

## **Louvain School of Management**

# Current and future situation of obsolescence in the automotive industry

Master thesis

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# Contents

Introduction .....	1
Part 1: Obsolescence .....	3
1.1 Why did obsolescence develop in our society? .....	3
1.2 What is obsolescence? .....	4
1.3 How is obsolescence used to limit the lifetime of a product? .....	5
1.3.1 Economic obsolescence .....	6
a. Cost of repair .....	6
b. Purchase subsidy mechanisms .....	6
1.3.2 Social (psychological) obsolescence.....	7
a. Psychological obsolescence due to the consumer .....	7
b. Marketing strategies .....	7
1.3.3 Technological obsolescence.....	8
a. Functional defect .....	8
b. Software obsolescence .....	9
c. Indirect obsolescence.....	9
d. Obsolescence by notification .....	10
e. Sophistication .....	10
1.3.4 Ecological obsolescence .....	11
1.3.5 Conclusion .....	11
1.4 Consequences of obsolescence .....	11
1.4.1 Economic consequences of obsolescence .....	12
1.4.2 Social consequences of obsolescence .....	12
1.4.3 Technological consequences of obsolescence .....	13
1.4.4 Ecological consequences of obsolescence .....	13
1.4.5 Conclusion .....	14
1.5 Who is responsible for obsolescence? .....	14
1.6 Solutions against obsolescence.....	16
1.7 Legislation regarding obsolescence.....	18
1.8 Future of obsolescence .....	20
1.9 Conclusion.....	20
Part 2: Overview of the automotive industry .....	22
2.1 Figures about the automotive industry .....	22
2.2 Automotive value chain analysis and key players.....	22

2.3	Automotive trends .....	24
2.3.1	The connected car .....	25
2.3.2	The autonomous car .....	25
2.3.3	The electric car .....	27
2.3.4	Shared mobility .....	28
2.4	Conclusion .....	28
Part 3:	Qualitative research .....	29
3.1	The problem and research questions .....	29
3.2	Methodology .....	29
3.2.1	Choice of qualitative approach .....	29
3.2.2	Choice of sample .....	30
3.2.3	Method of collecting information .....	31
3.2.4	Method to analyze information .....	32
3.3	Conclusion .....	33
Part 4:	Analysis of the results .....	34
4.1	Current situation of obsolescence in the automotive industry .....	34
4.1.1	Indicators of the presence or absence of obsolescence .....	34
4.1.2	Economic obsolescence .....	37
a.	Cost of repair .....	37
b.	Purchase subsidy mechanisms .....	40
4.1.3	Social obsolescence .....	42
a.	Psychological obsolescence due to the consumer .....	42
b.	Marketing strategies .....	43
4.1.4	Technological obsolescence .....	46
a.	Functional defect .....	46
b.	Software obsolescence .....	49
c.	Indirect obsolescence: availability of spare parts .....	49
d.	Obsolescence by notification .....	51
e.	Sophistication .....	52
4.1.5	Ecological obsolescence .....	54
4.1.6	Legal obsolescence .....	56
4.1.7	Conclusion .....	57
4.2	Future situation of obsolescence in the automotive industry .....	59
4.2.1	How will connectivity impact the situation of obsolescence? .....	59
4.2.2	How will autonomous cars impact the situation of obsolescence? .....	62

4.2.3	How will electric vehicles impact the situation of obsolescence? .....	64
4.2.4	How will shared mobility & service impact the situation of obsolescence? .....	68
4.2.5	Interdependencies between trends .....	71
4.2.6	Conclusion .....	73
4.3	Case study: XYT .....	75
4.4	Conclusion .....	75
	Conclusion.....	78
	Bibliography.....	81
	Appendix .....	90
	Appendix 1: Legislation regarding obsolescence .....	90
	a. Laws regarding obsolescence at the European level .....	90
	b. Laws regarding obsolescence in Belgium .....	91
	Appendix 2: Mobility service providers definition .....	95
	Appendix 3: European aftermarket landscape .....	96
	Appendix 4: Categories of experts interviewed and information about interviewees.....	97
	Appendix 5: Codes used in <i>Dedoose</i> .....	99
	Appendix 6: Percentage of inhabitants buying a new vehicle between 2005 and 2016.....	101
	Appendix 7: Average age of the European vehicle fleet by country in 2015 .....	102
	Appendix 8: Purchase and tax incentives for electric vehicles in the European Union ....	103
	Appendix 9: CO <sub>2</sub> emissions from production from 2007 to 2016.....	104
	Appendix 10: Euro standards .....	105
	Appendix 11-44: Transcripts .....	106





## Introduction

Initially, obsolescence means a product's wearing out. At some point, every product falls into disuse. However, products can become out-of-date in many other ways too. For instance, a consumer might discard his existing smartphone because he finds repair too costly compared to the price of a new one. He might also decide to replace his existing smartphone because a new one came out, which makes its current smartphone outmoded (ADEME, 2012). Products might thus be discarded although they are still functional. Moreover, the term "*planned obsolescence*" goes even further, by assuming that the product was intended to become obsolete faster (Dalhammar & Maitre-Ekern, 2016).

Obsolescence has been analyzed extensively in recent years (Brönneke, 2017). Much attention has been paid to the smartphone, computers, and the home appliances sector. In the automotive industry, a common example is the type of obsolescence invented by General Motors. In 1920s, General Motors used a strategy to outperform its competitor Ford, based on aesthetical modifications of its car models. *"Instead of waiting for technological innovations that would push consumers to trade in their older-model cars, General Motors turned to sleek styling as a way of making newer cars more desirable and pulling potential buyers into the showroom"* (Slade, 2006, p. 4). But, how has it all evolved since the 1920s? Are there other forms of obsolescence present in this industry? Is the automotive industry a sector not affected by obsolescence?

Except for the example of General Motors, which indicates the presence of obsolescence in the automotive industry already in the 1920s, there has been little empirical research on obsolescence applied in this sector. We find it interesting to consider the automotive sector as it plays an important role in our society. It is an essential sector for Europe, as it provides employment, contributes to the Gross Domestic Product and is strongly connected with other industries (European commission, 2018). In 2017, there were 573 vehicles per 1000 inhabitants of the European Union, which demonstrates a high motorization rate (European Automobile Manufacturers Association, 2017). Besides, cars are durable goods that represent a high involvement decision, unlike electronics and the households appliances industry. It would thus be of interest to evaluate if obsolescence is currently present in this industry and uncover the reasons that would suggest its absence or presence.

Furthermore, according to many studies, the automotive industry is at a crucial crossroads in its history, with four trends shaping its future. The future car would be connected,

autonomous, electrified and shared among people (Cathles, Corwin, Kelly, & Vitale, 2015; PWC, 2018). Therefore, it is interesting to assess whether these trends will impact obsolescence. How will each trend influence the current state of obsolescence? Will these trends drive it in the same direction or will they have opposite consequences?

The purpose of this thesis is to understand the current situation of obsolescence in the automotive industry as well as its future situation. It leads to the following research questions:

- What is the current state of obsolescence in the automotive industry?
- How will obsolescence in the automotive industry evolve in the future, with regard to connected car, autonomous car, electric car and shared mobility?

To answer these questions, we conducted 35 semi-structured interviews. Our contribution is to raise arguments made in these interviews that would indicate the presence or absence of obsolescence, both now and in the future.

The thesis is composed of four main parts, as illustrated in figure 1.

