POLITECNICO DI TORINO

Master of Science in

Automotive Engineering

Master´s Degree Thesis

Upgraded strategies to improve the spare parts management in the automotive aftermarket

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The science can reach anything after that God is on charge

Famous proverb

Table of contents

List of figures

List of tables

Abstract

After sales services or better well known as aftermarket, as one of the main profit generators for the companies as well as a hidden key to show a powerful brand reputation where they have gained increasing attention recently. Hence, companies are always looking for new strategies enabling them to provide the best possible service to the customers through the most efficient ways. In this trend, car makers companies operating in the automotive industry are no exceptions.

This thesis looks at how important are the services delivered by the car manufacturers after that a car is bought, and in specific the relevance of the strategies used in the supply strategies of the spare parts. The study includes the after sales services in the typical network of automotive dealers, the parts management in the automotive industry, a quick description of the main involved fields to improve the performance of parts businesses as well as new and main approaches used in the inventory management of parts, a brief description of the typical financial and key performance indicators of parts department.

Key words

Parts, spare parts, OEM replacement parts, aftermarket, after-sales, dealers, sales & operations, supply chain management, demand, Forecast, inventory management, key performance indicators (KPI).

Purpose

The purpose of this work will be to discuss the best strategies to get an optimal performance of a spare parts business focused in the automotive after-market industry.

It is well known that every part of the aftermarket business is affected by how manufacturers or dealers manage the product inventory. An effective control and management of spare parts are essential for many companies in most industries. The management of spare parts, enables companies to achieve high service levels without unnecessary high inventory cost. On the other hand, the availability of parts at your dealers drives sales, profit, and customer loyalty.

Therefore, the finding of the balance in the classic dilemma between sales, finance and procurement departments will be one of the main targets, and also taking into account the customer satisfaction required demanding very time harder in the automotive after-market industry.

Approach

As it was mentioned before, the purpose of this thesis, hence, is to investigate the challenges and new opportunities of parts business units within car makers managing the aftermarket, in applying supply strategies and preparing in advance for the new technologies. The thesis has been conducted through a qualitative study including literature study as well as investigation in different Parts areas where are involved: sourcing of parts, warehousing and distribution. In each best practice that will be discussed, some registers of an automotive dealer database will be used in order to show in better way the case.

List of abbreviations

OEM – Original Equipment Manufacturer.

KPI – Key Performance Indicator.

SCM – Supply chain management

OICA–Organisation Internationale des Constructeurs d'Automobiles (International Organization of Motor Vehicle Manufacturers)

GDP Gross Domestic Product

Chapter 1 Key facts about the automotive industry

The aim of this initial chapter is to provide a brief and general description of the automotive industry, the relevance of the after sales services as part of the automotive value chain as well as the significance of the parts management in the automotive brand reputation. The introduction starts with some important figures required to realize the volumes that usually involve the automotive global industry. Afterwards this chapter describes the automotive value chain in order to describe some areas of interest that are working with new strategies of inventory management and its motivation towards the deployment of the supply chain principles in different operations in the company.

1.1. Brief description of the automotive industry

The automotive industry is one of the largest manufacturing sectors, whose products are involved in the daily lives. Cars and trucks enable personal mobility and provide economic opportunity for billions of people. However, they also contribute to complex urban planning, environmental, and health challenges. The production of motor vehicles requires significant amounts of energy and material resources, and the after sales services in this industry play a challenging and competitive role every time.

Figure 1.1. - Toyota Corolla has been the best global selling vehicle in 2017.

Source: Toyota Motor Corporation [1]

The automotive industry is exploring significant changes in global market volumes, with flat sales in Western Europe and increasing importance of the emerging markets as Eastern Europe, Russia, China and India. This growing importance includes not only new car sales, but also the aftermarket.

1.2. Automotive industry key figures and Aftermarket volumes

First of all, the automotive aftermarket is a huge industry. If the total number of vehicles in operation on the planet has to be estimated, it would be an inaccurate number, even worst that this figure is growing continuously. However, if this variable can be determined or estimated, then another variable can be exploited, and it is the number of items used in the aftersales services; for instance, in repair, and maintenance activities of passenger and commercial vehicles. When presenting the aftermarket volumes in the area of vehicles, an assessment of the global and local car sales have a particular relevance before aftermarket will be analyzed.

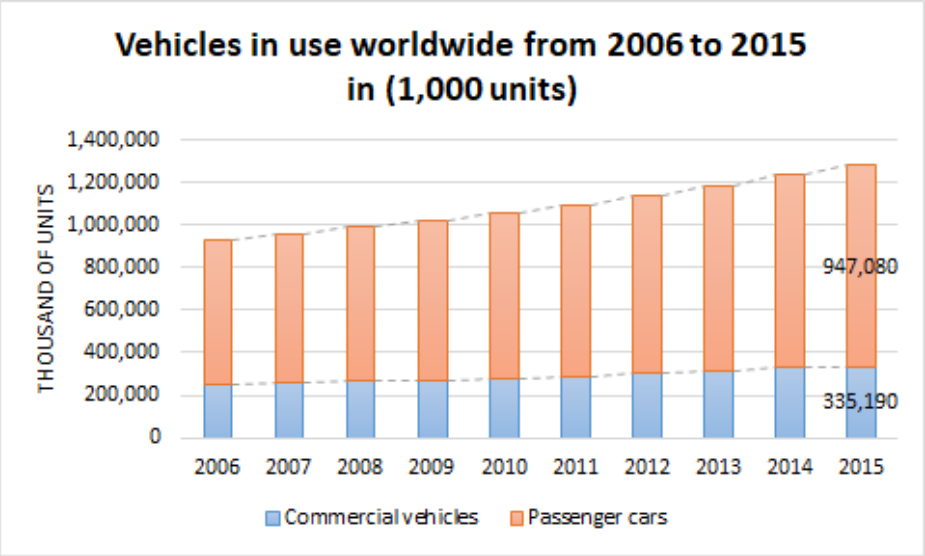


Figure 1.2. - Number of passenger cars and commercial vehicles in use worldwide from 2006 to 2015 in (1,000 units).

Source: Data from Statista [2], see also appendix A

WardsAuto Journal [3] had estimated that the total have overcame 1 billion vehicles during 2010. In 2014 there were more than 1.2 billion cars on the road, and by 2035, it is estimated 2 billion cars will be reached.

In addition, there is a vehicle density indicator called Motorization Rate [5] that represents the number of road motor vehicles per 1,000 inhabitants. In one hand, it is a common indicator in international comparisons of economic development and environmental issues. On the other hand, a high motorization rate basically shows how much a country is populated with vehicles, and the possible opportunities that an automotive brand can immerse in a market.

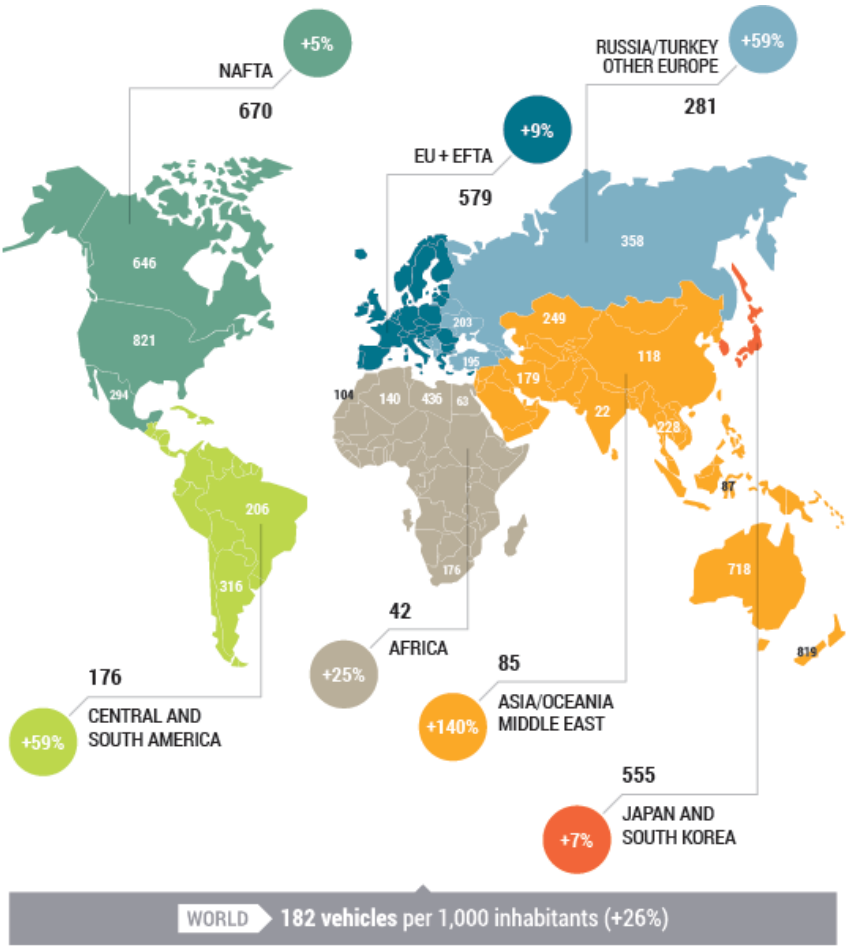


Figure 1.3. – Motorization rate / 1000 habitants, and % change 2015-2005

Source: ACEA [4]. See also appendix A.

From production volumes point of view, the today's vehicle production is around 100 million of unit per year; therefore, the same proportion of volume will be required in all the actors involved in the production and service of motor vehicles which are considered commercial and passengers' vehicles. As it can be seen in the below picture, the global production of vehicles is growing every year (Figure 1.4.)

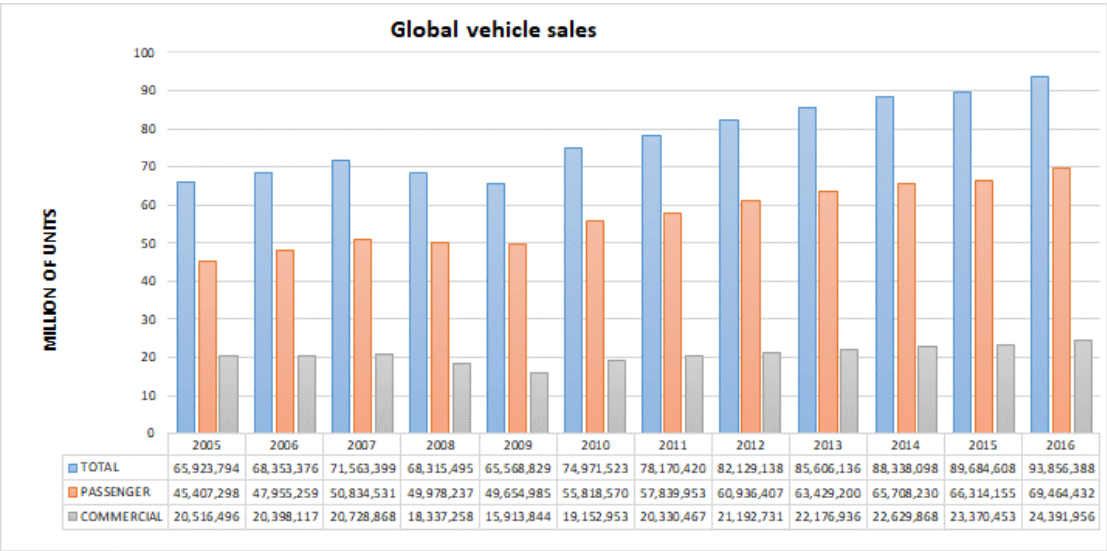


Figure 1.4. – Worldwide automobile production from 2005 to 2016 (in million vehicles).

Source: Author´s presentation based on data from OICA [5]. *See also appendix B.*

Also, it is important to highlight the production by area, country and the market share in order to realize the significance of the automotive industry in some markets. In the below picture we can identify the main actors in the global production, such as: Europe, China, Japan/Korea, and North America. The most significance increment is shown by China with around 14% only between two years where it is reaching a production of around 30 million of units per year.

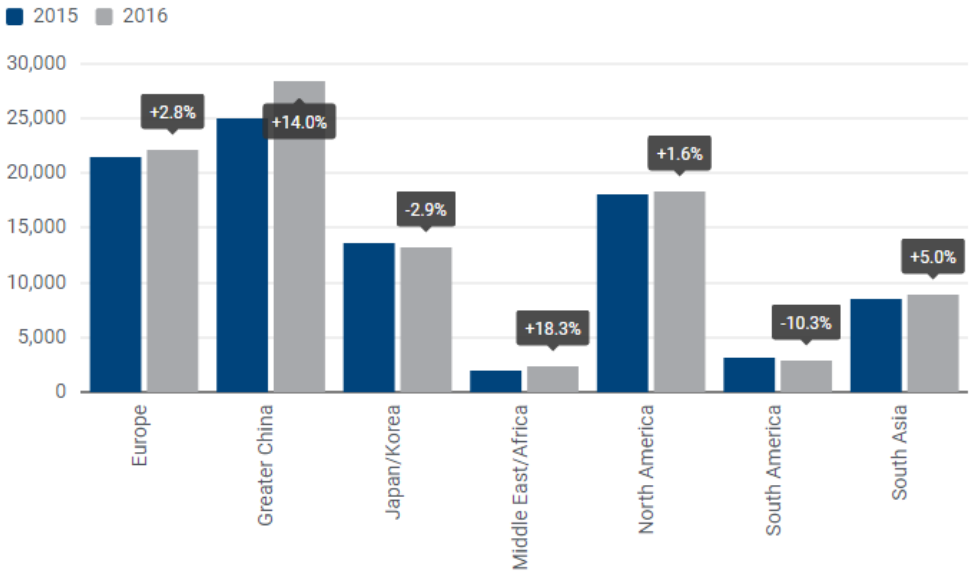


Figure 1.5. - World motor vehicle production by region during year 2015 and 2016 (in 1,000 units)

Source: ACEA [6]

The bar graph (Figure 1.6) provides information about the region share trends of automobile production every five years starting from 2001.

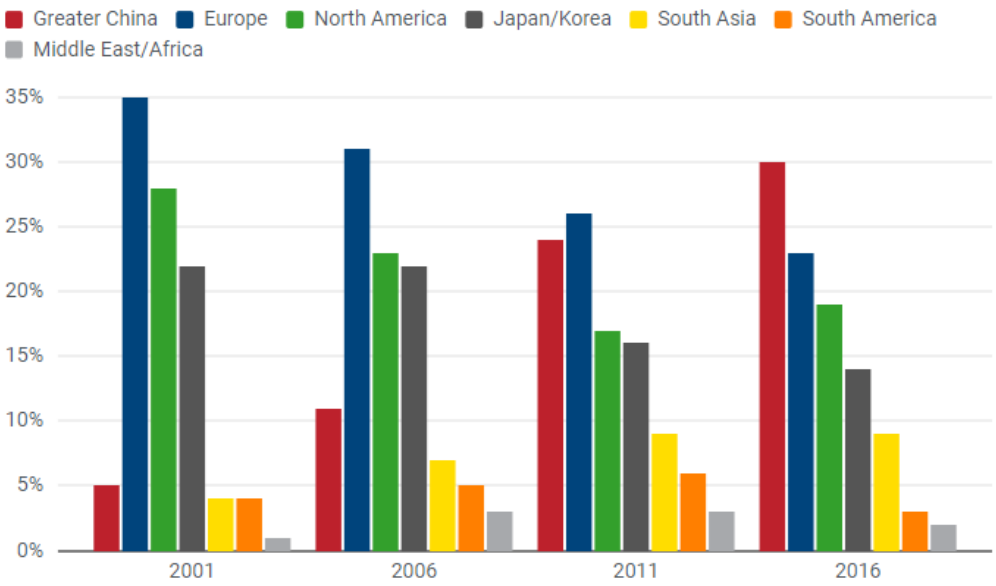


Figure 1.6. – World motor vehicle production every five years (% share)

Source: ACEA [6]

Some interesting trends are shown. One of the main important is the upward trend production of China, were up from 2001 a share of around 5% until 30% of the total share in 2016. By contrast, the production went down in Europe, Japan/ Korea, and North America basically. Those regions were occupying a share from 60 to 80 % of the global production.

