of the upholstery, for example, is made of reused plastic, as well as protective crates and the edges of the rear glass of most of their cars.

Remains of tissue are also used in the transmissions, air filters, and even batteries, which also have recycled plastic. Moreover, discarded computers and telephones come to life after being recycled in panels and grades of various models made by this assembler, as well as plastic soda bottles, used in different parts of the vehicles. Tires are recycled and used in brake-lights, bumpers, deflectors and other equipment using rubber in their composition.

The company also reveals that it invests in research for the development of economic sustainable alternatives in the regions of the Brazilian biomes, by financing some projects through partner institutions such as Conservation International. From 1996 to 1999, the company claims to have invested US\$ 1 million in such projects.

From the point of view of disseminating environmental sustainability throughout the production chain (upstream and downstream), assembler 2 (the first assembler in the country to have all its units certified with ISO 14001, 1999) also requires the certification from its direct suppliers, encouraging the participation of its distributors in environmental initiatives.

Automaker C

The third company (The Automaker C) settled in Brazil in the 1950s, producing only a SUV model. Only in the early 1990s did the Japanese company invest in establishing a new plant to produce lighter vehicles in the city of Indaiatuba, in the State of Sao Paulo. Currently producing about 58 thousand vehicles in its 2 operational units and exporting only 16 thousand units, it counts on about 2,700 employees (ANFAVEA, 2006).

From the point of view of their strategy for sustainability, the company already conducts more significant actions in the ir country of origin. The company developed, for example, the Prius hybrid model (with petrol and electricity engines), which is produced in Japan and sold in the normal range in the Japanese market, in the United States, the European Union and Australia.

Annually, the company invests more than US\$ 1 billion in several actions ranging from the separation and recycling of garbage to the development of new clean technologies. Assembler 3 has ISO 14001 certification in all factories round the world, including the

Mercosur plants. The ISO 14001 certification identifies companies committed to environmental issues.

In Brazil, the company remarks that its environmental policy "is booming", with actions in the Indaiatuba (SP) in Sao Bernardo do Campo (SP) plants and in the sales office in the city of Sao Paulo. According to the company, there are programs for waste recycling and aimed at saving energy. Some of these actions, they state, lie in the fact that their colleagues celebrate the World Environment Month in June, in addition to promoting an environmental education campaign, aiming to make their collaborators aware of the risks caused by the great deforestation occurring in Brazil. Other initiatives outlined by the company are:

- logistical support for trips to the Pantanal region, in Mato-Grosso (Project- "Arara Azul" to protect this typically Brazilian bird, threatened with extinction).
- donation of a collection of books for forming the library of the Escola Ambiental Bosque do Saber, a project of the city of Indaiatuba (SP).

Automaker D

This company is in the largest vehicle manufacturer in Brazil, producing around 550 thousand vehicles per year at its two plants, with exports in the order of 162 thousand units. It employs approximately 20,500 staff (ANFAVEA, 2006).

The company has as one of its main sustainability actions in Brazil, a literacy program for young people and adults. "Afabetização Solidária", a non-profit organization, founded in 1997, aiming to reduce the high levels of illiteracy among youths and adults, adopting a simple and low-cost model of literacy. During the 11 years of conducting this program, it has served 5.3 million young people and adults in 2,099 Brazilian municipalities. More recently (January 2008), the company established a new agreement with its distributors network throughout Brazil, aiming to expand the role of the program "Afabetização Solidária" to 24 counties that have the lowest Human Development Indices (HDI) and worse illiteracy rates than these two states - with 240 new rooms, classrooms for new students.

Conclusive remarks

Thinking about sustainability in general terms, it could be said that the increase in standards of living for everyone could lead to a resource consumption that will exceed ecological limits. On the other hand, the increase in resource productivity can contribute to a shift from cradle-to-grave to cradle-to-cradle economy and therefore to sustainable resource consumption and consequently an increased standard of living and balanced distribution of wealth. As mentioned by Seliger, Kernbaum and Zettl (2006), legislation can contribute to form paths for activities in sustainability. However, legislation should only set minimal social, labor and environmental standards without hindering entrepreneurial initiative and technological innovation in a competitive environment.

Some partial results indicate that the theme is relatively new to most of the automotive sector companies operating in Brazil. When some social responsibility and environmental management practices are identified, these are restricted to some formal procedures (ISO 14.000 Environmental Management Standards; AS 8000 Social

Assessment Norm; etc) and are imposed by the companies headquarters, in case the latter already counts on these practices in their countries of origin.

Sustainability actions, especially those aimed at environmental management and social responsibility are, in general, dealt with non-integratedly to the corporate strategy of companies. Conversely, it is observed that, in the deployment of new operational units, the automakers seek to define production processes aligned to the requirements of clean production, emphasizing aspects of re-manufacturing and recycling.

However, when questioned if there is a clear strategic direction of the company based on the broader requirements of sustainability, what is evidenced is that businesses are still in a nascent stage when compared to world-class standards. In some interviews with leaders of business and representatives of the National Association of Producers of Vehicles, there was a differentiated concern about the economic aspects of the auto industry survival in Brazil, due to the exacerbation in international competition, especially given the threat of manufacturers from emerging countries, such as China, India and Mexico. The dissemination of sustainability practices throughout the production chain has also proved to be at an early stage for the great majority of the companies surveyed. Some automakers formally require the certification ISO-14001 (Environmental Management) and impose a ban on the use of hand of child labor in its suppliers' operations.