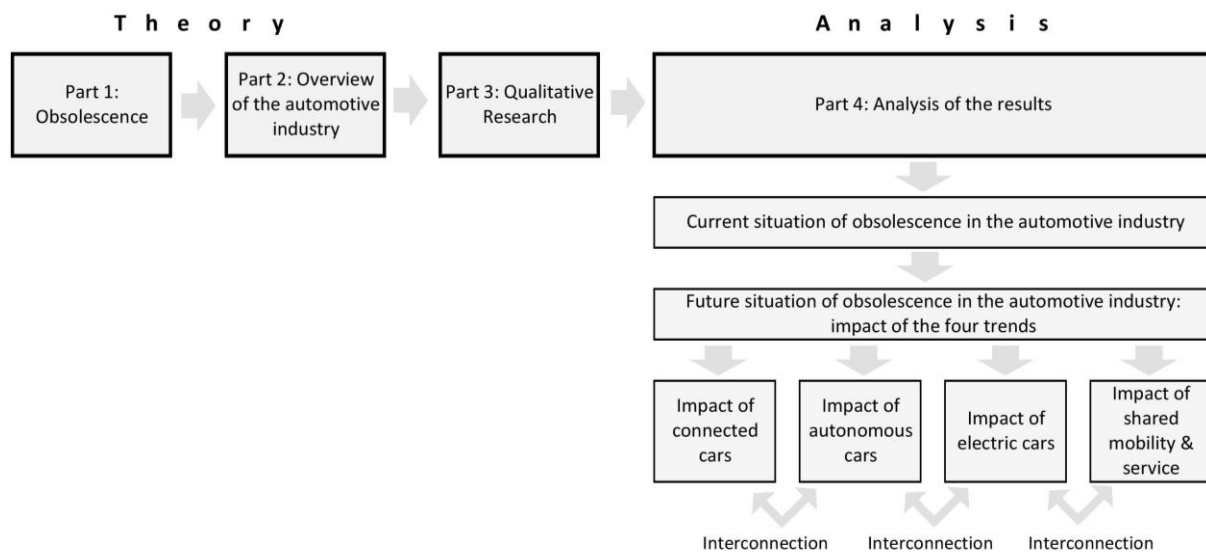


Figure 1: structure of the thesis

In the first two parts, we review the literature to present the two main topics of this thesis. The first part aims at introducing the concept of obsolescence and uncover each type of obsolescence. Then, we describe the automotive industry and the four trends that have the potential to transform this industry in the future. In the next part, we explain the research and the methodology followed to analyze the phenomenon. These three parts eventually lead to the analysis, which presents our research findings. This part is divided into two sub-analyses. We first assess whether obsolescence is present in this industry and then, we portray the future state of obsolescence by analyzing the impact of each trend.

## Part 1: Obsolescence

In this part, we analyze what has already been covered by the literature about obsolescence. Firstly, we explain the reasons underlying obsolescence, by identifying the forces that led to the emergence of this practice. Then, for a better understanding of the concept, we discuss what obsolescence is and draw the distinction from planned obsolescence, before explaining how exactly it is used in practice. After that, we analyze both positive and negative impacts of obsolescence. The question of responsibility for this practice is asked before reviewing all the possible solutions. Then, we analyze what already exists in terms of legislation on obsolescence. Finally, we review the different opinions about the future of obsolescence.

### 1.1 Why did obsolescence develop in our society?

The main reasons underlying obsolescence mentioned in the literature concerns planned obsolescence. The major and obviously reason why this practice exists is the pursuit of profit, particularly in mature industries where companies are struggling to ensure a high sales growth rate (Guiltinan, 2009; Aladeojebi, 2013). In this perspective, Guiltinan (2009) argues that creating long-lasting products did not seem an efficient strategy for firms, as it does not induce a repeat purchase process and therefore, results in a slowdown of sales growth rate. Conversely, goods with short economic life stimulate revenues to compete with other companies while also satisfying shareholders. Brouillat (2015) goes further by explaining that because markets were saturated, companies needed to continuously improve their products or introduce new ones if they wanted to remain profitable. Competition is therefore another driver towards obsolescence. He also explains that this saturation of markets was driven by technological advances. This led to better product development processes and mass production that reduced average unit prices. Firms were therefore able to produce faster and cheaper (Brouillat, 2015). This is in keeping with the idea expressed by Aladeojebi that consumers could then “*afford to shop for fun and not for need*” (Aladeojebi, 2013, p. 1505). He also argues that facing the problem of supply exceeding demand thanks to mass production, obsolescence appeared as a solution (Aladeojebi, 2013).

Moreover, obsolescence was seen as a way to reduce the competition against second-hand markets. This refers to the ‘time inconsistency problem’ (Guiltinan, 2009). Indeed, when products are more reliable and durable, companies face a fiercer competition coming from used versions of their products. Their replacement price is thus lower (Guiltinan, 2009;

Aladeojebi, 2013). Then, a reduction in durability results in a decrease of substitutability between the new and used versions (Waldman, 2003).

Finally, Aladeojebi (2013) adds that this strategy was possible because of the insatiable demand of consumers. Likewise, Guiltinan (2009) argues that the ultimate decision relies on consumers. They could choose not to buy new versions, in favor of durable goods. Instead, Cooper's (2004) study shows that consumers "often do not consider durability to be a critical attribute" (Guiltinan, 2009).

## 1.2 What is obsolescence?

First of all, we define what planned obsolescence is, to further define what we mean by the term "obsolescence".

Planned obsolescence has many different definitions but no consensus has been reached. Indeed, the concept raises a strong debate. At what point can we claim that planned obsolescence has been used? What is the goal of this practice? Who is responsible for it? Therefore, definitions are more or less restrictive, as determined by the authors' point of view. Hereunder follow some noteworthy definitions of planned obsolescence.

*"The outcome of a **deliberate** decision by suppliers that a product should no longer be functional or desirable after a predetermined period."* - (Cooper as cited in Wieser, 2016, p.156)

*"All techniques by which a company aims at **deliberately** reducing the lifetime of a product to increase its **replacement rate**."* [our translation] - (Legifrance, 2015)

*"Planned obsolescence is the catch-all phrase used to describe the assortment of techniques used to **artificially** limit the durability of a manufactured good in order to stimulate **repetitive consumption**."* - (Slade, 2006, p. 5)

*"The ploy by means of which the normative life span of a good (i.e. the functional life span of a product that can be measured in time units or by number of cycle) is reduced **from its conception**, thereby limiting its service lifetime, to increase its **replacement rate**."* [our translation] - (RDC environnement, 2017, p. 2)

All these definitions emphasize that planned obsolescence comes from an intention, either talking about a deliberate act or about techniques to modify the lifetime artificially. Except for the first one, they also explain the reason why an actor might use this practice; the purpose of planned obsolescence being to increase the product replacement rate.

These definitions also have some limitations. The two first ones only refer to companies. However, this practice concerns not only companies but also consumers and the government. Finally, the last definition only mentions the reduction of the normative life span, which excludes economic, psychological and ecological obsolescence (discussed in the following section). Planned obsolescence also occurs when products are still functional.

All in all, the term “planned” refers to an entity (i.e. firms, governments, consumers,...) that acts deliberately to incentivize or force the replacement of a product for a new one. However, this debate concerning whether the entity has really planned this obsolescence will not be covered in this master thesis. The “*intention on the part of producers is often hard to establish, however, even for experts*” (Dalhammar & Maitre-Ekern, 2016, p. 379). Indeed, it is very difficult to prove whether someone wanted to reduce the lifetime of a product intentionally to increase its replacement rate. This is why this thesis does not enter this debate and consider obsolescence in the broad sense.

By obsolescence, we refer thus to all the techniques that induce a higher replacement rate of products, not resulting from normal wear and tear. This can also be defined as the “*premature wear and tear of products*” (Brönneke, 2017, p. 361). By contrast with the previous definitions of planned obsolescence, it does not mention an intention behind this practice and the responsibility of one particular actor.