Furthermore, more in detail, according OICA, in the table 1.1 is shown the most important countries of vehicle production in relation to the global production obtained in the year 2016. The number of units produced in the year were around 95 millions of units (94,976,569 units in specific), and which percentile increment was 4.5% in relation to the year 2015.

Table 1.1. - List of top 20 countries of motor vehicle production

Source: Data from OICA [5].

Top 20	COUNTRY	2015	2016	VARIATION	DIFFERENCE	SHARE 2016 %
1	CHINA	24,567,250	28,118,794	14.5%	3,551,544	29.6%
2	USA	12,105,988	12,198,137	0.8%	92,149	12.8%
3	JAPAN	9,278,238	9,204,590	-0.8%	-73,648	9.7%
4	GERMANY	6,033,364	6,062,562	0.5%	29,198	6.4%
5	INDIA	4,160,585	4,488,965	7.9%	328,380	4.7%
6	SOUTH KOREA	4,555,957	4,228,509	-7.2%	-327,448	4.5%
7	MEXICO	3,565,218	3,597,462	0.9%	32,244	3.8%
8	SPAIN	2,733,201	2,885,922	5.6%	152,721	3.0%
9	CANADA	2,283,307	2,370,271	3.8%	86,964	2.5%
10	BRAZIL	2,429,421	2,156,356	-11.2%	-273,065	2.3%
11	FRANCE	1,972,000	2,090,279	6.0%	118,279	2.2%
12	THAILAND	1,911,751	1,944,417	1.7%	32,666	2.0%
13	UK	1,682,156	1,816,622	8.0%	134,466	1.9%
14	TURKEY	1,358,796	1,485,927	9.4%	127,131	1.6%
15	CZECH REPUBLIC	1,246,533	1,349,896	8.3%	*103,363*	1.4%
16	RUSSIA	1,378,246	1,303,989	-5.4%	*-74,257*	1.4%
17	IRAN	982,337	1,282,172	30.5%	299,835	1.3%
18	INDONESIA	1,098,780	1,177,389	7.2%	78,609	1.2%
19	ITALY	1,014,223	1,103,516	8.8%	89,293	1.2%
20	SLOVAKIA	1,038,503	1,040,000	0.1%	1,497	1.1%

Finally, as part of the main figures in the automotive industry, it is important as well to know the automotive brands with major production relevance. The number of units produced by each car maker in the year 2016 are shown in the below table. The traditional brands can be seen in first top ten; in addition, Chinese brands are taking part of the

industry as it can be seen in last ten car makers of the list. By means of this distribution, the units produced by each brand, it can be realized the magnitude of the investments made by manufacturers in order to strength the after sales services.

Table 1.2. - List of top 20 car makers of motor vehicle production

Source: Author's presentation based on data from OICA [5].

Ranking	GROUP	Year 2015	Year 2016	Difference	Variation	% Share
1	TOYOTA	10,083,831	10,213,486	129,655	1.3%	10.8%
2	VOLKSWAGEN	9,872,424	10,126,281	253,857	2.6%	10.7%
3	HYUNDAI	7,988,479	7,889,538	-98,941	-1.2%	8.3%
4	G.M.	7,484,452	7,793,066	308,614	4.1%	8.2%
5	FORD	6,393,305	6,429,485	36,180	0.6%	6.8%
6	NISSAN	5,170,074	5,556,241	386,167	7.5%	5.9%
7	HONDA	4,543,838	4,999,266	455,428	10.0%	5.3%
8	FIAT	4,865,233	4,681,457	-183,776	-3.8%	4.9%
9	RENAULT	3,032,652	3,373,278	340,626	11.2%	3.6%
10	PSA	2,982,035	3,152,787	170,752	5.7%	3.3%
11	SUZUKI	3,034,081	2,945,295	-88,786	-2.9%	3.1%
12	SAIC	2,260,579	2,566,793	306,214	13.5%	2.7%
13	DAIMLER AG	2,134,645	2,526,450	391,805	18.4%	2.7%
14	B.M.W.	2,279,503	2,359,756	80,253	3.5%	2.5%
15	CHANGAN	1,540,133	1,715,871	175,738	11.4%	1.8%
16	MAZDA	1,540,576	1,586,013	45,437	2.9%	1.7%
17	BAIC	1,169,894	1,391,643	221,749	19.0%	1.5%
18	DONGFENG MOTOR	1,211,355	1,315,490	104,135	8.6%	1.4%
19	GEELY	999,802	1,266,456	266,654	26.7%	1.3%
20	GREAT WALL	869,592	1,094,360	224,768	25.8%	1.2%
	Total	**90,297,736**	**94,771,814**	4,474,078	5.0%	

Therefore, it is comprehensible that all of these number of vehicles should require the full range of service from maintenance of items like oil and filters to repair of any several thousand functional parts on each vehicle. The magnitude of car after-sales services will be proportional, and will be in function of the units sold mainly. Afterwards, the after-sales services issues will be developed in more detail.

After the last figures and facts that they have been displayed, it is important to highlight that the global automotive industry is a key part of the economy for every main country in the world. This industry is labor and capital demanding and its dynamics have deep impact on growth, employment and overall development. Also, it is facing deep transformations as new technologies and demands are pushing towards a radical transformation of vehicles (i.e. smaller, safer, greener, connected, driver-less) and their use (i.e. shared-cars, mobility services), aiming to major changes for the future for automakers and suppliers. The industry is growing, registering a 30 percent of increment over the past decade (1995-2005) [5].

Finally, according to Euler Hermes [7], in 2018, global vehicles sales should exceed 98 USD million, reaching a +2.5 percent of increment. Forecasts fueled by rising incomes

and still low interest rates, will support new registrations in passengers' cars (74% of the total) and commercial vehicles (26%) in the majority of countries.

1.3. The after- sales services activities as part of the automotive value chain.

1.3.1. General description of the value chain

Before the automotive value chain will be discussed, the value chain concept will be detailed as follows. It is well known that value is the heart of every business organization. From Porter´s theory [8], the way in which a business change the inputs into the outputs, it will be the value obtained , and it has to be greater than the original cost of creating those outputs. Michael Porter, describes "the profit margin is the amount of value that a business can create, minus the cost of creating that value". So, the greater the value and the lower the costs, the higher the profits will be.

$$Value\ created - Cost\ of\ creating\ that\ value = Profit\ Margin \qquad (1.1)$$

Porter´s book [8] describes the value chain as a set of activities that an organization does to create value for its customers. Also, it is proposed a general- purpose value chain that any company can use to examine all its activities, and to see how they are linked. This organization general model can be used to evaluate either where value can be increased or where costs can be reduced, or both. Porter´s value chain focuses on systems, rather than departments or accounting cost types.

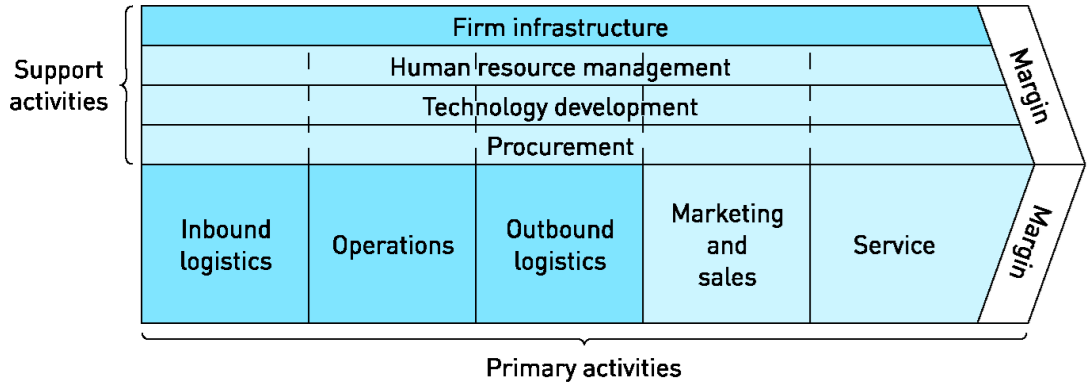


Figure 1.7. – The generic value chain

Source: Porter, M. [8, p. 37]

The value chain displays total value, and is composed of value activities and margin. The former constitutes the physically and technologically distinct activities an organization carry out. Basically, they are the building blocks in which an organization creates a product valuable to its buyers. On the other hand, the latter is the difference between total value and the collective cost of performing the value activities.

In general terms, the value chain divides the activities of the system into two categories: primary and support.

i. Primary: they are related directly to the creation, sale, maintenance, and support of a product or service.
    - Inbound logistics – Processes related to receiving, storing, and distributing inputs internally. The supplier relationships are a key factor in creating value in this activity.
    - Operations – Transformation activities that change inputs into outputs that are sold to customers. Here, the operational systems create value.
    - Outbound logistics – These activities deliver the product/ service to the customer. Some internal or external activities to the organization are involved as collection, storage, and distribution systems.
    - Marketing and sales – All the processes to persuade clients to purchase from the organization instead of the competitors. The benefits offered, and how well the communication is done, are sources of value here.
    - Service – All the activities related to maintaining the value of the product/ service to the customers, once it has been purchased.

ii. Support: activities that feed into one or more of the primary activities. All the activities are described:
    - Procurement (purchasing) – what the organization does in order to get the resources that it needs to operate. It is required to find specialist in purchases which negotiates the best prices.
    - Human resource management –how well a company recruits, hires, trains, motivates, rewards, and retains its workers. People are a significant source of value, so businesses can create a clear advantage with good HR practices.
    - Technological development –activities related to managing and processing information (Technologies of information and communications TIC). Minimizing information technology costs, staying upgraded with

technological advances, and maintaining technical excellence are also sources of value creation.

- Infrastructure – Company's support systems, and the functions that allow it to maintain daily operations. Additionally, sources of creation can be: accounting, legal, administrative, and general management.

1.3.2. The automotive value chain

As it was described in some paragraphs before; in particular, the automotive industry is highly concentrated, with few countries and automotive companies leading the world production. Undoubtedly, its value chain is increasing in a complex way, and characterised by a growing number of players operating in different sectors and located in different geographical areas. The after-sales services or aftermarket plays an important role in the global automotive industry; therefore, it will be important to describe the whole automotive value chain.

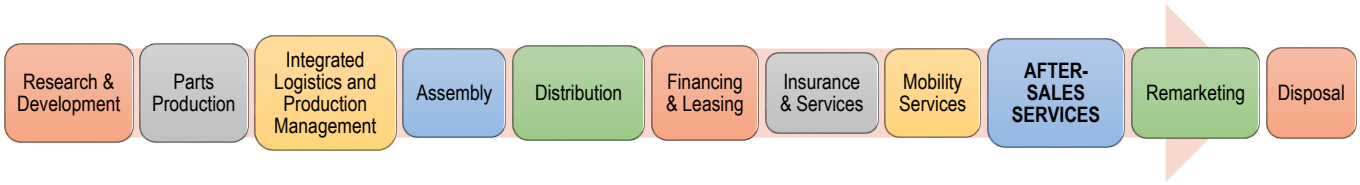


Figure 1.8. – The automotive value chain

Source: Author´s presentation based on [9, p. 2]

First of all, the value chain in the automotive industry starts with the research & development (R&D). In the following steps are the activities of the automotive supplier, the integrated logistics of distribution and the production management. Once the vehicle is totally assembled, it is sold.

Then, the three milestones in the finance are followed: financing and leasing, insurance and services as well as mobility services. The next step focuses on the activities that will be discussed deeply afterwards, and they are the aftermarket or also denominated after sales services, repairs and maintenance as well as on remarketing. Finally, the value chain is completed with the disposal of the vehicle to the end customer.

Figure 1.9 shows more in detail the main components of the automotive after-sales services and also gives an outline of average margin expectations per component. In addition, the illustration shows how the value chain of an OEM (Original Equipment

Manufacturer) and OES (Original Equipment Supplier) is structured and where the after sales activities are based in the chain.

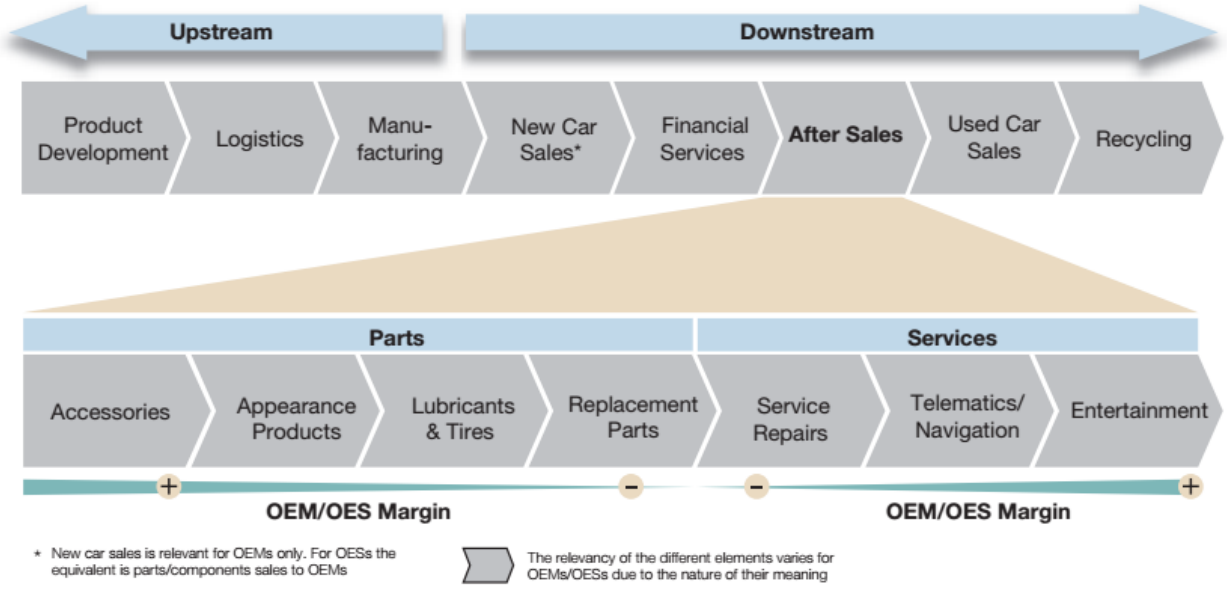


Figure 1.9. – The Value Chain of OEM/OES and Focus of Study.

Source: Consulting, Capgemini; St. Gallen, University [10]

In relation to car after-sales services operations, it has a wide scope and contain all activities related to maintain a car after its initial sale till the end of its lifecycle. The relevant activities are also referred to aftermarket parts and services purchased for light- and heavy-duty vehicle.