Especially talking about one of the most interesting Brazilian experiences, with more than 30 years accumulated in the development and manufacturing of ethanol vehicles, Brazil pioneered the creation of the bi-fuel or flex-fuel engine, which allows supplying the vehicle with ethanol and / or gasoline. Cheaper and less polluting than oil fuel, ethanol today is a reality for Brazilians, and the bi-fuel engines have changed the sales profile of the automotive industry: in the first half of 2005, 40% of vehicles sold had flexible engine, against 21.6% in the previous year.

In addition to ethanol, other fuels, less environmentally impactant are being investigated, such as biodiesel and ethanol made from plants seed. Another clean fuel is hydrogen, most widely disseminated in the United States and Europe, in addition to electric vehicles.

Acknowledgements

The author would like to acknowledge Mr. Alfredo Pavone Ferreira, Manager of Automotive Certification of Vanzolini Foundation and thank him for the valuable pieces of information given, and Vanzolini Foundation for funding the participation in GESPIISA 16th.International Conference.

References

ADDIS, C. (1997), *Cooperação e desenvolvimento no setor de autopeças*, in: Arbix, G.;

AGUIAR DA SILVA, L. S.; QUELHAS, O. L. G. (2006), *Sustentabilidade empresarial e o impacto no custo de capital próprio das empresas de capital aberto*, *Revista Gestão & Produção*, Universidade Federal de São Carlos-UFSCar, Brazil.

AMATO NETO, J. (1993), *Desintegração vertical/"terceirização" e o novo padrão de relacionamento entre empresas: o caso do complexo automobilístico*

brasileiro" - (Vertical desintegration/"outsourcing" and the new pattern of relationship among companies: the case of the Brazilian automobile complex). São Paulo - Thesis (doctorate). Polytechnic, University of São Paulo (Brazil).

AMATO NETO, J.; D'ANGELO, F. (2000), Supply chain and new industrial organization forms: the case of Brazilian automobile complex, in 1st World Conference on Production and Operations Management (POM), Sevilla.

ANFAVEA (2006), Associação Nacional dos Fabricantes de Veículos Automotores, Anuário Estatístico, <http://www.anfavea.com.br/anuario>, accessed in 03/26/2008.

DAIMLERCHRYSLER, http://www.daimlerchrysler.com.br/meio_ambiente/Relatorio_Ambiental/cenrelAmbiental_05.htm, accessed in 03/24/2008.

FLEURY, A. (1997), Estratégias, organização e gestão de empresas em mercados globalizados: a experiência recente do Brasil. *Gestão e Produção*, v.4, n.3, p. 264-277, dez.

FORD, http://www.ford.com.br/not_noticias_474.asp?canal=des%22, visited in 03/24/2008

HILL, R. C.; BOWEN, P. A. (1997) Sustainable construction: principles and a framework for attainment. *Construction Management and Economics*, London, n. 5, p. 223-239.

SELIGER, G.; KERNBAUM, S.; ZETTL, M. (2006), Remanufacturing approaches contributing to sustainable engineering, *Revista Gestão & Produção*, Universidade Federal de São Carlos-UFSCar, Brazil.

SILVA, F.A.P. (1998) Avaliação da implementação e manutenção de um sistema da qualidade certificado: estudo de caso de uma empresa de autopeças. MsC Dissertation, Production Engineering Department, Polytechnic School. University of São Paulo, São Paulo.

_____. (2002) Análise da influência das montadoras de automóveis sobre as empresas de autopeças sob o paradigma da produção enxuta – um estudo de caso de empresas brasileiras. Phd Thesis. Production Engineering Department Polytechnic School, University of São Paulo, São Paulo.

SKERLOS, S. J.; ZETTL, M.; BASDERE, B.; SELIGER, G. (2004), Collaborative Development of Sustainable Strategies for the Reuse of Mobile Phones in a Global Educational Environment. In: *Proceedings Global Conference on Sustainable Product Development and Life Cycle Engineering*, Berlin, Germany.

SOCIETY OF AUTOMOTIVE ENGINEERS. (1999a) Identification and measurement of best practices in implementation of lean operation. SAE J 4000. SAE, Warrendale.

_____. (1999b) Implementation and lean operation user manual. SAE J 4001. SAE, Warrendale.

TOYOTA, http://www.toyotaimprensa.com.br/imprensa.php?id_setor=28&tex_codigo=375&vei_codigo, accessed in 03/25/2008.

VEENAN, T.S; POLYTILO, J. (2003), The role of institutions in policy in enhancing sustainable development and conserving natural capital. Environment Development and Sustainability, Netherlands, v. 5, n. 3-4.

VOLKSWAGEN, http://www.administradores.com.br/noticias/volkswagen_investe_em_sustentabilidade/13702/, accessed in 03/23/2008.

WOMACK, J.P.; Jones, D.T.; Roos, D. (1990) The Machine that Changed the World. Rawson Associates New York

YIN, C. (1998), Case study research: design and methods, Sage Publication, California.