### **1.3 How is obsolescence used to limit the lifetime of a product?**

In this section, we explain the different categories of obsolescence that we identified from the literature. We summarize these categories drawing on the well-known framework called PESTEL in a table illustrated in figure 2. Although this framework is usually used to analyze the external environment of a firm, it can also be useful to adopt a comprehensive approach. Therefore, obsolescence is analyzed through four main dimensions, namely Economic, Social, Technological and Ecological. The political and legal dimensions of the PESTEL are not covered because the forms of obsolescence identified in the literature did not relate to these two dimensions.

Dimensions	Economic	Social	Technological	Ecological
<b>Types of obsolescence</b>	<ul style="list-style-type: none"> <li>• Cost of repair</li> <li>• Purchase subsidy mechanisms</li> </ul>	<ul style="list-style-type: none"> <li>• Psychological obsolescence due to the consumer</li> <li>• Marketing strategies</li> </ul>	<ul style="list-style-type: none"> <li>• Functional defect</li> <li>• Software obsolescence</li> <li>• Indirect obsolescence</li> <li>• Obsolescence by notification</li> <li>• Sophistication</li> </ul>	<ul style="list-style-type: none"> <li>• Ecological obsolescence</li> </ul>

Figure 2: Table summarizing the categories of obsolescence using PESTEL dimensions

### 1.3.1 Economic obsolescence

Economic obsolescence is an indirect type of obsolescence as the product is still working but other reasons are constraining consumers to buy another product (Centre Européen de la Consommation, 2013).

#### a. Cost of repair

Repairing, which comprises the price of the replacement parts but also the service, can be either too costly or too close compared to the product price. Due to mass production, the average selling price decreased, thereby reducing the gap between repair costs and replacement costs. Besides, costs are not only financial. Repair is often considered as time consuming, which discourages consumers to repair their products (Duvall, McIntyre, & Opsomer, 2016). This is why it sometimes appears more advantageous to buy a new product rather than repair it (RDC environnement, 2017).

Since repair services are more difficult to guarantee, manufacturers and distributors focus on product warranties. Facing breakdowns of products before the end of these warranties, they choose either to reduce the warranty term or to increase the durability of products so that it would be broken after the warranty was exceeded. More recently, because of “increased physical durability”, extended warranties are proposed to consumers at excessive costs to protect them against breakdown longer (Maycroft, n.d., p. 22).

#### b. Purchase subsidy mechanisms

An informational report of the French Senate identifies another type of obsolescence, which is particularly developed in the cell phone industry. This consists in selling

products at lower prices than their real costs, through the purchase of a subscription. For instance, when a consumer buys a telephone subscription, he can get a cell phone at the symbolic price of one euro. This induces a higher replacement rate, as the length of these plans is generally two years. Bouygues Telecom, a French mobile phone provider called itself “*the only provider that allows you to change your smartphone every year*” [Our translation] (Blandin, 2016).

### **1.3.2 Social (psychological) obsolescence**

This type of obsolescence is more subjective as it is based on the psychology of consumers. In this case, products are considered as obsolete in consumers’ minds although they are still working (Aladeojebi, 2013; Centre Européen de la Consommation, 2013).

#### **a. Psychological obsolescence due to the consumer**

Some authors believe that humans feel a desire for novelty and enjoy possessing innovative products (Déméné & Marchand, 2015; Fabre & Winkler, 2010). Consumers therefore contribute to the reduction of product lifetime, by desiring the newest product with the latest technology (Brouillat, 2015). To satisfy this desire for new products, consumers tend to choose low-cost products that are therefore not durable (Baron, 2013). Campbell (1992) identifies three types of consumer behaviours that desire new products for different reasons. The first type of consumers is what Campbell calls “*pristinians*”, ones that are more attracted by untouched products. The second type is that of technophiles, who want the latest technologies and innovations. Finally, there are consumers that desire strange, unfamiliar products and consider “*the known as boring*” (Campbell, 1992, p. 56). All these three behaviours conduct to a higher replacement rate.

This desire for new products has also been translated in a weakened motivation to repair their products (Déméné & Marchand, 2015). According to the French multinational retailer Carrefour, when returning the product, some consumers immediately ask for a new product rather than its repair (Fabre & Winkler, 2010).

#### **b. Marketing strategies**

In order to attract new customers, marketing activities generally influence consumer preferences so that they are more inclined to buy the marketed product. These marketing strategies promote new styles through, for instance, “*heavy promotion of annual model changes*”, an increase in catalogue numbers, direct mail, influencer marketing and

products exhibitions (Maycroft, n.d., p. 25). According to Guiltinan (2009), this results in consumers perceiving their products as outmoded. Aladeojebi (2013) explains that the rapid introduction of new products lowers the perceived value of consumers' product as they think about the new benefits of the latest product. Therefore, these marketing activities tend *"to maintain the situation which contributes to locking the market into short product-life trends"*. (Brouillat, 2015, p. 447) As an illustration, fast fashion is an industry that designs clothes that will quickly become out-of-date (Howard, 2010).

Joseph Guiltinan (2009) argues that this voluntary obsolescence comes not only from fashion, but also from incremental features that enhance product design. He also highlights the power of others' opinion on the evaluation of a product. Indeed, this type of obsolescence is particularly strong when many people consider the old product to be outmoded *"or when the incremental features of the new product are universally perceived as beneficial and desirable"* (Guiltinan, 2009, p. 21).

Maycroft (n.d.) and Wieser (2016) are of the view that manufacturers use consumer's desire for the new as an argument to justify their own actions. Maycroft (n.d.) goes further by claiming that these manufacturers realized *"consumers would be far less suspicious of such stylistic obsolescence if they could be convinced that regular stylistic changes were an opportunity rather than a costly inconvenience"* (Maycroft, n.d., p. 25).

### **1.3.3 Technological obsolescence**

Technological or technical obsolescence is the major type of obsolescence as it refers to several techniques used to limit the functional life of a product. In this type of obsolescence, the product is not functional anymore, which forces the consumer to replace the product.

#### **a. Functional defect**

It represents a technique by which manufacturers intentionally shorten the product's lifetime. It consists in installing a delicate part in the product. Then, when this part breaks down, it implies the replacement of the whole product (Centre Européen de la Consommation, 2013). The time it takes for the part to break down can be statistically predicted by manufacturers (Centre Permanent pour la Citoyenneté et la Participation, 2014). An example of that is television capacitors that were placed too close to the heat sink, causing premature failure (Centre Européen de la Consommation, 2013). Similarly, some products are designed with permanently attached integral parts that cause problems with regard to repair (Centre permanent pour la Citoyenneté et la participation, 2013). For



instance, in some cell phones, the battery is not easy to remove. In tablets, some batteries are “*welded into the device so that they are impossible to repair and thus have to be replaced*” (Haber & Libaert, 2013, p. 2). Sometimes, these parts can be accessed but only with dedicated tools. As a result, consumers cannot try to repair the product. And this is reinforced with warranties stipulating that it is cancelled if the product has been dismantled (Maycroft, n.d.).

#### **b. Software obsolescence**

Software obsolescence concerns mainly the computer and smartphone industry. For instance, some updates and security patches may not be available for older phones, like Apple did with the iPhone 4 (RDC environnement, 2017). Also, some new applications used on smartphones are not compatible with the old ones as they require more and more random-access memory (RAM) (Centre Européen de la Consommation, 2013). In the computer industry, Fabre & Winkler (2010) illustrate this phenomenon by increasingly demanding software that requires the purchase of new hardware to support it. Such software can reduce hardware performance by, for instance, being slower, and some functionalities may also not be usable anymore (RDC environnement, 2017). Then, the consumer can choose between “*using the obsolete software with functional hardware or non-obsolete software with unwanted, new hardware*” (Maycroft, n.d., p. 23). In his article, Maycroft claims that many consumers will see this choice as an imperative. He also argues that it can be considered as obsolescence because, often, the same company manufactures the incompatible components. Similarly, Pope (2017) claims that, when technology companies push the consumer to change the software, they “*will not only turn the previous software obsolete, but the hardware where it is installed itself*” (Pope, 2017, p. 47). However, Déméné & Marchand (2015) balance this negative consequence with the fact that it also results in innovations and technological improvements.