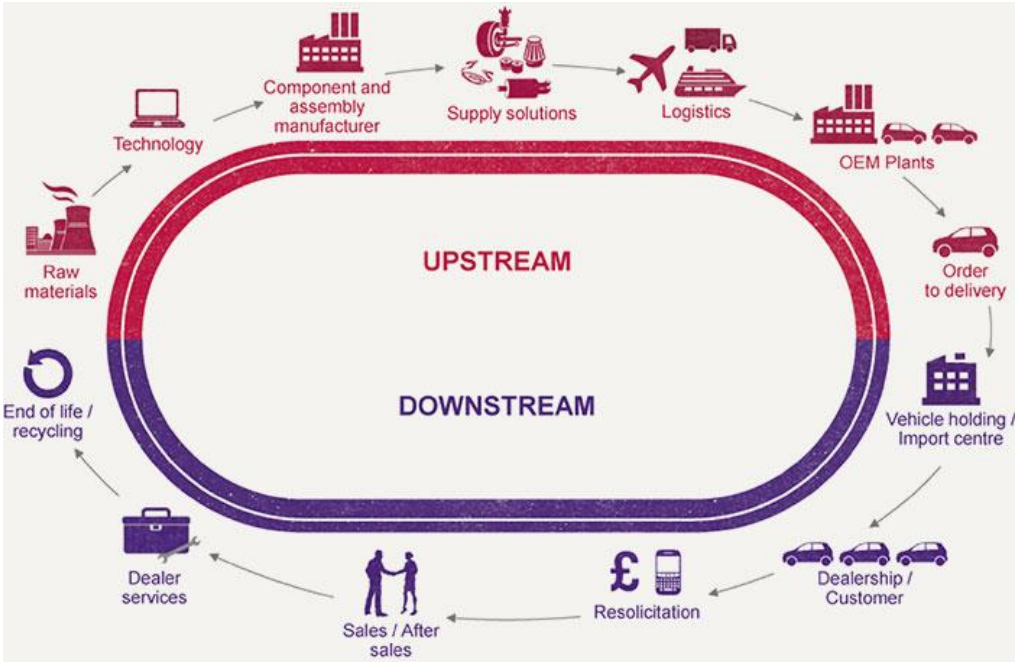


Figure 1.10. – Upstream and downstream of the automotive value chain.

Source: Grant Thornton UK LLP [11]

Finally, now it is more comprehensible that the automotive value chain is a whole process, and it cannot be isolated one activity without understanding the interaction of all stakeholders within the process. However, primary and supporting activities can be break down into sub-activities, and identifying them could give the most value to the chain. As it can be seen in the Figure 1.10, almost all the activities that are taking part in the downstream value chain are involved within the sales and after-sales services. So, it will be the starting point to discuss afterwards the importance of the activities related to offer service to new car buyers.

Chapter 2 The aftermarket or after-sales services in the automotive industry.

This chapter describes some literature review of some influential authors, researchers, consulting companies, and personal experiences in the field of the car after-sales services or as well knows as automotive aftermarket. After reading this chapter one should understand the motivations and relevance that will be covered in next chapters about the parts management. The first part that will be discussed is the description and the importance of the services in any industry, based on importance to customer's relationships and profits. The next section describes the role of the car after- sales services, followed by a section describing best practices of car makers in the automotive aftermarket.

2.1. General definition and characteristics of service and after-sales services

Henry Ford, once said "A business absolutely devoted to service will have only one worry about profits. They will be embarrassingly large". This is just a worth statement describing how some companies that are following this concept have achieved success and been rewarded for their continuous investment in *Services*.

Figure 2.1. – Service and its main correlations.

Source: CarToq [12]

As it was stated in the previous chapter, the service and intangible experience obtained for car buyers in the automotive dealers which are the authorized representative of car makers, will play a key role in the customer satisfaction, and therefore loyalty of

customers. The idea of linking service value and customer satisfaction has existed for a long time. There are some references that attempt to establish connections between service quality, customer satisfaction, customer loyalty, and profitability, and they will be described afterwards.

Firstly, it will be useful described briefly and in general terms some important concepts and characteristics of the concept "*Service*". Kotler [13] defines as "form of products that consists of activities, benefits, or satisfactions offered for sale that are essentially intangible and do not result in the ownership of anything". In particular, it can be seen in all the sub-activities that are performing a car manufacturer in order to support a new car buyer after the sale in order to accomplish customer's satisfaction.

Generally, when a product has to be designed, the product development designers have to think products and services on three levels. Each level adds more customer value than the other. Starting from the most basic level: *core customer value*, which are the problem-solving benefits or services that consumers are looking for.

At the second level: *Actual product*, the designers have to turn the core value into the real product. Then, specific product or service features are developed. Features can be found as packaging, brand, quality level, components, among others.

Finally, the last level: *Augmented product*, and probably the most important, from brand experience point of view, which is offering around the other levels, additional consumer services and benefits. Here is important to highlight this level of product where if the product as a vehicle, the complex bundles of benefits will be analysed in order to satisfy the customer needs.

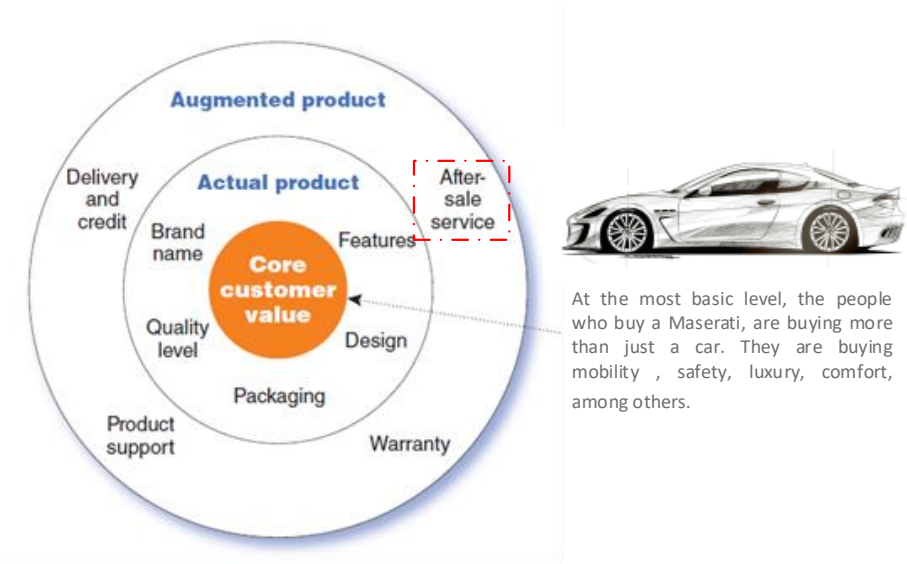


Figure 2.2. – The three levels of product.

Source: Author's presentation adapted from Kotler's book [13, p. 250]

When a product is designed; in particular, a car, the services offered by a manufactures after the purchase must consider four special service characteristics, which are describes in the below picture.

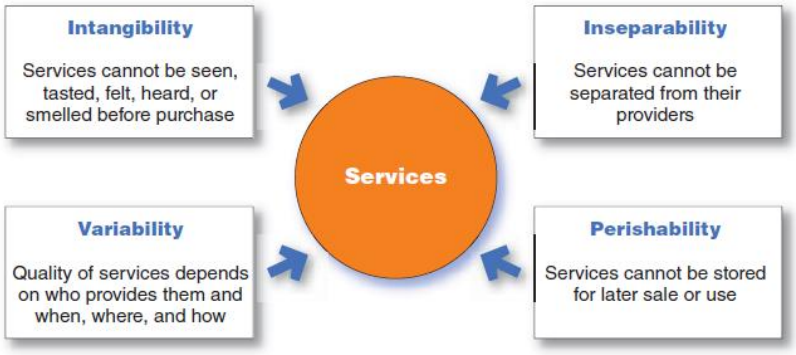


Figure 2.3. – Four service characteristics.

Source: Kotler [13, p. 261]

For instance, the warranty service covered by a car manufacturer is part of the product itself, therefore, it can be seen as intangible in a vehicle. The technical services after the purchase, as repair, maintenance, and diagnosis activities cannot be separated from the providers. In relation, to the quality of service offered by a parts consultant when it is required a spare part, even in the same dealer network, it will vary according to employee´s energy and frame of mind at the time of each customer. Finally, service perishability is showed when a service car appointment in the workshop is lost, it cannot be stored to use later.

2.2. Definition of after-sales services

Currently, the after-sales services are well known as a relevant source of revenue, profit, lifetime customer and competitive advantage in most manufacturing industries. Therefore, it should focus on the definition According to Gaiardelli [14], after-sales can be described as “set of activities taking place after the purchase of the product devoted to supporting customers in the usage and disposal of goods to make them loyal”. Instead, Rigopolou [15], after- sales services are clearly synthetized as “product support activities”.

In last years, more companies are encourage to improve the existing customers retention rather than attracting new customers, and taking into account statements mentioned by Kotler [13], a new customer is five times greater than the cost to keep an existing satisfied customer.

In general terms, the after-sales activities pursue that an organization after the transaction of its product try to minimize potential problems related to product use, and maximizes the value of the consumption experience.

The after- sales sector, after the delivery of the product, represents a continuous contact between the producers and the customers by means of the dealers. For instance, as a result of the unique vertical marketing system practised in the car industry, and the fact that the balance of power lies with the car makers, the dealers have been forced to assume leadership in an aftersales process in order to retain end customers through total satisfaction. At the end, aftersales optimizes both the *delivery of the product* and the *service aspect of the process.* [16].

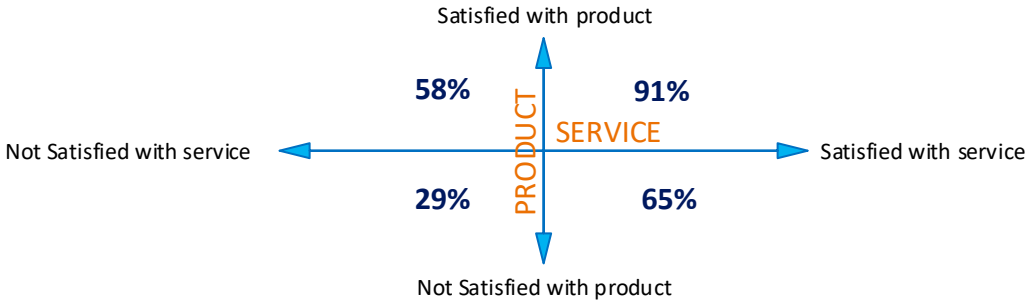


Figure 2.4. – Car repeat buying in relation to customer satisfaction.

Source: Author's presentation adapted from [16].

2.3. Importance and contributions of the services in the global industry

Currently, it is well known that the global industry is plenty of companies devoted to service businesses, and in order to survive and prosper each company must transform itself into a services business. Even though a business begins offering products, it has to be focused in offer the service after the purchase of a product.

In the Figure 2.5, an U.S analysis [17] clearly notices the share that occupies the service industry in the global sales. Services dominate industries, and it is not only in U.S., also is around the global industry. In the study reflects that more or less the 70 percent of the industry correspond to the contribution of Services in the Gross Domestic Product (GDP), and they are growing dramatically in last years.

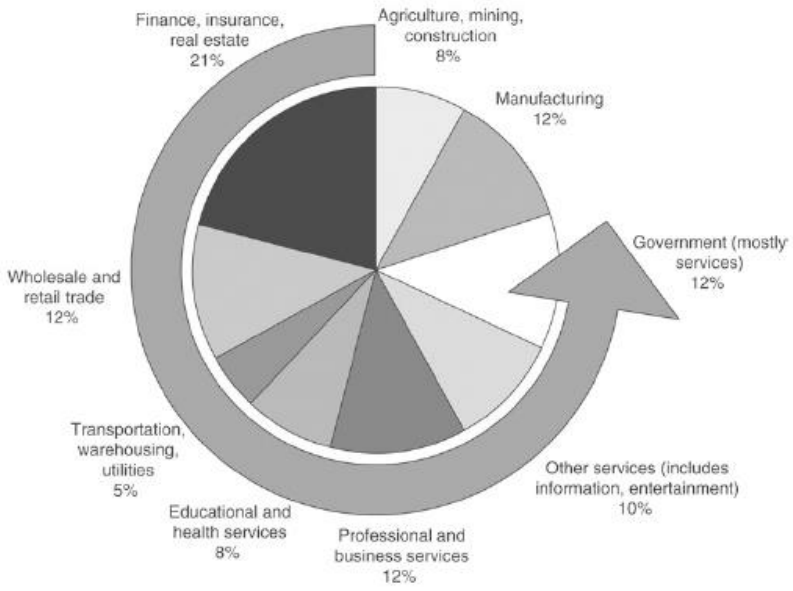


Figure 2.5. – Contributions of the service in the global industry in U.S.

Source: Bureau of Economic Analysis [17, p. 19]

Furthermore, the importance that a company get focused in Service offers can be displayed in the below bar graphs. Similarly, by means of the same analysis mentioned previously, the contributions of service companies in labour as well as in the GDP in the U.S. analysis done in 2007 show that they are undoubtedly more than in other industries, such as: manufacturing industries, mining, agriculture, and construction.

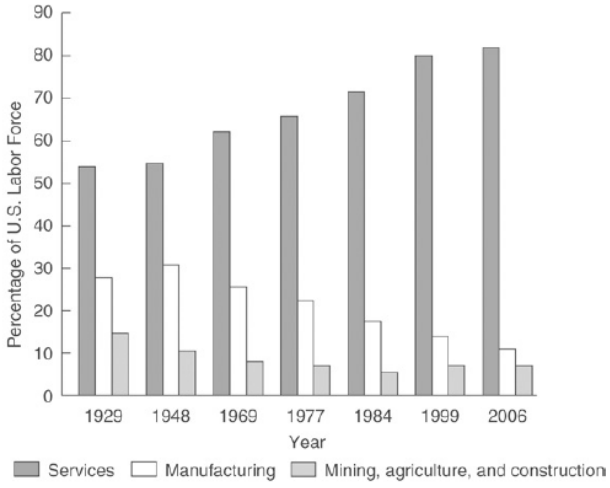


Figure 2.6. – Percentage of Labour Force by Industry

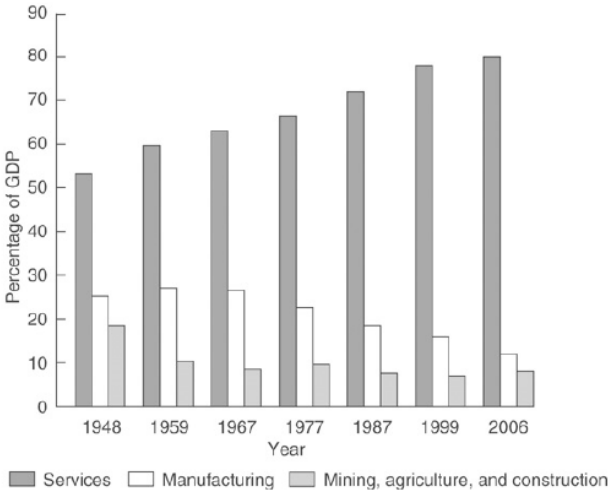


Figure 2.7. – Percentage of GDP by Industry

Source: Bureau of Economic Analysis [17]

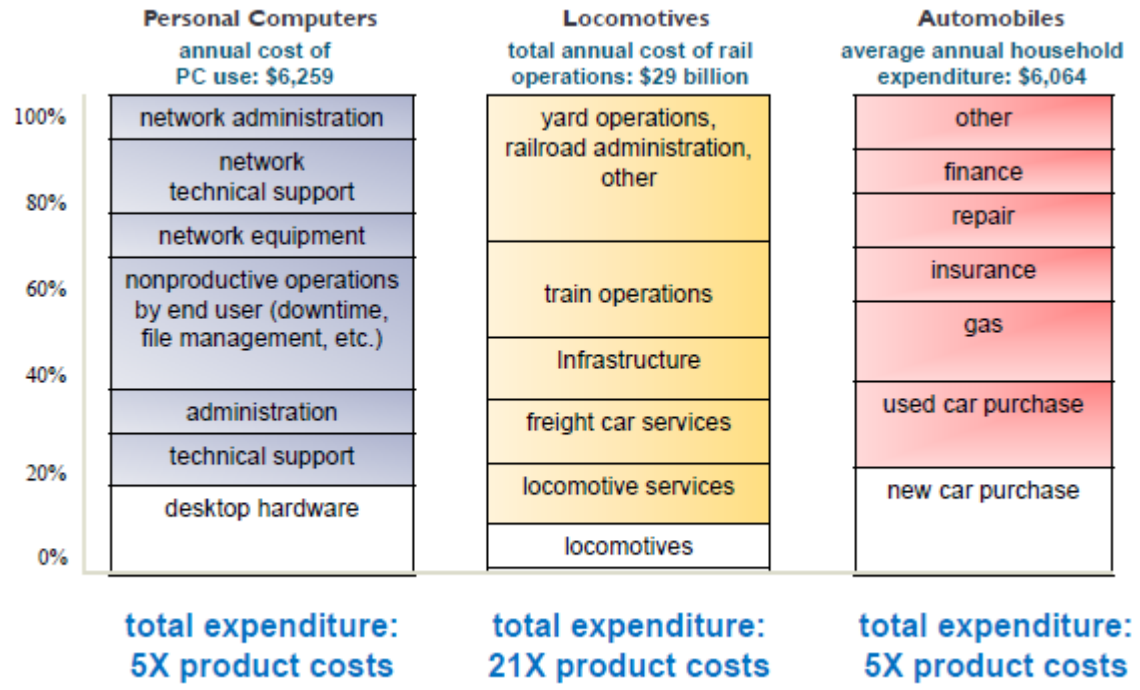


Figure 2.8. – Relationship of new purchases and services expenditures in different industries.

Source: Harvard Business Review [18]

Finally, in relation to the Figure 2.8., it is remarkable to highlight the terms upstream and downstream parts of a process. Upstream is related to the material inputs needed for production, while downstream is the opposite end, where products get produced and distributed. In fact, downstream markets offer important benefits besides large new sources of revenue. They tend to have higher profits and to require fewer assets. Clearly, the money lies downstream, and not anymore in the production. As it can be seen in last figure, there is a comparison among three different industries.

For instance [18], firstly, in a computing company spends only about one-fifth of its annual personal-computer budget on purchasing the computer themselves; the rest goes to technical support, administration, and other maintenance activities. Second, in the rail industry, the railroads spend around $29 billion per year maintaining and operating their locomotives and related infrastructure, but they only purchase less than $1.4 billion worth of new locomotives. Finally, a household spends more than $6,000 per year on auto-related expenses, but only about 20% goes to the purchase of a new car; the rest covers expenses as fuel, insurance, car service, and financing. Then, it is remarkable how the products accounts only a small portion of overall revenues, and how the services are taking the market in nowadays.

2.4. After-sales services in the automotive market

Once the general concept and characteristics of the service has been detailed, it is important discuss the concept in relation to the automotive after-sales market.

In today's automotive market, the after-sales service has become a critical success factor in car sales, and even more in new or youth automotive brands part of emergent markets that have appeared in last decades; in particular, automotive Chinese brands, as Great Wall, Geely, BYD, and Chery are an example that how the after-sales services can be the key of the success or failure.

Even though the tendency for considering the purchase of a car itself as the biggest cost item, the downstream sector is a major part of the cost of driving. It is also the profit engine of the industry. Figure 2.9 shows how significant the downstream sector is for the global automotive industry. As many authors said it is actually where the money is made. Everything downstream actors contribute more than half of all profits, only in exception fuel, the government and other.

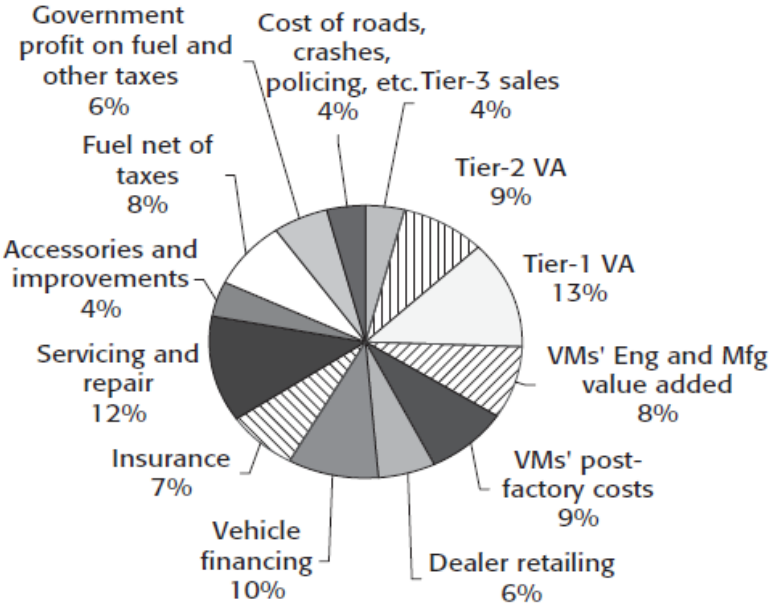


Figure 2.9. – The significance of the aftermarket: breakdown of industry value added.

Source: Maxton & Worlmald [19]

In the Figure 2.10, it is shown a breakdown of the cost of driving in Europe, expressed as the lifecycle costs of a vehicle. The vehicle owner carry the depreciation of the vehicle which can reach 36%. Excluding only the financing cost (the cost of the capital spent in

the lifecycle of vehicle), insurance, and taxes, the downstream sector costs about 60 per cent of the total. Even without fuel, it is still about 40 per cent. [19]

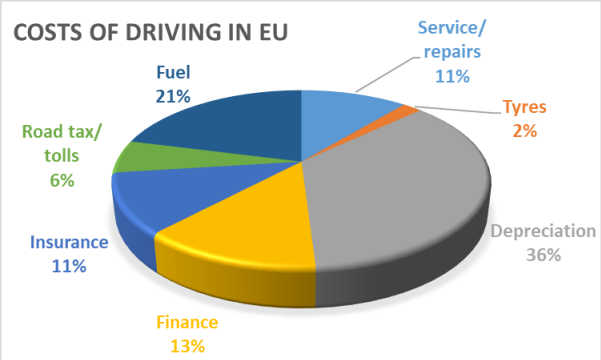


Figure 2.10. – Lifecycle costs in a vehicle.

Source: Maxton & Worlmald [19]

The financial numbers involved in the aftermarket are so big, but interesting. Since, dealers typically earn fairly limited amounts on new car, it will be the after-sales activities that can reach significance profits. In industries such as automobiles, white goods, industrial machinery, and information technology, companies have sold so many units over the years that their aftermarkets have become four to five times larger than the original equipment businesses. For instance, according a Harvard article [18] the sale of spare parts and after-sales services in the United States corresponds to 8% of annual GDP.

Some practical references that we can understand better the significance of the great after- sales business performance. First, according AMR Research in 1999, businesses produce 45% of gross profits from the aftermarket, although it accounts for only 24% of revenues. Second, it will be by means of a study made some years ago by the Accenture Consultant Company evaluating the after-sales service network in GM. It states that GM earned relatively more profits from $9 billion in after-sales revenues in 2001 than it did from $150 billion of income from car sales [18] . Therefore, even after-sale revenues comprise only a small amount of GM's total sales, they are by far the largest creator of shareholder value on a service focused company.

This analysis reflects why more companies are focusing service management programs to boost profits and provide competitive differentiation. In the automotive market, after-sale services and spare parts can cover for nearly 80% of all revenue, and more than 50% of the average automobile dealer's profits. Across manufacturing companies, after-sale services and parts have been shown to contribute about 25% of all revenue, and 40 to 50% of all profits. [20]

As a result, we can found that with nearly double the profit potential of first-time product sales, service management is the new frontier of competitive differentiation and profit enhancement.

2.5. The purpose of the after-sales services in car market

The automotive aftermarket is getting dramatic changes with evolving customer expectations, acceleration of technological innovation, and shifts in competitive power. These changes will reshape the way customers, automotive suppliers, and other aftermarket companies think of cars and driving and how business in the automotive aftermarket is conducted and value is created.

For some reasons, the aftermarket is far from easy, since it entails significant complexity, a large number of maintenance and parts activities, and crucial supply chains.

Generally, the after sales services in the automotive industry play an important role from several point of views. In below lines, it is aimed to explain the role of after-sales service on the main fields.

2.5.1. Loyalty and retention through excellence in customer service.

Customer satisfaction means that the customer's requirements are satisfied, product and services are met, and customers' experience is a positive. Customer satisfaction itself is not an indicator that there will be customer retention. A loyal customer is a customer whose expectations are met and exceeded, as a result they proactively would refer the supplier. As it was mentioned, the service leads to customer retention and loyalty cause besides being a long-term potential revenue source, the after-sales service constitutes a mean to uncover customer needs and a strategic driver for customer retention.

The actual demand, stronger price/quality consciousness, increased emphasis on service and general economic pressures which have reduced buying power have necessitated the need to develop other strategies that are aimed towards achieving greater *brand loyalty* among customers. There is, more than ever, a need to ensure customers are not just satisfied but also continuously *delighted*.

When a customer is happy with the service a dealer provides them, they're more likely to suggest their friends and family members about it. This experience creates promoters for the vehicle brand who are more likely to return to a dealer for repairs and common services like oil changes and replacement of batteries, brakes and tires. In fact, one number that tells a company how loyal its customers are likely to be is how high they rate the firm's after-sales services. [18]

As some included characteristics of the customer satisfaction, they can be listed:

- Increases the lifetime value of the customer.
- It is a point of differentiation, it will be a little more described afterwards.
- It is helpful to reduce the negative communication of word to mouth.
- It shows the loyalty and repurchase intentions of the customer.

Finally, it is important highlight in this point that in a certain organization, the frontier people is usually either the service advisor or the service manager who is part of the care phase who communicate with the customer, and have an impact on customer relationships and on customer satisfaction. Having a direct impact on customer satisfaction. Furthermore, how he/she manages delivered services indirectly influences customer satisfaction and customer loyalty. It will be most visible output from the organization in the care phase and the customer's perception of the services determines his/her customer satisfaction.

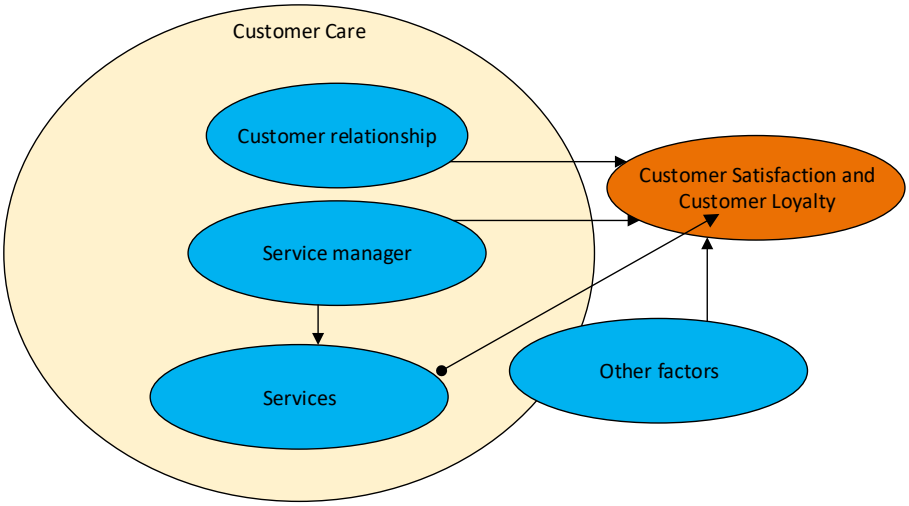


Figure 2.11. – Connections of elements in customer's care purposes.

Source: Koskela [21]

2.5.2. Attractive profits and revenues

As businesses began offering solutions instead of products, it became evident that selling spare parts and after-sales services conducting repairs; installing upgrades; reconditioning equipment; carrying out inspections and day-to-day maintenance; offering technical support, consulting, and training; and arranging finances—could be a generous source of revenues and profits as it was mentioned in previous sections.

After-sales services are a high-margin business, and they account for a large piece of corporate profits. Profit generated by after-sales services is often higher than the one obtained with sales; the service market can be four or five times larger than the market for products, and it has to be exploited.

According to McKinsey Group [22], a modeling of the automotive aftermarket was developed, the model represents values at the end-customer price level, including: parts, labor, maintenance, and crash-relevant revenues, with a granular differentiation by region. It gives a total global value for the market in 2015 of approximately USD 760 billion. Furthermore, three regions accounted for over 75% of this value: more than a third came from USA (35%, USD 267 bn), Europe was second with approximately USD 237 bn (31%), and China's approximately USD 72 bn market accounted for 10% of global value

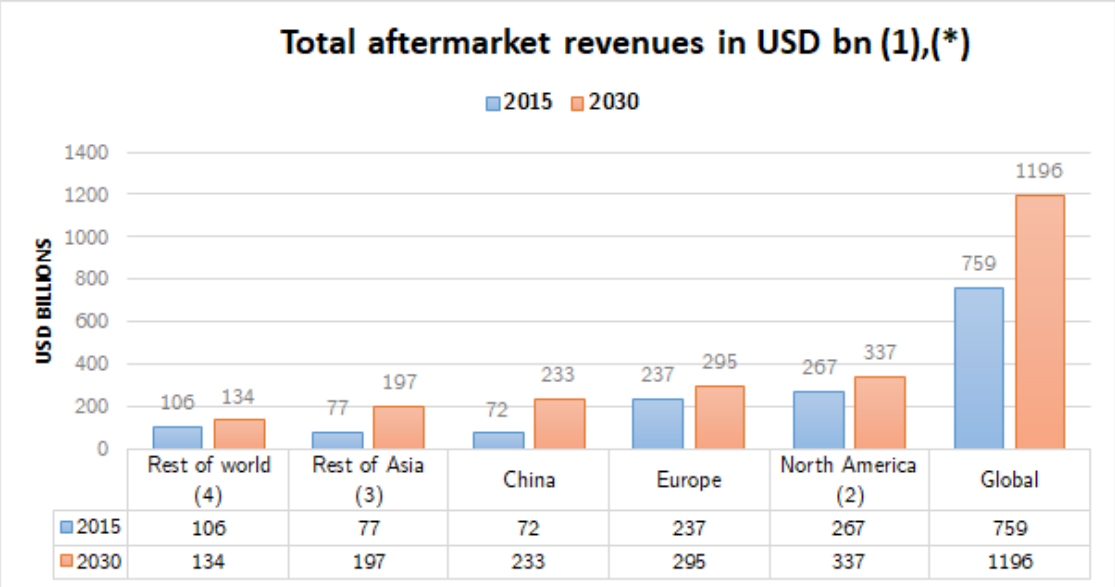
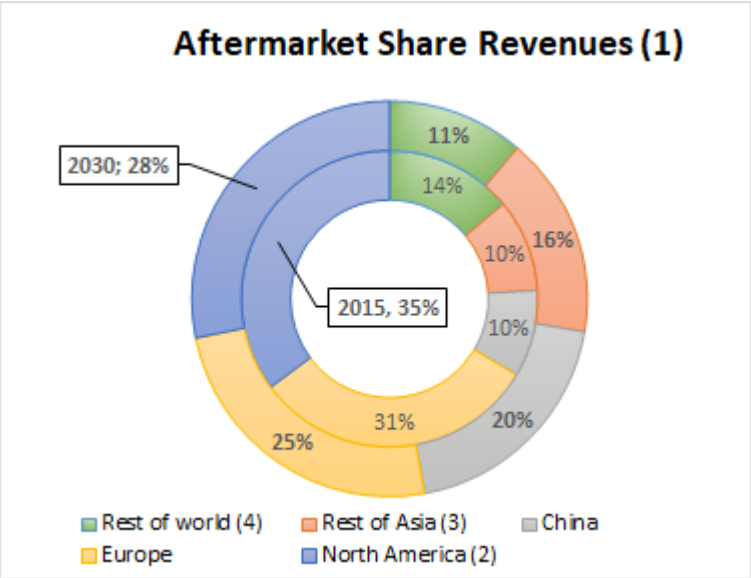


Figure 2.12. – Total aftermarket revenues.