#### **c. Indirect obsolescence**

When replacement parts are less available, it becomes difficult or even impossible to find them if they are not produced anymore (Aladeojebi, 2013). According to the company BUT, specializing in house equipment, “*availability and prices of spare parts [...] are often fatal both for the retailer during the warranty period and the consumer outside of warranty*” [Our translation] (Fabre & Winkler, 2010, p. 17). According to an interview conducted by Linda Bendali, manufacturers of electronic devices such as televisions and

DVD drives do not provide spare parts after the two-year legal guarantee (Fabre & Winkler, 2010).

Another problem arises when the availability of associated products is reduced or nonexistent. This concerns, for instance, printer cartridges or cell phone chargers (Centre Européen de la Consommation, 2013; Centre permanent pour la Citoyenneté et la participation, 2013).

***d. Obsolescence by notification***

Obsolescence by notification refers to products that indicate when they are broken and have to be replaced. An example of that is purifying water jugs that tell consumers when the filter has to be replaced, based on a predefined time period. Therefore, this method does not consider the real indicator to judge the expiry of the filter: the amount of water that has been purified by the water jug (Maycroft, n.d.). Another well-known example is printers in which smart chips disable the device when it reaches a certain number of printings. And then it sends a notification to contact the supplier (Centre permanent pour la Citoyenneté et la participation, 2013). Some printers also notify the user when the ink goes below a certain level in the cartridges although there is still enough ink to do the job (Aladeojebi, 2013).

***e. Sophistication***

Fabre & Winkler (2010) identify another category of obsolescence as well. As parts are more and more specific, products become more complex, and therefore more prone to breakdown and more difficult to repair. In the electronics business, Gordon Moore theorized a law predicting a twofold increase of computing power and complexity (Hodges & Taylor, 2005). As a consequence, repair workers need more and more competencies to follow technological breakthroughs, which increases the cost of repair (ADEME, 2012). This is made even more difficult by the fact that repair workers are short of repair information from manufacturers (Duvall, McIntyre, & Opsomer, 2016). Therefore, instead of investing in training, some companies decided to exchange the product rather than repair it when it is still covered by the guarantee (Fabre & Winkler, 2010).

### **1.3.4 Ecological obsolescence**

Environmental concerns push the consumer to buy new products because they are more environmentally friendly – either more energy-efficient or more recyclable. As environmental concerns are growing, companies are trying to increase the consumption of their products by attracting consumers with ecological arguments (Centre Européen de la Consommation, 2013). Some companies even do some forms of greenwashing. This consists in misleading the consumer by pretending to be more environmentally friendly than they are in reality. Here, authorities also play a role, by encouraging consumers to replace their existing energy-consuming products for newer and more energy-efficient ones (Déméné & Marchand, 2015).

However, the manufacturing of products also consumes large amounts of resources. Therefore, consumers must pay attention to “*the use stage of the product compared to its lifecycle*” [Our translation] (Fabre & Winkler, 2010, p. 14). Furthermore, as mentioned before, often being more sophisticated, those environmentally friendly products are more subject to breakdown, thereby contributing to obsolescence. Moreover, it depends on the characteristics of the new product. If we take the example of the television, some consumers choose a bigger one, with more options and related products that finally offset the benefits (Déméné & Marchand, 2015).

Altogether, when purchasing a new product for environmental reasons, consumers must consider the trade-off between the positive and negative impacts it has on the environment.

### **1.3.5 Conclusion**

This section identified the different forms of obsolescence according to the PESTEL framework. On the economic side, there are two forms of obsolescence: costs of repair exceeding the residual value of the product and purchasing subsidy mechanisms. The second dimension is social obsolescence, which comprises psychological obsolescence due to the consumer and marketing strategies. Then, we identified five technological forms of obsolescence: functional defect, software obsolescence, indirect obsolescence, obsolescence by notification and sophistication. Finally, the last category identified is ecological obsolescence. In the following section, we review both the positive and negative impacts resulting from obsolescence, to better understand this concept.

## **1.4 Consequences of obsolescence**

To understand why it is interesting to study obsolescence, in this section, we analyze the consequences of this practice. Again, we use the dimensions of the PESTEL framework to

structure the consequences of using obsolescence on the society. However, we find it important to mention that this analysis is not exhaustive and it would require further investigation to measure clearly the consequences of obsolescence globally.

#### **1.4.1 *Economic consequences of obsolescence***

Obsolescence has an impact on the purchasing power of consumers as it results in monetary loss for them. The replacement of products decreases consumer surplus. However, it has to be balanced by the reduction of average prices, which benefits consumers in its turn. This reduction results in supply diversification as well as broadening price ranges (Déméné & Marchand, 2015). Similarly, Brouillat (2015) argues that increased lifetime would statically result in higher prices, but, taking a dynamic point of view, the reduction of product replacement would also benefit consumers. This is one of the reasons why Brouillat suggests that firms should optimize their product lifetime rather than maximize it.

Regarding the employment level, this practice creates jobs through an increase in production but at the same time, it also reduces repair jobs (Hadhazy, 2016; Aladeojebi, 2013). Indeed, as already discussed in section 1.3.1, 1.3.2 and 1.3.3, the cost of repair, availability of spare parts and the desire for the new all contributed to the decrease in repair. Besides, due to competition, production is increasingly outsourced to countries where labour is cheaper (Les amis de la terre, n.d.).

#### **1.4.2 *Social consequences of obsolescence***

Obsolescence can be indirectly related to poor working conditions, due to increasing product manufacturing. Companies need cheap labor to decrease prices, and consequently discourage repair (Centre Européen de la Consommation, 2013). Baron (2013) illustrates this impact with the example of China where the population is exploited, working in poor conditions.

Furthermore, as financially vulnerable people cannot afford durable goods, they are more affected by obsolescence than others. They would have to buy new products at shorter intervals (Libaert, 2015). Some people even go into debt to be able to replace those products. This contributes to an increase in inequalities (Centre permanent pour la Citoyenneté et la participation, 2013).

Libaert (2015) also argues that obsolescence can have detrimental effects on health due to toxic substance releases. Another example mentioned by Baron (2013) and Fabre & Winkler (2010) is the water shortage in Peru, resulting from mining. Indeed, this country being a huge

exporter of copper, it exploits enormous quantities of water to extract copper. This has also created health problems for the surrounding population, with around three times higher lead content than the recommended threshold (Fabre & Winkler, 2010).

In some countries where resources become rare, geopolitical tensions are emerging. For instance, in Congo, the desire for rare resources has created political instability as well as armed conflict and lootings (Centre permanent pour la Citoyenneté et la participation, 2013).

#### **1.4.3 Technological consequences of obsolescence**

Technologically, obsolescence has led to innovations and technological improvements (Aladeojebi, 2013). In a context of creative destruction developed by Schumpeter, companies have to keep innovating if they do not want to be outcompeted (Guiltinan, 2009). Indeed, as competition is increasing, companies are looking for new ways to attract and retain their customers by creating new products that fit to their needs. Therefore, Brouillat (2015) argues that obsolescence can foster new and more efficient technologies, which has a positive impact on consumer welfare. As an illustration, we could mention that cars are now less polluting and more secure than before (Centre Permanent pour la Citoyenneté et la Participation, 2014).

#### **1.4.4 Ecological consequences of obsolescence**

The biggest issue about obsolescence is the environmental consequences it is responsible for.

As products are increasingly quickly replaced, manufacturers overexploit natural resources, especially fossils and minerals. For illustrative purposes, the European consumption of natural resources approximately doubled compared to thirty years before. In 2014, 43 kg of resources were consumed every day by a European, compared to 10 in Africa (Libaert & Haber, 2013). Wetlands are excavated, which leads to “*land-clearing, removal of vegetation and degradation of fertile land*” [Our translation] (Fabre & Winkler, 2010, p. 4). Electronic devices generate huge pressure on metal resources as they require the exploitation of rare-earth metal. To illustrate the significance of the issue, up to 12 different metals can be used for the production of cell phones and represent around a quarter of its weight (Fabre & Winkler, 2010). The Organization for Economic Co-operation and Development (OECD) estimated in 2009 that, if primary production continues to increase by 2% annually, there will be no more copper, lead, silver, nickel, zinc and tin left in thirty years’ time (Fabre & Winkler, 2010). Many studies also predict that resource depletion will be a major issue in the future (KPMG International, 2014).

As manufacturers are producing more, the amount of waste increases as well. Already in 2005, about 50,000 tons of cell phones were discarded (Slade, 2006). As reported by the United Nations, more recently, in 2017, 44.7 million tons of e-waste was generated, which corresponds to an 8% increase from 2014 (ONU, 2017). These figures show the need to recycle or reuse products. However, Fabre & Winkler (2010) claimed that in France, recycling of municipal waste only reached 18%, with the rest being either cremated or landfilled. What is more, a quarter of e-waste is sent in Southern countries, such as Ghana and Nigeria, to be cremated, releasing toxic substances and therefore causing health problems (Nies & Vanhaelewyn, 2017). Meanwhile, there is invisible waste too, when the product is manufactured, for example (Centre permanent pour la Citoyenneté et la participation, 2013).

All in all, upstream, by using considerable amounts of resources, it heads towards resource depletion; and downstream, obsolescence results in large amounts of waste (Fabre & Winkler, 2010).

#### 1.4.5 Conclusion

This section showed that this practice leads to both positive and negative outcomes, which are summarized in figure 3. Although it drives supply diversification, price range growth and technological improvements, it has detrimental effects on the environment in terms of waste and resource depletion, as well as consequences on social welfare. As this is not sustainable in the long run, it shows the need to investigate who is mainly responsible for obsolescence, what kind of solutions could be adopted and how this practice is considered legally.

Dimensions	Economic	Social	Technological	Ecological
<b>Consequences of obsolescence</b>	<ul style="list-style-type: none"> <li>• Monetary loss for the consumer</li> <li>• Impact on the level of employment</li> <li>• Supply diversification</li> <li>• Enlargement of price ranges</li> </ul>	<ul style="list-style-type: none"> <li>• Bad working conditions</li> <li>• Inequalities</li> <li>• Detrimental effects on health</li> </ul>	<ul style="list-style-type: none"> <li>• Innovation and technological improvements</li> </ul>	<ul style="list-style-type: none"> <li>• Waste</li> <li>• Reduction in resources</li> </ul>

Figure 3: PESTEL of the consequences of obsolescence

### 1.5 Who is responsible for obsolescence?

After evaluating the consequences of obsolescence, it is interesting to take a closer look at the actors responsible for this practice.

Traditionally, only manufacturers were accused of being responsible for obsolescence, while the consumer was seen as a victim. Consumers and authorities are generally not considered as responsible by many authors (Déméné & Marchand, 2015). Instead of continuously blaming companies, it is important to consider the role of consumers who desire new products with new technological improvements, as well as the role of the government.

While suppliers often argue that designing new products is fuelled by consumer demand, consumers, in their turn, accuse producers of incentivizing the replacement of their old products through adding features that decrease the value of these old products. However, according to Harald Wieser (n.d.), the responsibility for obsolescence cannot be solely attributed either to the supplier or to the consumer. It is more complicated since “*few durable goods fall out of use and are rendered completely useless from one day to another*” (Wieser, 2016, p. 158). Instead, their value decreases progressively and they finally become obsolete at some point, determined both by producers’ and the consumers’ will. To illustrate this: even when a product breaks down, consumers can choose between repair or replacement. However, it all depends on the producer too, as spare parts need to be available and repair needs to be economically viable compared to the product value (Gultinan, 2009; Wieser, 2016).

Political authorities are often neglected when it comes to identifying those responsible for obsolescence. However, their inactivity can also be considered as encouraging obsolescence, or at least, not preventing it. By not acting, government does not play its role as a protector of consumers. Besides, they are sometimes accused of contributing to ecological obsolescence. For instance, they incentivize consumers to buy less energy-consuming products and they even recalled energy-consuming products from the market. But, as mentioned above, an increase in demand or the fact that they purchase bigger products with more options could reverse the environmental benefits (Déméné & Marchand, 2015). Furthermore, determining who is responsible does not only mean to blame someone. It also means to be accountable for something, by having the duty to do something. In this sense, government is responsible for obsolescence, as it has to act against practices harmful to consumers.

All in all, keeping with the idea of Harald Wieser, it would be too simplistic to single out producers as the only ones responsible for obsolescence. Producers, consumers and even authorities contribute to some forms of obsolescence, ones that have negative consequences on the society, as already mentioned in the previous section. The following section will review the solutions to counteract these negative consequences.

## 1.6 Solutions against obsolescence

Now, with the consequences and responsibilities discussed, we review the solutions that address this concern. In the literature, several solutions are proposed to decrease the use of obsolescence. We divided these solutions according to the main players that could engage in the activities.

The consumer could take the following actions (non-exhaustive list):

- **Frugal living:** Buying more and more products does not conduct to personal enrichment and well-being. Therefore, consumers could try to adopt a more simple way of living, which acts against overconsumption (Fabre & Winkler, 2010).
- **Focus on quality over quantity:** Consumers could also focus more on quality over quantity (Fabre & Winkler, 2010). Designing longer-lasting products would be beneficial to the environment, as fewer products would be bought. As a result, fewer resources would be used and it would decrease the amount of waste.
- **Responsible lifestyle:** Another method to address obsolescence is to adopt a responsible lifestyle by reusing products. For instance, consumers could purchase second-hand products or simply “*rent, exchange, donate or maintain devices to increase the products’ life span*” [our translation] (Fabre & Winkler, 2010, p. 21).
- **Sharing economy:** Consumers could engage in mutually exchanging goods. For instance, some washing machines are shared by everyone living in a building (Fabre & Winkler, 2010). By now, consumers share their cars through applications such as Uber. Numerous studies predict that this trend will increase in the future (Aboltins & Rivza, 2014; Cathles, Corwin, Kelly, & Vitale, The future of mobility, 2015).
- **Engage in citizenship activities:** Some people engage in activities that facilitate repair, such as repair cafés. This initiative is driven by volunteers that try to repair products freely (Adam, Bückner, Desguin, Madsen Vaage, & Saebi, 2017). Another example is the community-based website called iFixit that provides advice by way of manuals that help people repair their products by themselves (Centre Permanent pour la Citoyenneté et la Participation, 2014).
- **Give or sell products on second-hand markets:** Instead of discarding, consumers could bring their products to second-hand corners that will then resell them at lower prices (Adam, Bückner, Desguin, Madsen Vaage, & Saebi, 2017). This not only gives



another life to the product but also allows financially vulnerable people to buy cheap products (Centre Permanent pour la Citoyenneté et la Participation, 2014).

Firms could also engage in activities that act against obsolescence (non-exhaustive list).