Source: Author's publication based on McKinsey's article [22]

In past five years, the global automotive aftermarket has shown healthy growth and profitability. This trend is expected to continue and the aftermarket will increase till approximately EUR 1,200 bn by the year 2030. [22]



(1) Including parts, labor, maintenance, and crash-related revenues
(2) Including the US, Canada, and Mexico; (3) Including India; (4) Including South America, Africa, and Oceania.
(*) More than 80% of aftermarket experts agree with this outlook.

Figure 2.13. – Revenues Aftermarket share.

Source: Author's publication based on McKinsey's article [22]

As it can be seen in last two pictures, the automotive industry is experiencing significant changes in global market volumes, with flat sales in Western Europe and increasing importance of the emerging markets of Eastern Europe, Russia, China and India (countries considered as the BRIC group).

2.5.3. Correlation to the vehicle sales

The after sales service, and with more incidence in automotive parts consumption is directly correlated to the demand for new vehicles. If vehicle production goes down, automotive parts production and sales follow.

For instance, this trend is reflected in the total number of vehicles in China. There were an estimated 170 million vehicles by 2015 end with rising vehicle service life. As a result, the aftersales market including: auto parts sales, maintenance and other after- sales services are playing an increasingly prominent role in the automobile industry.

As the competition for new car sales gets fiercer, the aftersales service market too gets affected. It is becoming one of the factors critical for closing a sale. In such a scenario, it is imperative for all players in the automobile industry to assess the trends and challenges in aftersales services and devise viable coping strategies.

The after sales service, and with more incidence in automotive parts consumption is directly correlated to the demand for new vehicles. If vehicle production goes down, automotive parts production and sales follow.

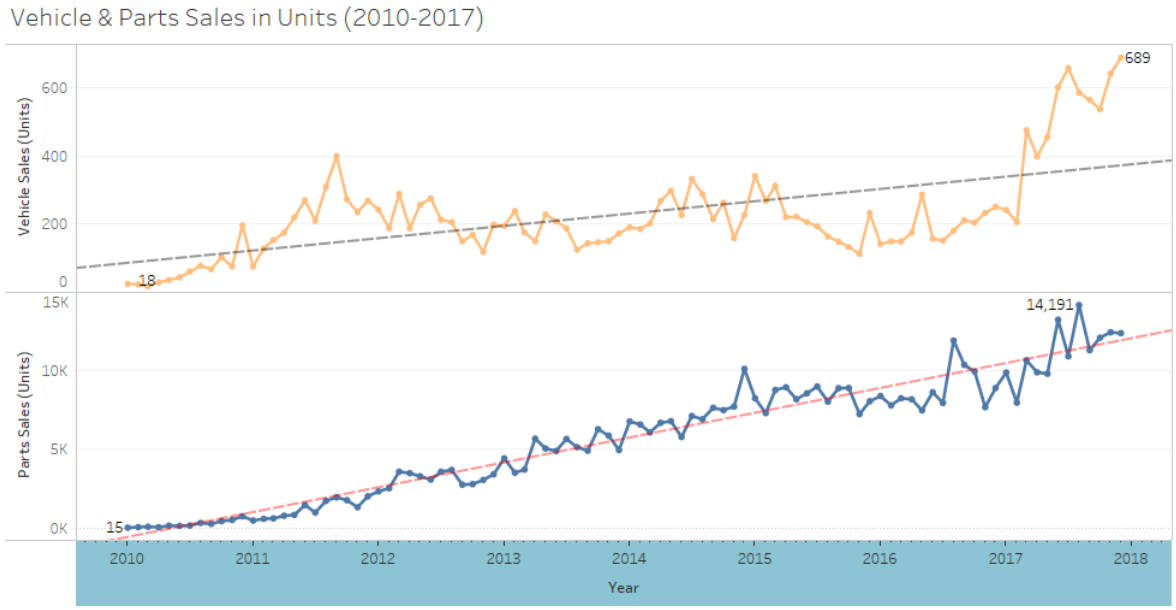


Figure 2.14. – Vehicles and Parts Volumes (2010-2018)

Source: Author's publication based on Ecuadorian Company Database

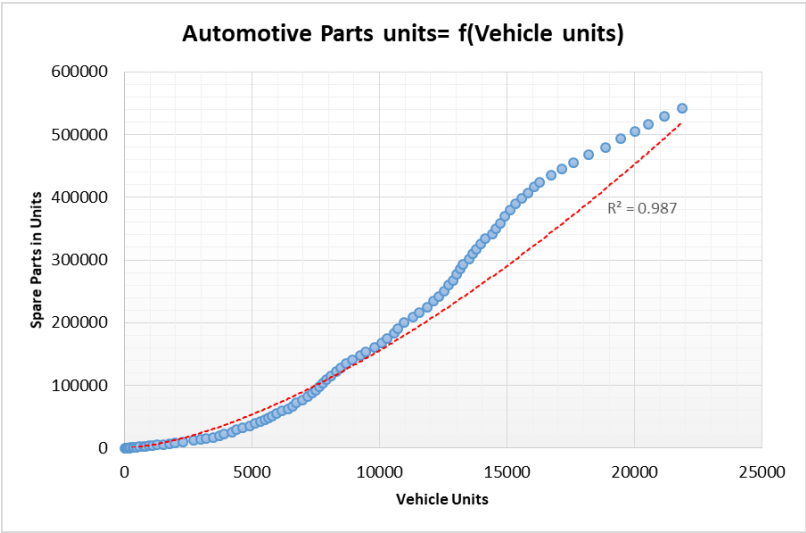


Figure 2.15. – Correlation obtained from Vehicles and Parts Sales of an Automotive brand with operation in Ecuador (2010-2018)

Source: Author's publication based on Ecuadorian Company Database

As it can be seen in last two pictures, the parts and vehicles trend deploys an almost a linear correlation reflecting the dependence of the parts in function of the vehicles volume.

2.5.4. Growing average age of vehicles

This significant trend in the automotive industry over the last 10 years has been the increase in average age of vehicles owned by consumers. Car owners are more likely to be on preventive maintenance and scheduled servicing, to prolong the lifetime value of their vehicles.

As a result, the aftermarket industry for automotive service has grown substantially, and represents a profitable and sometimes unexploited, opportunity for revenue.

Figure 2.16. – Average age of the EU vehicle fleet

Source: ACEA [4]

The rising average age of vehicles in EU reach a record about 11.4 years, projected growth in the light vehicle fleet and new light vehicle sales expected to exceed $15 million in 2014.

Since the 2008 economic recession that lead to Americans holding on to their aging vehicles a little bit longer, demand for new vehicles has been rising. Therefore, a parallel increase in maintenance opportunities for parts and components.

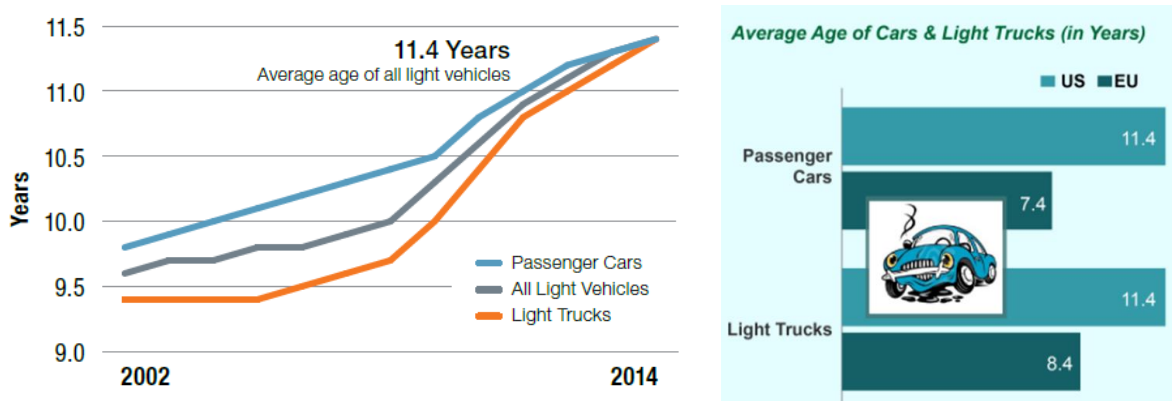


Figure 2.17. – Average age of cars in EU and US

Source: IHS Automotive, driven by Polk

2.5.5. Source of carmaker brand reputation

The term brand can be analysed from different perspectives and defined in various ways. There are also different valuation methods that can be used to assess the brand value, ad one of them it is the after-sales services offered to the new vehicle customers.

The functions of a brand already give a first indication of the enormous benefits of a fully established company brand.

A strong brand management also gives a company a competitive advantage over existing competitors. An overview of the advantages of a brand from the company perspective is provided in Fig. 2.18.

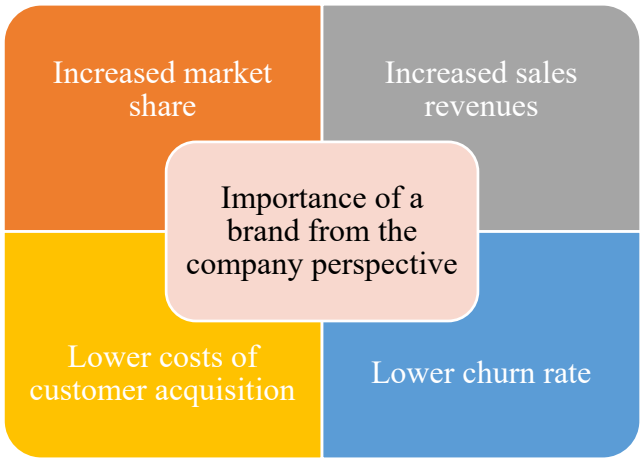


Figure 2.18. – Importance of a brand from the company perspective

Source: Diehlmann [9]

2.5.6. Source of competitive advantage in automotive market

Companies can benefit in several strategic ways by focusing on after-sales services. It will be a key differentiator for manufacturing companies and resellers.

After-sales is thus a potential source of competitive advantage for the firm (Armistead and Clark, 1992; Goffin, 1999). Therefore, most manufacturing companies are shifting from a traditional product-centric view into a more innovative customer-centric view.

Long-term relationship and life time value to the customer is new marketing trends (Gupta and Lehmann, 2007). Service quality plays a pivotal role in obtaining competitive advantage to the organization.

Globally, aftermarket volume, including retail sales, is growing rapidly and becoming increasingly important to automotive companies compared to new car sales due to the higher margins. As it can be seen in Figure 1.3, the Western European aftermarket is more or less flat, while attractive growth rates exist in emerging markets such as Eastern Europe. The average growth rate per year is estimated at about 1% in Western Europe, whereas in Eastern Europe it is about 5.3% per annum over the past seven years. Among Western European markets with a total aftermarket volume of approximately 165 billion euros.

2.6. The structure of the automotive aftermarket

The aftermarket is the part of the automotive industry sector comprising the automotive services and parts businesses. The service business (maintenance and repair of vehicles) generates about 45% of total aftermarket revenues in Europe, while retail and wholesale of vehicle parts make up the remaining around 55%. Together, the two businesses are an important part of the overall automotive industry as they deliver substantial revenue of approximately USD 760 bn globally (2015) or around 20% of total automotive revenues and higher profitability than most of the industry's other subsectors. [22]

2.7. Products and services

On the product side, aftermarket executives indicated that currently about half of revenues comes from wear-and-tear parts, followed by crash-relevant parts, diagnostics products, services, and other parts. Going forward, it is expected that the growth of wear and-tear parts will slow down due to increasing part quality, e-mobility, and price pressure. Similarly, crash rates will decrease as a result of enhanced safety. Although the higher use of sensors might increase the average cost of each single crash, in sum a decrease is expected. Instead, growth will come from diagnostics and services as new offerings emerge, many of which are linked to digitization and car data. Growth rates of the latter are expected to be approximately 3 percentage points above the average for the aftermarket as a whole.

Chapter 3 Introduction to automotive parts management

As automotive market matures, the potential of the after-sales market has started to be gradually realized. The spare parts business has become more strategically important and will become one of the key areas for future competition in the mature markets.

The spare parts business is considered the main driver to enhance customer satisfaction and generate repurchase opportunities: Spare parts operations is one of the key factors in ensuring favourable service levels for customers. As the proportion of additional sales and replacements has gradually increased, customers have begun paying more attention to the quality of after-sales services, which directly affect their purchase decisions. The importance of after-sales service and spare parts operations to overall automotive sales is becoming increasingly obvious.

3.1. Automotive parts and categories

Automotive parts are defined as either Original Equipment (OE), or aftermarket parts. Original equipment parts that are used in the assembly of a new motor vehicle (automobile, light truck, or truck) or are purchased by the manufacturer for its service network are referred to as Original Equipment Service (OES) parts. Suppliers of OE parts are broken into three levels. The first level is “Tier 1" suppliers who sell finished components directly to the vehicle manufacturer. The next level is “Tier 2" suppliers who sell parts and materials for the finished components to the Tier 1 suppliers. The third level is “Tier 3" suppliers who supply raw materials to any of the above suppliers or directly to vehicle assemblers. There is often overlap between the tiers. Original equipment production accounts for an estimated two-thirds to three-fourths of the total automotive parts production.

Aftermarket parts are divided into two categories:

- Replacement parts are automotive parts built or remanufactured to replace OE parts as they become worn or damaged.
- Accessories are parts made for comfort, convenience, performance, safety, or customization, and are designed for add-on after the original sale of the motor vehicle.

3.2. The shape of and size of auto parts inventories

Automotive replacement parts exhibit a huge range of popularity and demand potential. At the high end of the scale are a few very high volume items like motor oil. At the other end of the scale are many parts that each fit a very small universe of vehicles, and rarely require replacement.

A fact of life in the automotive parts business is that there has been a huge proliferation of items, and many have very small demand potential.

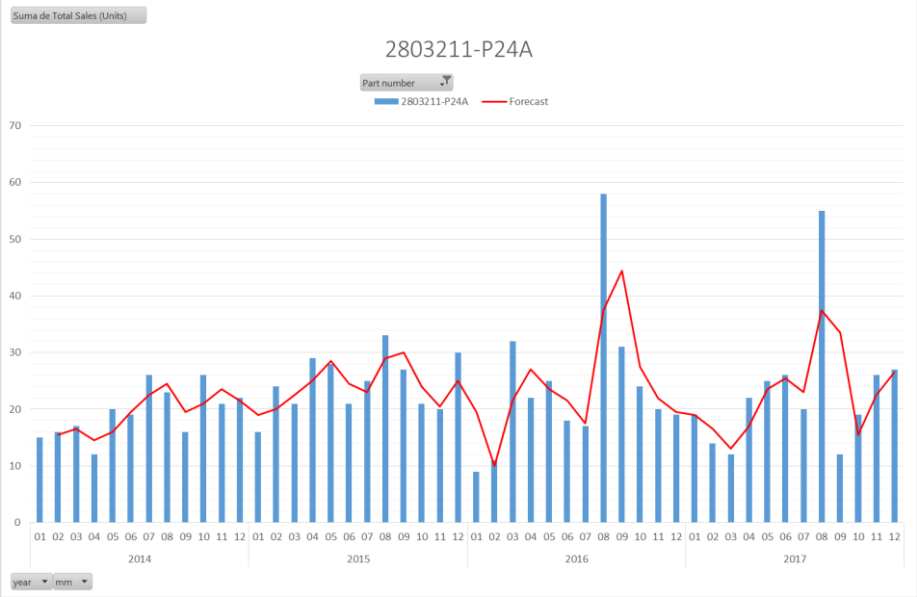


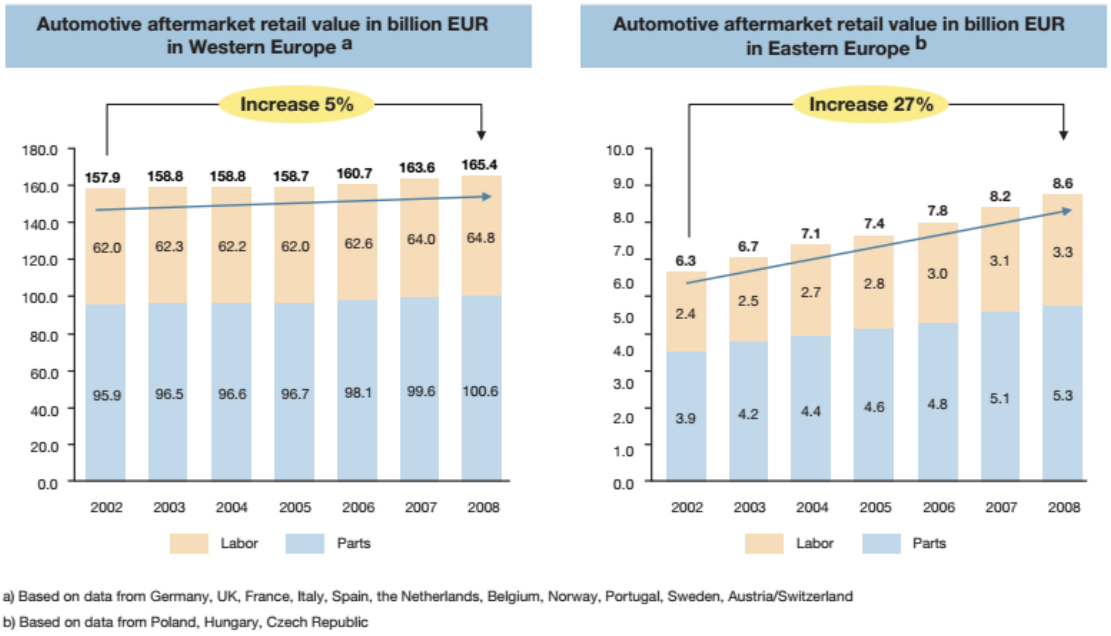
Figure 3.1. – Time series of a typical behaviour a spare parts with high demand

Source: Author's publication based on Ecuadorian Company Database

3.3. Contribution and importance of the spare parts in the after-sales services.

Globally, aftermarket volume, including retail sales, is growing rapidly and becoming increasingly important to automotive companies compared to new car sales due to the higher margins. As it can be seen in Figure 3.2, the Western European aftermarket is more or less flat, while attractive growth rates exist in emerging markets such as Eastern Europe. The average growth rate per year is estimated at about 1% in Western Europe, whereas in Eastern Europe it is about 5.3% per annum over the past seven years. Among

Western European markets with a total aftermarket volume of approximately 165 billion euros. [10]



a) Based on data from Germany, UK, France, Italy, Spain, the Netherlands, Belgium, Norway, Portugal, Sweden, Austria/Switzerland

b) Based on data from Poland, Hungary, Czech Republic

Figure 3.2. – Contribution of parts and labour in aftermarket

Source: [10]

Chapter 4 Best technical and management practices in Parts Departments

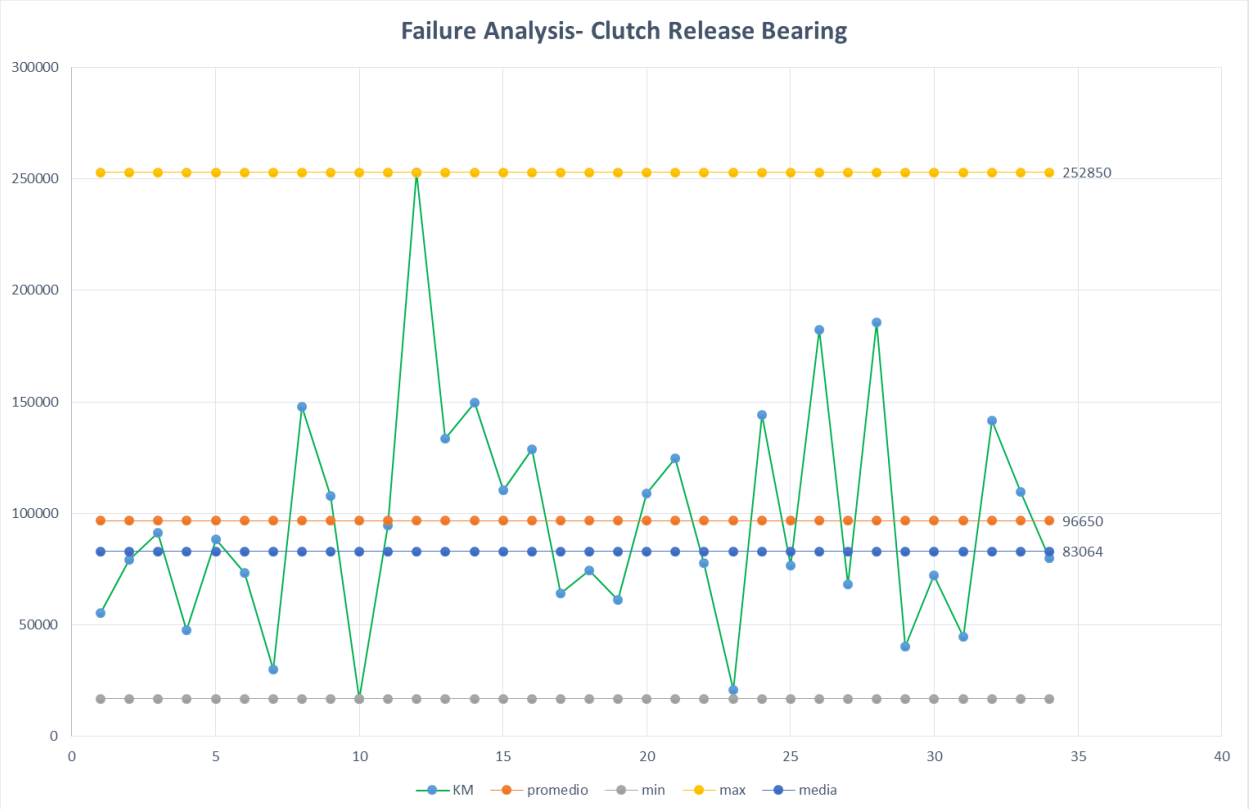
Auto parts business need to make sure that their parts inventory matches the vehicles in operation (VIO) trends and their part failure rate trends if they want their business to succeed. As well as the typical and more likely part that is used in the after-sales services workshops. In fact, in below lines will be discuss in detail these keys points in ordet to get a good performance of a spare parts business.

4.1. Failures Analysis of frequent automotive parts.

One of the main points that it can be suggested , it is the failure analysis of automotive parts that are frequently used and changed in corrective tasks in the workshops of the automotive dealers.

The analysis could be executed by means of work order data of all customers that attend for repair activities or warranty claims.

The approach will be done by Weibull analysis, as it can be showed for a release bearing.



i	VIN	t	PDF	Reliability R(	Failure F(t
10	8L4DBC178GC000367-2	16908	2.30487E-06	0.981646628	0.01835337
23	8L4DBC172GC000428	20695	2.87489E-06	0.971838607	0.02816139
7	LGWDBC179BB618280	30000	4.24495E-06	0.938657406	0.06134259
29	8L4DBC178FC000206	40349	5.63135E-06	0.887384775	0.11261523
31	8L5CBC179DC000042	44790	6.15798E-06	0.861189011	0.13881099
4	LGWDBC176DC619125	47797	6.48634E-06	0.84217227	0.15782773
1	LGWEFCA50BB600953	55453	7.20759E-06	0.789642492	0.21035751
19	8L4CBC171GC000495	61104	7.62526E-06	0.747684601	0.2523154
17	8L4DBC176GC000478	64243	7.81291E-06	0.723445972	0.27655403
27	8L4DBC178EC000107	68124	8.0002E-06	0.692744573	0.30725543
30	8L5CBC179DC000056	72254	8.14494E-06	0.659385537	0.34061446
6	LGWDBC171DC601986	73467	8.1768E-06	0.649485919	0.35051408
18	8L4DBC17XGC000452	74563	8.20146E-06	0.640510275	0.35948973
25	8L4DBC174EC000072	76725	8.23871E-06	0.622735731	0.37726427
22	8L4DBC175EC000002	77879	8.25246E-06	0.613219916	0.38678008
2	LGEDBC179BB618280	79306	8.26362E-06	0.601434933	0.39856507
34	LGWDBC170CC609513	80095	8.26704E-06	0.59491346	0.40508654
5	LGWDBC179DC603646	88353	8.18988E-06	0.526823703	0.4731763
3	8L5CBC175DC000037	91297	8.11512E-06	0.502816958	0.49718304
11	8L4DBC176FC000169	94512	8.00733E-06	0.476893018	0.52310698
9	8L4DBC171FC000175	107941	7.30325E-06	0.373671937	0.62632806
20	LGWDBC174DC644766	108957	7.23597E-06	0.366285873	0.63371413
33	LGWDBC178EC602022	109717	7.18458E-06	0.360806008	0.63919399
15	8L4DBC170GC000394	110379	7.13909E-06	0.356064836	0.64393516
21	8L4DBC179FC000151	124624	6.03476E-06	0.261990068	0.73800993
16	8L4DBC178GC000367	128842	5.67769E-06	0.237285813	0.76271419
13	8L4DBC174FC000185	133647	5.26443E-06	0.210995751	0.78900425
32	8L5CBC175DC000037-2	141619	4.57909E-06	0.171765946	0.82823405
24	LGWDBC176DC644767	144156	4.36435E-06	0.16042172	0.83957828
8	8L4CBC176EC000182	147807	4.06045E-06	0.145044299	0.8549557
14	LGWCBC17XDC615607	149727	3.9036E-06	0.137399165	0.86260084
26	LGWDBC371BB601066	182466	1.71671E-06	0.048199401	0.9518006
28	LGWEFCA54BB600955	185456	1.57067E-06	0.043287063	0.95671294
12	LGWCBC178DC654471	252850	1.15827E-07	0.002239716	0.99776028

Weibull Computations:

n	34
Sum(ln(t))	385.130338
x	11.3273629
Sum([ln(t)-x]2)	11.818475
S^2	0.35813561
S=σ	0.59844432
β	2.14313978
α	108736.995
γ	0
p	50%
tp	91644.3451

4.2. Main typical parts used in the after-sales services.

By means of the registers either in maintenance and inventory, there is an US association that suggest the main parts required and need in the inventory of a parts warehouse. They are listed below

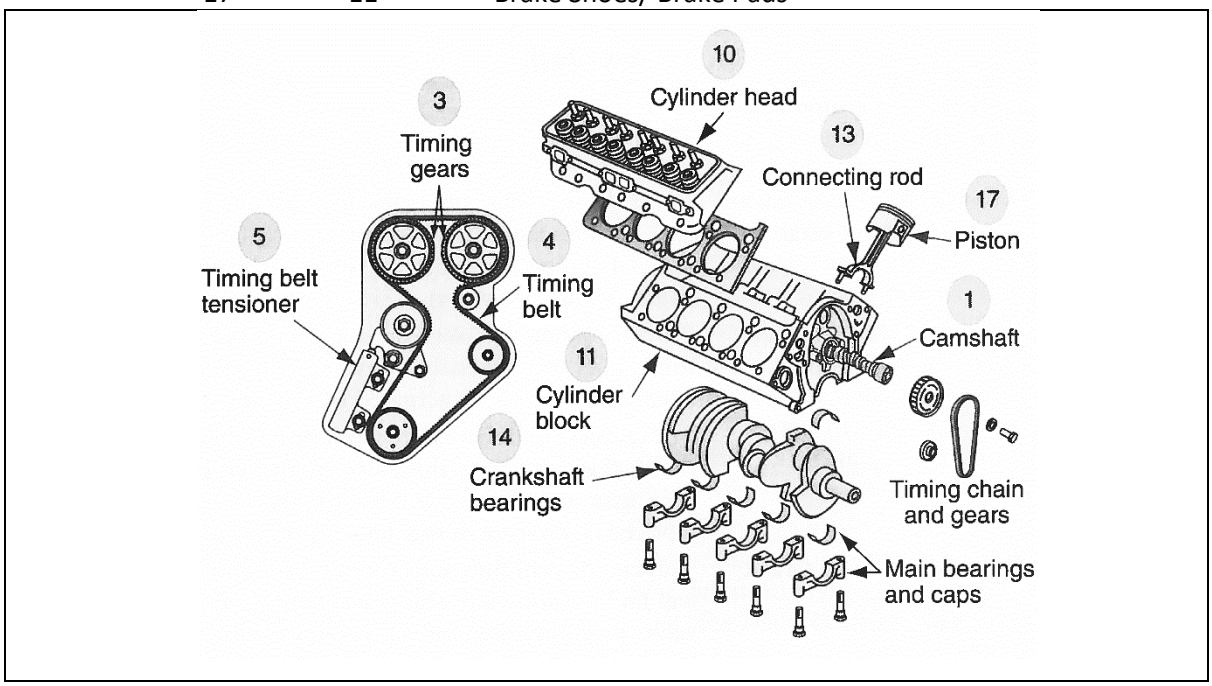
System Number	System Name
1	Engine Mechanical Parts- Valve Train
2	Engine Mechanical Parts- Short Block Assembly
3	Engine Cooling System
4	Engine Intake System
5	Engine Fuel System
6	Engine Ignition System- w/ Distributor
7	Engine Ignition System- Distributorless
8	Engine Exhaust System
9	Engine Emissions Control System (PCV, EGR, EVAP)
10	Manual Transmission- Transaxle
11	Manual Transmission- Clutch Assembly
12	Automatic Transmission- Transaxle
13	Drive Trainline- CV Axle
14	Drive Trainline- Conventional axle
15	Drive Trainline- Differential
16	Drive Trainline- 4WD Transfer case
17	Brake system
18	Suspension and Steering System
19	Heating, Ventilation and Air Conditioning (HVAC)
20	Electric Systems- Generation, Storage, Distribution, and Starting
21	Electronic Control Systems

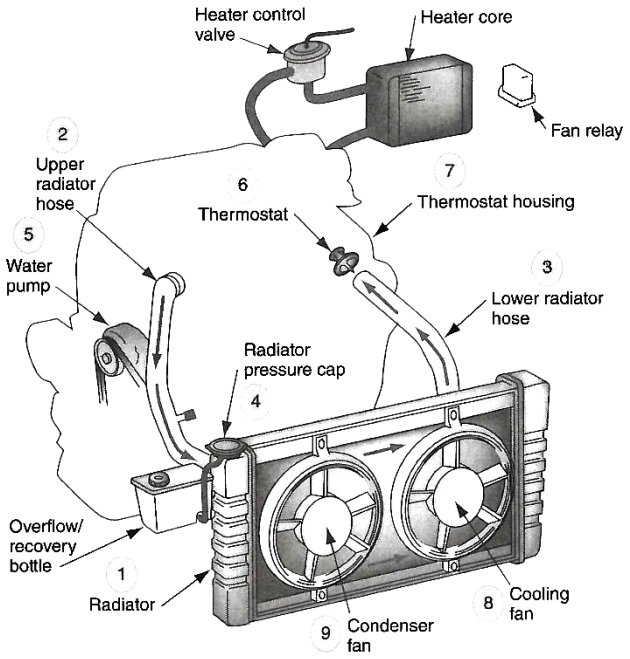
System	Figure Number	Component Name
1	1	Camshaft
1	2	Intake valve
1	3	Exhaust valve