- **Circular economy:** It consists in reusing and recycling materials, while a linear economy simply produces and disposes of materials at the end of their life cycle (Fabre & Winkler, 2010). It would benefit the company for several reasons. Being more concerned about the environment, consumers are more inclined to reject the linear model in favor of a more sustainable consumption. Also, as resources are being depleted, prices are increasing and resources are becoming more and more volatile.
- **Design products with longer life spans:** Firms can also find advantages in products with longer life spans through the capturing effect of demand. Indeed, they tend to keep customers longer than firms marketing products with short life spans. With the latter, the customer must look for a new product more frequently, which makes him easier to capture by competitors. However, offering longer-lasting products is difficult due to fast obsolescence or unaffordable prices. Therefore, only niche markets can handle this strategy (Brouillat, 2015).
- **Product-service system:** Service economy consists in selling a service instead of a product. Customers lease their products, which means that they pay for using the product. The particularity of this model is that ownership is shifted to the retailer that will find sustainable goods more profitable (Adam, Bücker, Desguin, Madsen Vaage, & Saebi, 2017). Indeed, the service provider has incentives to design products that are easily repaired and also compatible with other products. It is also better if the product can easily integrate innovations (Fabre & Winkler, 2010).
- **Eco conception:** It means the integration of environmental concerns in the conception of products and during its entire lifecycle (Dejong, 2014). Firms could design upgradable products that would be able to integrate further innovations without being forced to design a new product. Therefore, they would use resources more efficiently, so that the product does not have to be discarded (Fabre & Winkler, 2010).
- **Facilitate repair:** Firms could engage in activities that facilitate repair such as providing spare parts longer, develop the after-sale service or design products that are modular or adaptable to new technologies (Guiltinan, 2009). For instance, Fairphone has created a modular phone that lasts longer, and provides spare parts to change the modules (Fairphone, n.d.).

Finally, public authorities could also take action to set legal limits to obsolescence. The government could impose the display of the product lifetime as well as extend the warranty period to ten years and support repair (Fabre & Winkler, 2010). As repair workers are less subject to job relocation, this would be beneficial for the employment rate. Therefore, some suggest that manufacturers should be obliged to make spare parts available and affordable at least ten years after the purchase. At the same time, repair must also be economically worthwhile. Also, tax deduction and the reduction of social security contributions could make repair more attractive (Centre Permanent pour la Citoyenneté et la Participation, 2014). Another way to reduce obsolescence could be the creation of an obsolescence observatory at the European level, which would be in contact with customers through national networks. The government could also introduce a certification to attest that there is no obsolescence in the product. Furthermore, it could educate consumers by raising their awareness about their consumption and the resulting negative consequences (Centre Permanent pour la Citoyenneté et la Participation, 2014). Finally, an action plan in Belgium presents several interesting actions (see appendix 1).

In summary, there are many possible solutions to address this issue, which can be undertaken not only by companies but also consumers and public authorities. Together, they will be able to shift towards a more responsible and environmentally friendly society.

## **1.7 Legislation regarding obsolescence**

Legislation regarding obsolescence is divided into two methods of action. Firstly, legislation could foster the solutions identified in the previous section. However, effective measures to lengthen product lifetime are difficult to put in place (Déméné & Marchand, 2015). Secondly, legislation could sanction the use of planned obsolescence. As already mentioned when defining the concept of planned obsolescence, the major hurdle to address this practice is the difficulty to find evidence, to prove that the product's lifetime was voluntarily reduced. This explains why, according to RDC environnement (2017), no case of planned obsolescence has ever been sanctioned. Actually, there is no law sanctioning this practice yet. The only exception is France, which is the first country that may impose a prison sentence of 2 years and a penalty of 300.000€ for planned obsolescence (Legifrance, 2015).

So far, there have been at least 12 measures related to obsolescence that we present in the timeline in figure 4 (non-exhaustive list of measures). It gives a temporal vision of the legal framework concerning planned obsolescence, both at the European and Belgian level. We

briefly describe the measures identified but the reader can find deeper explanations in appendix 1.

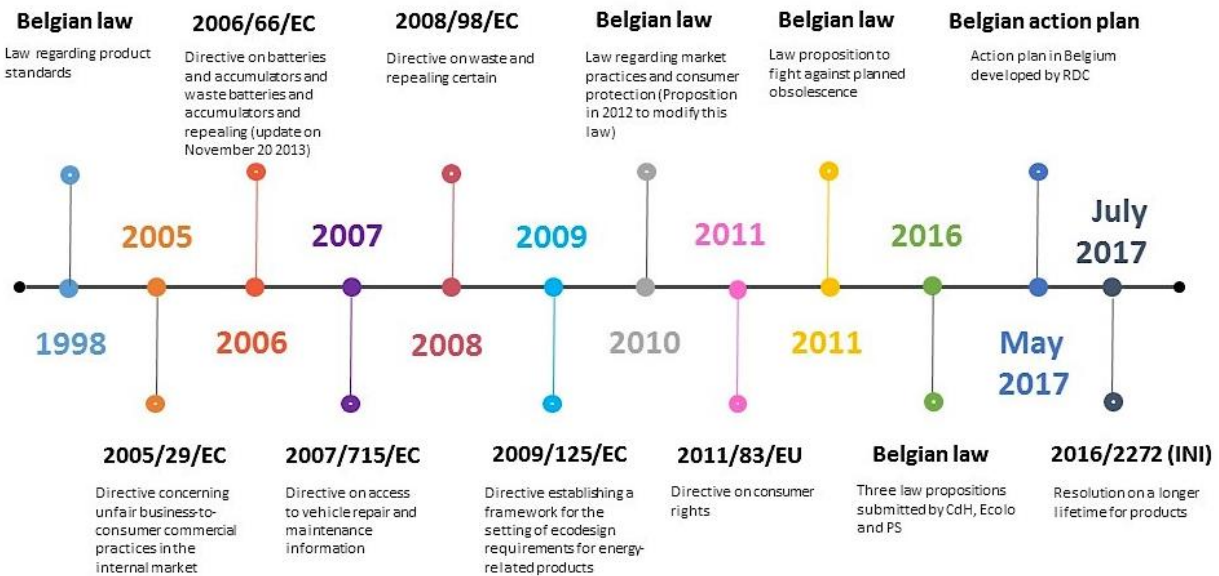


Figure 4: Legal framework of planned obsolescence at the European and Belgian level

Although the majority of these directives and regulations do not restrict the use of planned obsolescence, they try to act somehow against it, and reduce its negative consequences. The Belgian law of 1998 and the European directives of 2008 and of 2009 aim at reducing the environmental consequences of obsolescence such as the amount of waste and pollution (Loi relative aux normes de produits ayant pour but la promotion de modes de production et de consommation durables et la protection de l'environnement, 1998; The European Parliament and the Council of the European Union, 2008; The European Parliament and the Council of the European Union, 2009). The directive of 2005 concerns unfair B2C practices, which could be used to protect consumers against planned obsolescence (Glansdorff & Legros, 2014). The European directive of 2006 particularly acts against the design of non-detachable batteries (Meunier, 2017). The European directive of 2007 aims at facilitating the repair of vehicles, by giving access for everyone to information concerning maintenance and repair (Meunier, 2017). The Belgian laws of 2010 and 2011 relate to information that has to be provided to the customer (6 AVRIL 2010. - Loi relative aux pratiques du marché et à la protection du consommateur, 2010; The European Parliament and of the Council of European Union, 2011). In 2011, Belgium was considered as a pioneer in combatting planned obsolescence due to a proposition made by Muriel Targnion to fight against planned obsolescence of energy-related products (Centre Européen de la Consommation, 2013; Sénat de Belgique, 2011). In 2016, three propositions have also been submitted to fight against planned obsolescence by the cdH, Ecolo and PS political parties. Recently, in May 2017, Belgium introduced an action

plan divided into three objectives: eco-conception, better use and repair of products. The same year, the European Parliament made a resolution to lengthen product lifetime (The European Parliament, 2017).

This shows that various actions are undertaken on various fronts such as environmental consequences, consumer protection, need for information, ease of repair, product lifetime or even, actions directly against the use of planned obsolescence. All these measures demonstrate that there is a growing interest in obsolescence in the legal framework.

## 1.8 Future of obsolescence

There is little empirical research studying how obsolescence will evolve in the forthcoming years. Nevertheless, few authors have tried to depict the picture of obsolescence in the future.