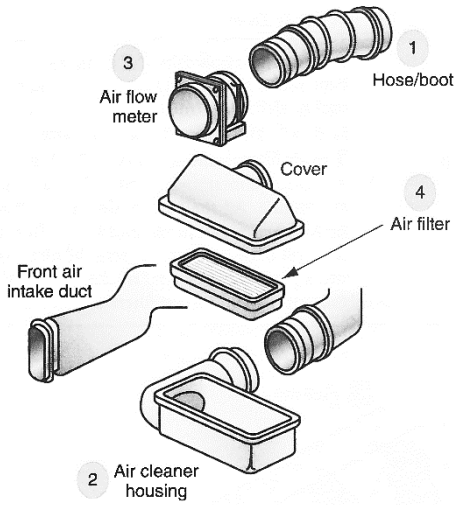
1	4	Timing Gear
1	5	Timing Belt/ Chain
1	6	Timing Belt Tensioner
1	7	Camshaft Pulley Seals
1	8	Front Crank Seal
1	9	Valve Springs
1	10	Valve Retainers
1	11	Timing Cover
1	12	Valve Cover
1	13	Cylinder head
2	1	Cylinder Block
2	2	Crankshaft
2	3	Connecting Rod
2	4	Crankshaft Bearings
2	5	Oil Pump
2	6	Rear main seal
2	7	Piston
2	8	Piston rings
3	1	Radiator
3	2	Upper Radiator Hose
3	3	Lower Radiator Hose
3	4	Radiator Pressure Cap
3	5	Water Pump
3	6	Thermostat
3	7	Thermostat Housing
3	8	Cooling Fan
3	9	Condenser Fan
3	10	Fan Clutch
3	11	Heater Core
3	12	Overflow/Recovery Bottle
4	1	Air Intake Hose/Boot
4	2	Air Cleaner Housing
4	3	Air Flow Meter
4	4	Air Filter
5	1	Fuel Rail
5	2	Fuel Filter
5	3	Fuel Pressure Regulator
5	4	Fuel Injector
5	5	Fuel Pump
5	6	Rollover Valve
5	7	Fuel Tank
5	8	PCV Valve
5	9	Carburetor
6	1	Distributor Cap
6	2	Distributor Rotor
6	3	Spark Plug

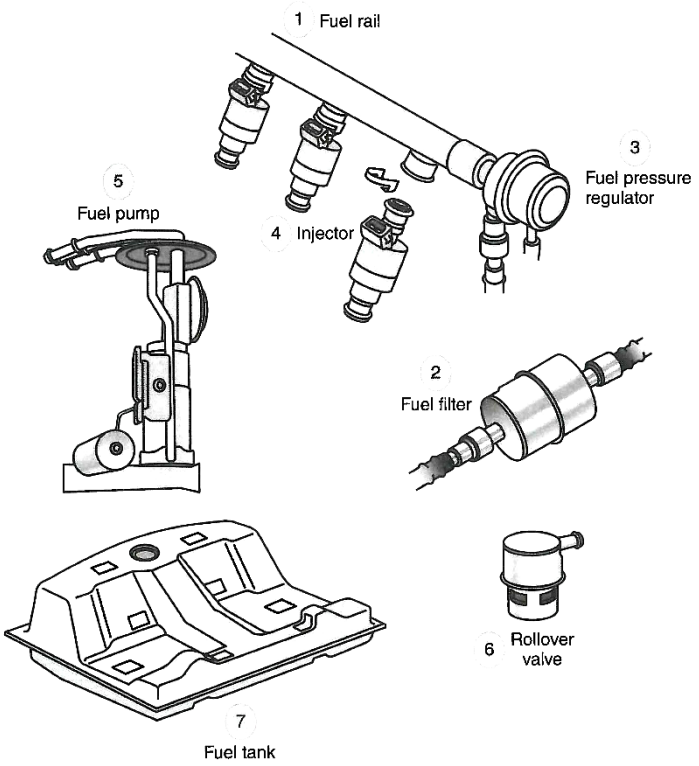
6	4	Thick Film Ignition(TFI) Module
6	5	Distributor Assembly
6	6	Ignition Coil
7	1	Powertrain/Engine Control Module (PCM/ECM)
7	2	Spark Plug
7	3	Ignition Module
7	4	Ignition Coil Pack
7	5	Crankshaft Position Sensor (CKP)
7	6	Camshaft Position Sensor (CMP)
8	1	Catalytic Converter
8	2	Exhaust Head Pipe
8	3	Resonator
8	4	Intermediate Pipe
8	5	Muffler
8	6	Tail Pipe
8	7	Heated Exhaust Oxigen Sensor (H-EGO)
9	1	Positive Crankcase Ventilation (PCV) Valve
9	2	Charcoal Canister
9	3	Canister Purge Valve
9	4	Exhaust Gases Recirculation (EGR)Valve
9	5	EGR Vacuum Solenoid
10	1	Transaxle Case
10	2	Clutch Lever
10	3	Shift Forks
10	4	Differential
10	5	Cover
11	1	Clutch Disc
11	2	Flywheel
11	3	Flywheel Ring Gear
11	4	Pressure Plate
11	5	Throw-Out/Release Bearing
11	6	Slave Cylinder
11	7	Release Fork
11	8	Clucth Cable
12	1	Torque Converter
12	2	Front Hydraulic Pump
12	3	Planetary
12	4	Transmission/Transaxle Case
12	5	Valve Body
12	6	Side Cover
12	7	Oil Dipstick
12	8	Pan and Filter
12	9	Differential
13	1	Inner CV Joint
13	2	CV Boot
13	3	Axle Shaft

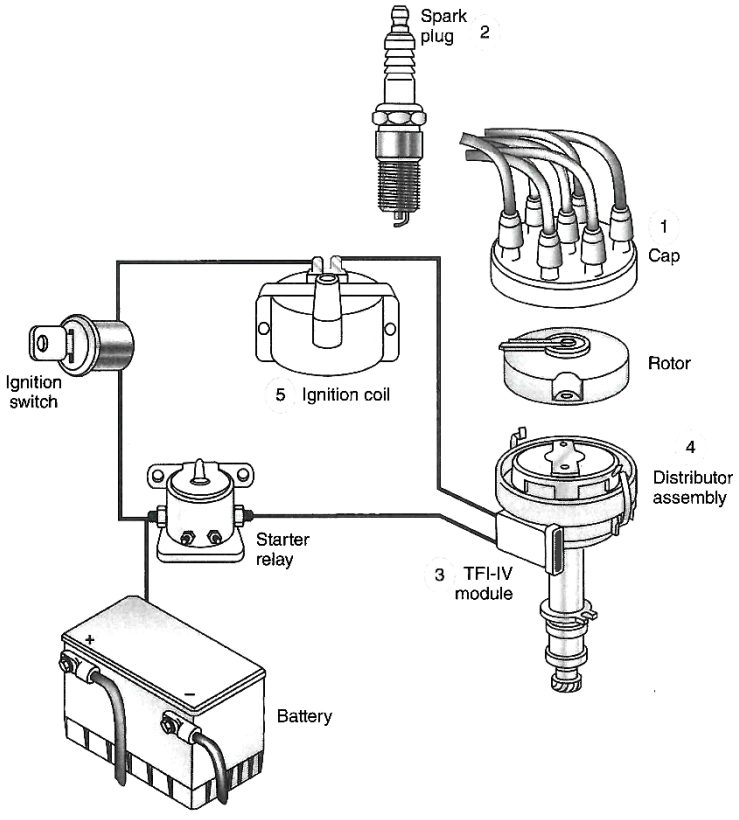
13	4	Outer CV Joint
14	1	Companion Flange
14	2	Drive Shaft
14	3	Universal Joint
15	1	Differential
15	2	Drive Pinion & Ring Gear
16	1	Input and Front Output Shafts
16	2	Rear Output Shaft
16	3	Drive Chain
16	4	Shifting Mechanism
17	1	Brake Hose
17	2	Brake Line
17	3	Brake Caliper
17	4	Brake Rotor/Disk
17	5	Caliper Housing
17	6	Caliper Piston
17	7	Slide Bolts
17	8	Drum Backing Plate
17	9	Park Brake Cable
17	10	Wheel Cylinder
17	11	Brake Shoes/ Brake Pads

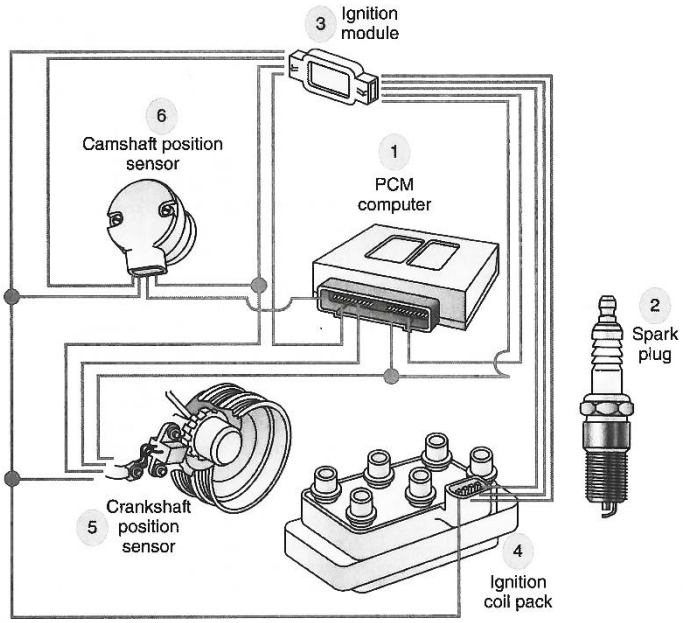


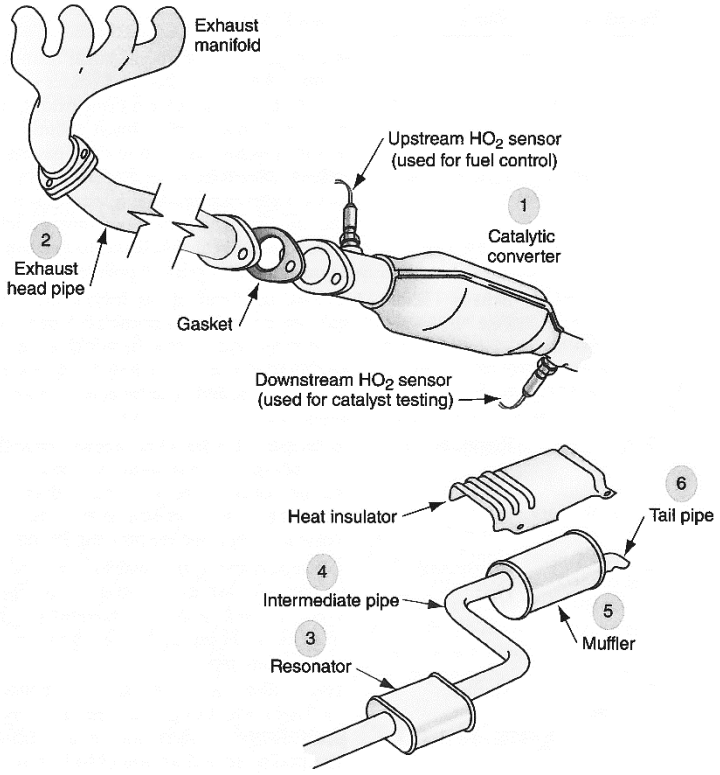

Heater control valve
Heater core
Fan relay
2
Upper radiator hose
6
Thermostat
7
Thermostat housing
5
Water pump
3
Lower radiator hose
Radiator pressure cap
4
Overflow/ recovery bottle
1
Radiator
9
Condenser fan
8
Cooling fan


3
Air flow meter
1
Hose/boot
Cover
4
Air filter
Front air intake duct
2
Air cleaner housing

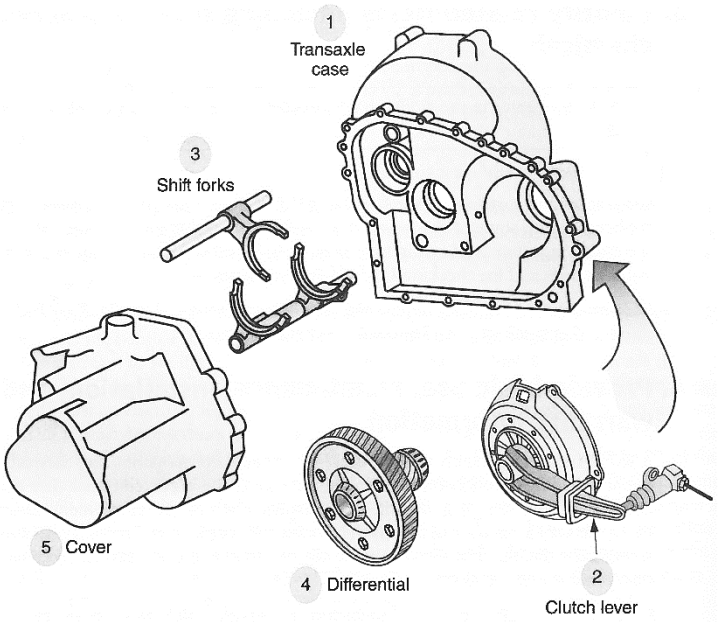

1 Fuel rail
3 Fuel pressure regulator
5 Fuel pump
4 Injector
2 Fuel filter
6 Rollover valve
7 Fuel tank

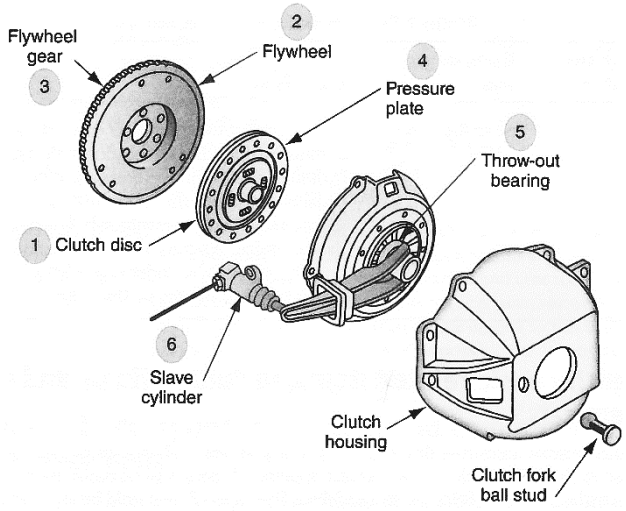

Spark plug 2
1 Cap
Rotor
Ignition switch
5 Ignition coil
4 Distributor assembly
Starter relay
3 TFI-IV module
Battery

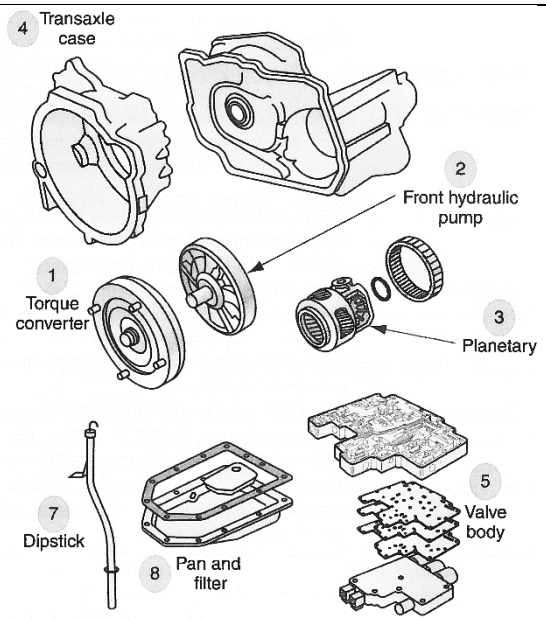

3 Ignition module
6 Camshaft position sensor
1 PCM computer
2 Spark plug
5 Crankshaft position sensor
4 Ignition coil pack

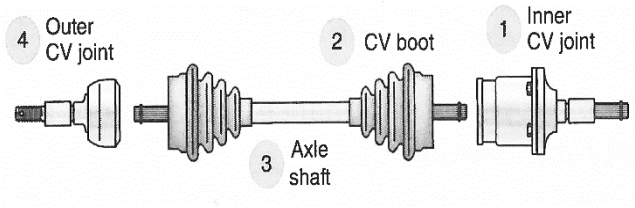

Exhaust manifold
Upstream HO_2 sensor (used for fuel control)
1 Catalytic converter
2 Exhaust head pipe
Gasket
Downstream HO_2 sensor (used for catalyst testing)

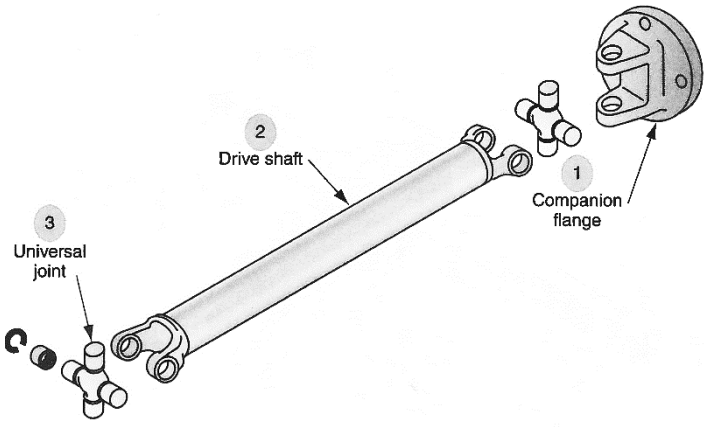
Heat insulator
6 Tail pipe
4 Intermediate pipe
5 Muffler
3 Resonator

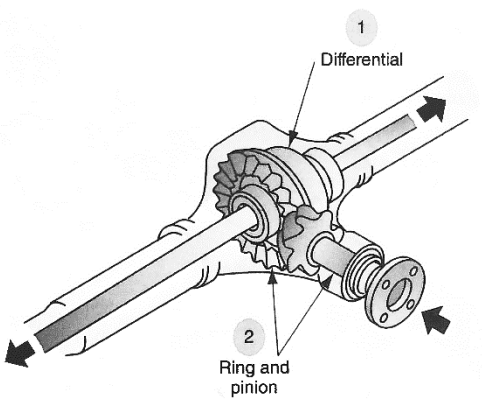

1
Transaxle case
3
Shift forks
5 Cover
4 Differential
2
Clutch lever

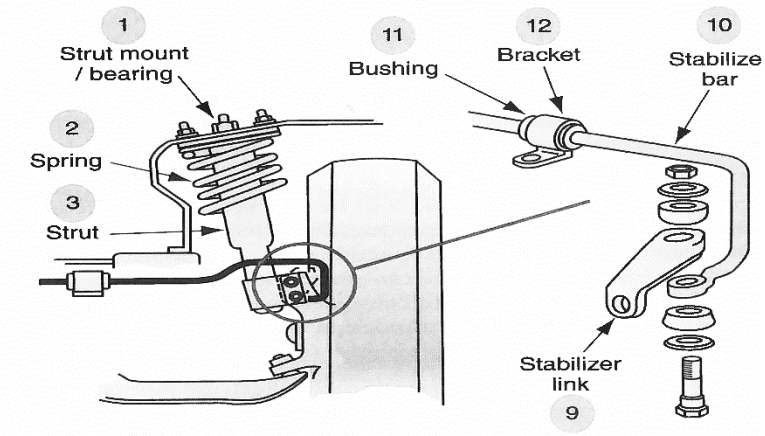

2
Flywheel
Flywheel gear
3
4
Pressure plate
5
Throw-out bearing
1 Clutch disc
6
Slave cylinder
Clutch housing
Clutch fork ball stud


4 Transaxle case
2 Front hydraulic pump
1 Torque converter
3 Planetary
5 Valve body
7 Dipstick
8 Pan and filter

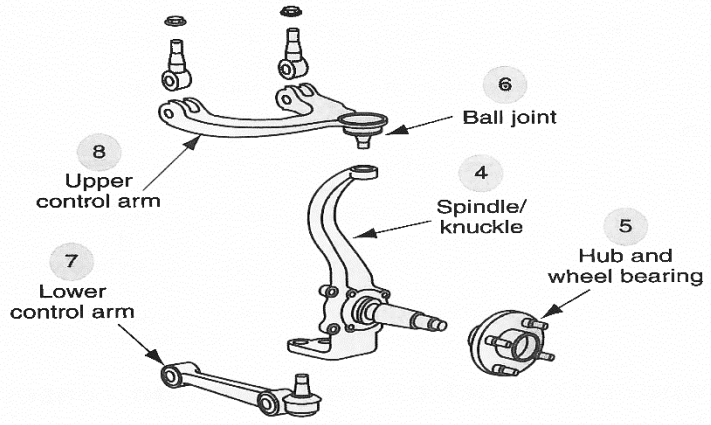

4 Outer CV joint
2 CV boot
1 Inner CV joint
3 Axle shaft


2 Drive shaft
1 Companion flange
3 Universal joint

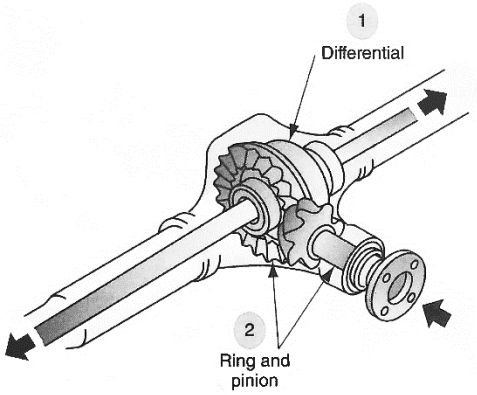


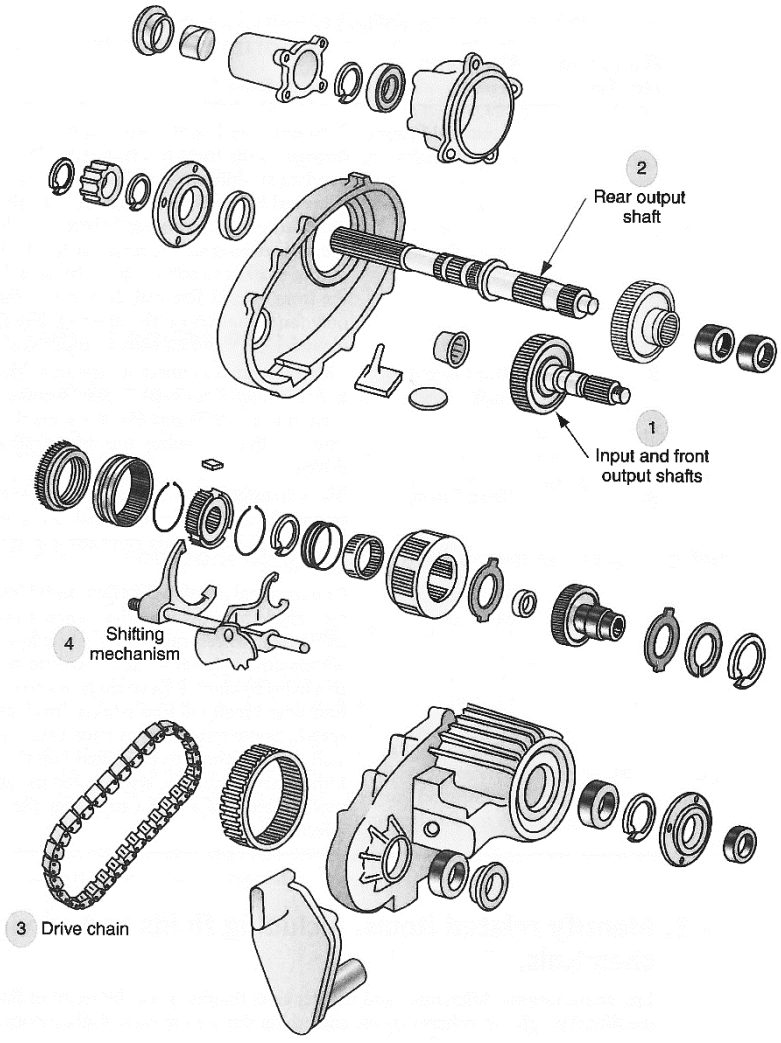


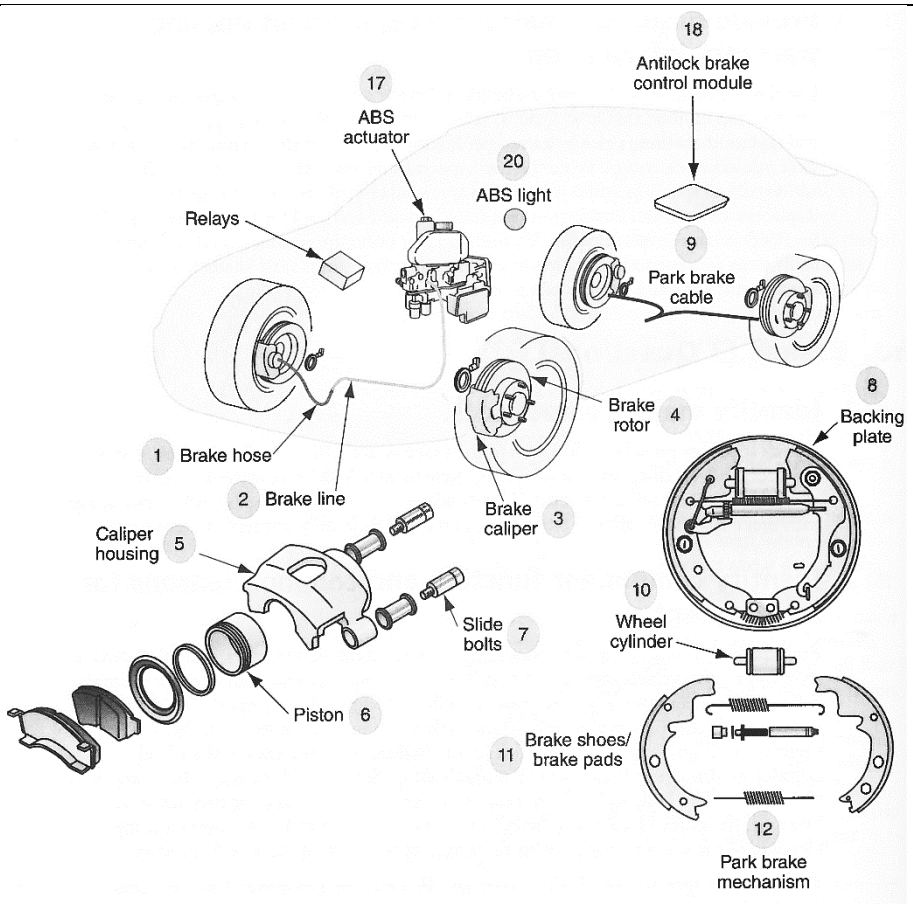
McPherson strut suspension

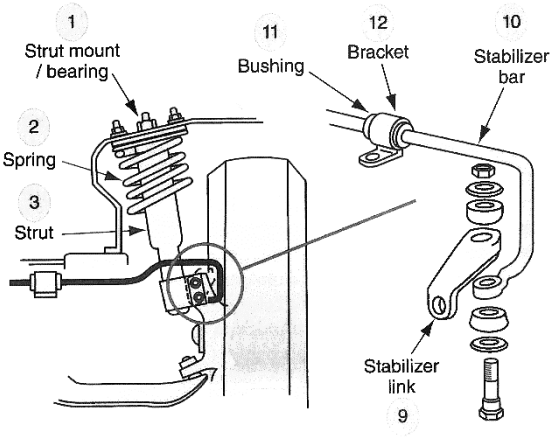


SLA suspension

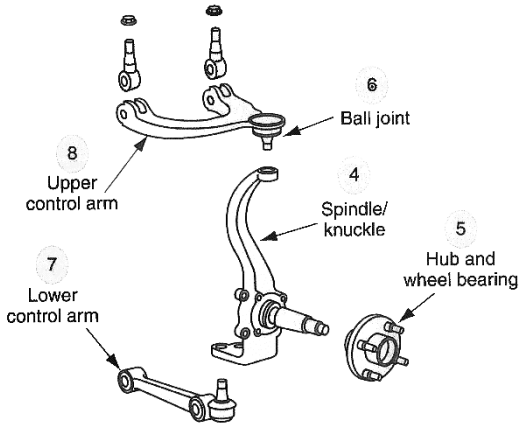

1
Differential
2
Ring and
pinion


2
Rear output
shaft
1
Input and front
output shafts
4
Shifting
mechanism
3
Drive chain

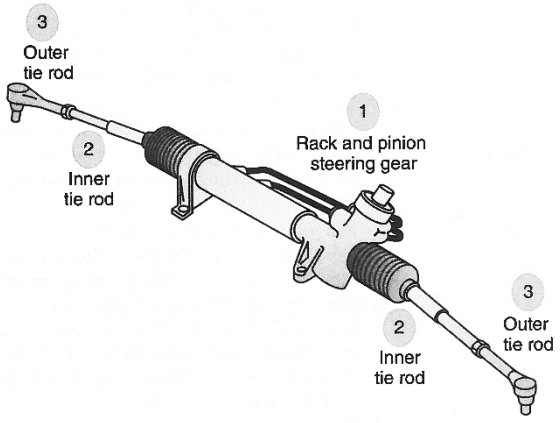

18
Antilock brake control module
17
ABS actuator
20
ABS light
Relays
9
Park brake cable
Brake rotor 4
8
Backing plate
1 Brake hose
2 Brake line
Brake caliper 3
Caliper housing 5
10
Wheel cylinder
Slide bolts 7
Piston 6
11 Brake shoes/ brake pads
12
Park brake mechanism

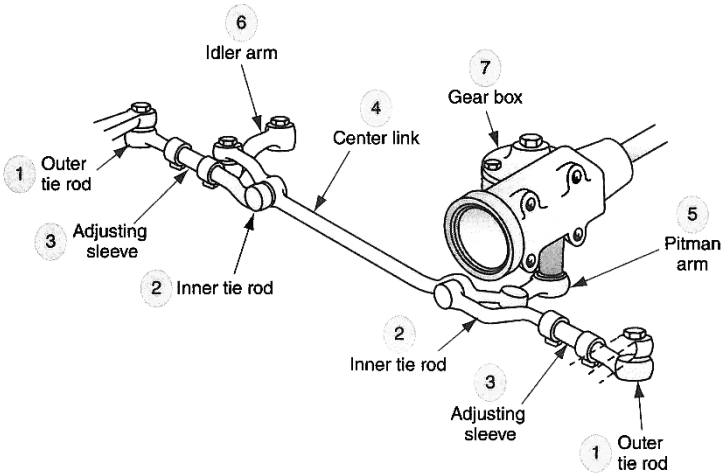


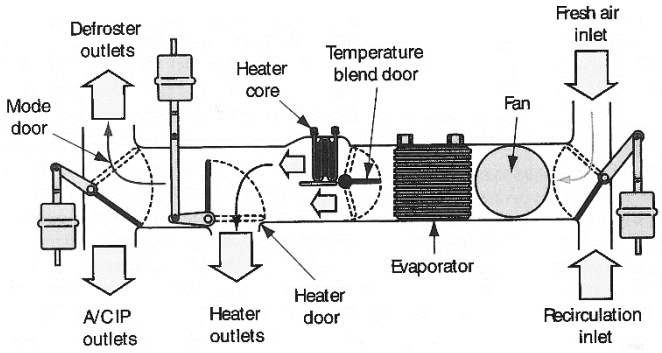
McPherson strut suspension



SLA suspension




6
Idler arm
7
Gear box
4
Center link
1
Outer
tie rod
3
Adjusting
sleeve
2
Inner tie rod
5
Pitman
arm
2
Inner tie rod
3
Adjusting
sleeve
1
Outer
tie rod


Defroster
outlets
Heater
core
Temperature
blend door
Fresh air
inlet
Mode
door
Fan
Evaporator
A/C
outlets
Heater
outlets
Heater
door
Recirculation
inlet

Conclusions

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Appendix A.- Motorization rate / 1000 habitants

Appendix B. - Worldwide automobile production from 2005 to 2016