Laetitia Vasseur (2017), co-founder of the association “*Halte à l’obsolescence programmée*”, gave her opinion about the future state of obsolescence by 2035. She is of the view that technical obsolescence will be far less reduced as more and more actors are trying to act against obsolescence, such as the European government, small companies or consumers. She argues that trends are going towards circular economy, sharing economy, eco-conception, modularity, repair and display of products’ lifetime. She also thinks that our economy will be more driven towards services, rather than products, with a shift from ownership to experience. This is consistent with Boumphrey & Brehmer’s (2017) study that calls this trend “*Experience more*” and expects an increase in services combined with a decline in durable goods. However, she claims that psychological obsolescence and incompatibility between software are likely to increase in the future. Technology is probably going to be more and more introduced in products related to our daily lives. As predicted in Frost & Sullivan’s (n.d.) study, our products are increasingly connected and this trend has ecological consequences, not only due to huge amounts of waste but also to the increasing need in resources (Vasseur, 2017).

## 1.9 Conclusion

This part gives an overview of obsolescence, by analyzing all the aspects related to this concept. Initially, we analyzed the underlying reasons that fostered the development of obsolescence before clarifying the concept and explaining the different forms that coexist.

Obsolescence does not always result in the reduction of product lifetime. With some forms of obsolescence, the product is replaced even if it is still working. Economically, products can

become obsolete when the costs of repair exceed the residual value of the product or when purchase subsidy mechanisms accelerate the replacement rate of the product. Consumers could also consider the product obsolete psychologically, which means that the product still works but is not desirable anymore. They would then replace the product, either because they are attracted by novelty or because marketing strategies made this product obsolete in people's minds. Technologically, there are various techniques that force the consumer replacing its product, such as functional defects, software obsolescence, indirect obsolescence (i.e. unavailability of spare parts), obsolescence by notification and sophistication. Finally, consumers can also replace the product due to ecological arguments, promoted either by the manufacturer or the government. However, even if the product is greener, the product life cycle must be analyzed to determine if it has a real positive environmental impact to replace the old product for the new one.

All these forms of obsolescence have both negative and positive consequences. Concerning the positive impacts, they can foster innovation and technological improvements, diversify supply and broaden price ranges. However, it also has bad consequences, environmentally (i.e. waste and reduction of resources), socially (i.e. poor working conditions, inequalities and detrimental effects on health) and economically (i.e. monetary losses for the consumer).

After that, we highlighted that companies are not the only actors of obsolescence. Consumers and public authorities also have a role to play. As this practice causes several negative consequences, many possible solutions have been proposed, not only to companies but also to consumers and public authorities.

While electronic devices and household appliances have been studied extensively, the second part of this thesis focuses on the automotive industry particularly. As a reminder, this industry is essential for Europe's prosperity and is at a turning point of its history, which could potentially have big impacts on obsolescence. Then, the following part aims at providing an understanding of this industry, before evaluating if some forms of obsolescence exist in this sector.

## Part 2: Overview of the automotive industry

This section aims at a better understanding of the automotive industry, to further analyze the current and future situation of obsolescence in this industry. We first give some figures about this sector, before analyzing its value chain and key players. Finally, we identify and explain four trends that would the most likely impact the future of this sector.

### 2.1 Figures about the automotive industry

In 2016, the automotive industry produced 96.1 million motor vehicles worldwide, of which 81% is made up by passenger car production and the remaining 19% by commercial vehicle production. The European market is the second largest globally, with a 24% market share, behind the Asian market with a 29% market share. This industry is crucial for the European Union (EU), accounting “for 5.7% of all EU jobs” and “for 4% of the EU’s GDP” (European Automobile Manufacturers Association, 2017, p. 14; European commission, 2018). The European automotive sector also generates a positive trade balance of 90 billion euros. Concerning the passenger cars in use, the EU has the largest fleet with 256 million cars in 2015. The second largest fleet is the Asian fleet with only 136 million passenger cars. Regarding new registrations, in 2016, there were 77.3 million new car registrations worldwide, with 46% of these in the Asian market. The American and European markets made up 26.3% and 22.5%, respectively (European Automobile Manufacturers Association, 2017).

To analyze the situation of obsolescence, in this thesis, we focus on passenger cars and we limit our geographical scope to Europe, and especially Belgium (see section 4.1).

### 2.2 Automotive value chain analysis and key players

Industry value chain analysis is a process divided into different steps followed by an organization to offer valuable output to its clients (Angwin, Fréry, Johnson, Regnér, Scholes, & Whittington, 2014). As illustrated in figure 5, automotive value chain analysis is divided into three main stages: supply, production and customer interface. In the traditional configuration, there are three levels of *automotive suppliers*, going from tier 3 to tier 1 (e.g. Bosch, Continental). Then, *Original Equipment Manufacturers (OEMs)* design, manufacture and then assemble the vehicle parts. Finally, *conventional dealers* sell cars to customers and *car rental and fleet providers* sell a service to customers (KPMG International, 2012).

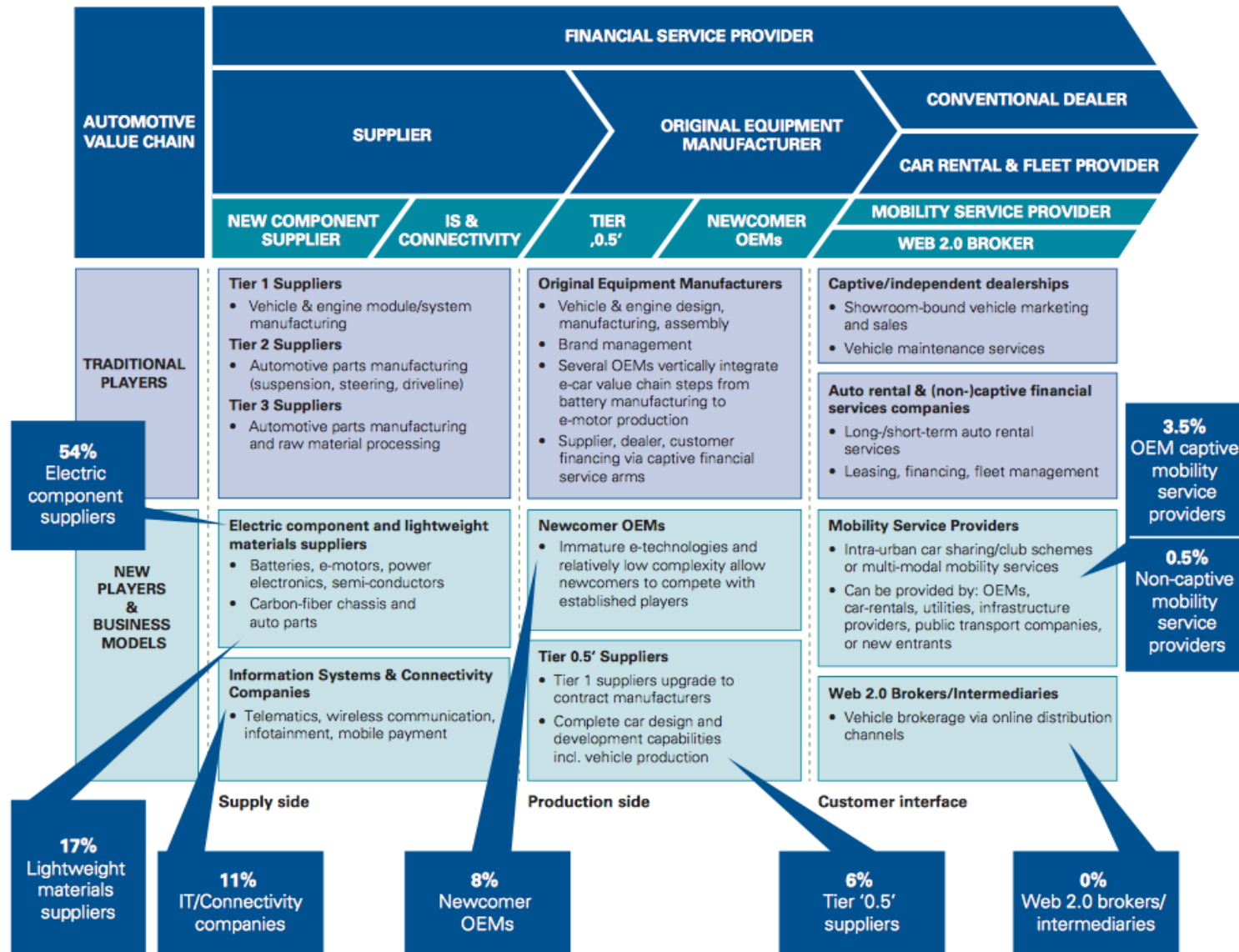


Figure 5: Automotive value chain, retrieved from (KPMG International, 2012)

There are also new players entering the automotive industry, related to four main trends (i.e. connected, autonomous, electric cars and shared mobility) that we describe in the following section. On the supply side, there are two main entrants. Firstly, *Electric components and lightweight material suppliers* provide electric and electronics parts. Secondly, *IT/Connectivity companies* provide connectivity features. On the production side, there are new entrants also: *newcomer OEMs* and *tier 0.5 suppliers* that assemble the products from tier 1 (KPMG International, 2012). Finally, *mobility service providers* offer new transportation services giving users access to a vehicle. There are different types of mobility services: ridehailing (e.g. Uber), ridesharing (e.g. Blablacar), carsharing (e.g. Zipcar), bikesharing (e.g. Motivate), microtransit (e.g. Bridj), mobility-as-a-service (e.g. MaaS Global), and shared autonomous vehicle (see appendix 2) (Center for Automotive Research, 2016).

The automotive aftermarket is also very important in this industry, accounting “for about half of the profits of European automotive OEMs” in 2007 (Capgemini consulting, 2010, p. 7). It is divided into two channels (see appendix 3):

1. *Independent channel*, which are independent repair shops. These are not contracted with a car manufacturer.
2. *Authorized channel*, which are authorized dealers and repair shops, which are contracted with a car manufacturer.

Finally, there are other stakeholders that interact with the automotive industry:

- a. *Automobile federations* represent actors and politics of the automotive industry.
- b. *Vehicle leasing companies and associations*. Vehicle leasing companies provide vehicles for a fixed period of time for a given amount of money. Leasing associations such as *Renta* in Belgium, representing the leasing business.
- c. *Roadside assistance providers* provide assistance services in case of breakdowns.
- d. *Auto insurance companies* provide insurance for vehicle owners adapted to their needs and meeting local regulations (Insurance Europe, 2015).

## 2.3 Automotive trends

Historically, the automotive industry has not faced revolutionary shifts as it was continuously improving existing technologies. However, current trends are expected to significantly impact this industry, driven by the pace of innovation. Four major trends have been identified, and are called the ACES, which stands for Autonomous, Connectivity, Electrification and Shared mobility (McKinsey&Company, 2015; London, Padhi, & Tschiesner, 2017).



### **2.3.1 The connected car**

The connected car can be defined as a “*car equipped with communication technology that allows direct flow of data to and from the car, without the need of a mobile device*” (McKinsey&Company, 2015, p. 11). This car communicates with its surroundings, via sensors and connectivity systems, using Internet connection. Also, connected vehicles can communicate with other vehicles (vehicle-to-vehicle, V2V) and with the infrastructure (vehicle-to-infrastructure, V2I). This would therefore enhance the driving experience.

Thanks to connectivity, there would be driving-related applications such as connected navigation (e.g. real-time traffic information), parking spot finder, vehicle relationship management or automatic collision avoidance, and driver fatigue detection (Coppola & Morisio, 2016; McKinsey&Company, 2015). The connected car could not only alert in case of mechanical problems but also send the vehicle condition data to service centers, which could offer remote maintenance services. Thanks to V2V and V2I communications, the car could benefit from advanced driver assistance “*such as blind spot object and pedestrian detection, lane assist, active city safety, active cruise control radar collision warning with full auto brake, and active parking assistance*” (Habeck, et al., 2014, p. 4). V2I is essential to enable traffic management, by communicating with road signs, and traffic lights (Coppola & Morisio, 2016). And, this would support the development of the autonomous car.

There would also be driving-unrelated functionalities through infotainment<sup>1</sup> systems such as messaging, listening to music and browsing the Internet (Coppola & Morisio, 2016; McKinsey&Company, 2015).

### **2.3.2 The autonomous car**

The autonomous vehicle is a potentially disruptive innovation that could significantly transform the automotive industry. The self-driving vehicle can be defined as a “*self-driving vehicle that has the capability to perceive the surrounding environment and navigate itself without human intervention*” (Jo, Kim, Kim, Jang, & Sunwoo, 2014, p. 7131). Both connected and autonomous vehicles are based on similar technologies such as sensors, V2V/V2I communication, and driver-assistance systems (i.e. emergency braking, adaptive cruise control, self-parking systems) (Heineke, Kampshoff, Mkrtchya, & Shao, 2017).

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<sup>1</sup> Infotainment refers to an “integrated graphics processor with related electronics, software and display technologies”. (Dirlea, et al., 2014, p.1)

In the end, technology advancements in “*sensors, positioning, imaging, guidance, machine learning and artificial intelligence (AI), mapping, and communications technologies, combined with advanced software and cloud computing capabilities*” would lead to fully autonomous vehicle (Samsung Electronics Co., 2015).

The Society of Automotive Engineers (SAE) identified six levels of automation (figure 6).

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
<b>Human driver monitors the driving environment</b>						
<b>0</b>	<b>No Automation</b>	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
<b>1</b>	<b>Driver Assistance</b>	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
<b>2</b>	<b>Partial Automation</b>	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	<b>System</b>	Human driver	Human driver	Some driving modes
<b>Automated driving system (“system”) monitors the driving environment</b>						
<b>3</b>	<b>Conditional Automation</b>	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	<b>System</b>	Human driver	Some driving modes
<b>4</b>	<b>High Automation</b>	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	<b>System</b>	Some driving modes
<b>5</b>	<b>Full Automation</b>	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	<b>All driving modes</b>

Figure 6: Driving automation levels, retrieved from (Society of Automotive Engineers, n.d.)

The introduction of self-driving cars could have major benefits. First, it would dramatically reduce the number of car accidents by removing human control. Indeed, drivers can be tired, drunk, distracted or exceed speed limits. It would also benefit disabled, young children and the elderly, who do not have a driving license. As autonomous cars are connected to one another, they will communicate about their position, thereby increasing synchronization (e.g. lane changing, distance-keeping) and reducing congestion. They would avoid stop-and-go traffic and favor less fuel demanding speeds, impacting positively air quality. By driving smoother, it would decrease brake wear and improve traffic flows. Mobility would be more efficient and less expensive (Coppola & Morisio, 2016; Fagnant & Kockelman, 2015).

Autonomous cars also face several hurdles. There still are technically difficult situations, such as sensor recognition that does not differentiate between a human and an object. Furthermore,

the costs of developing an autonomous vehicle are high, due to the “*addition of new sensor, communication and guidance technology, and software for each automobile*” (Fagnant & Kockelman, 2015, p. 176). Moreover, self-driving vehicles could raise ethical issues. An example is the situation where the vehicle has to decide whether involving its passengers or pedestrians in an accident. This would require a clear definition of automakers’ liabilities in situations involving self-driving vehicles. There are also security concerns about hackers and terrorist organizations, for instance. Finally, since autonomous cars handle large amounts of data, there are also data privacy issues (Fagnant & Kockelman, 2015).

### **2.3.3 The electric car**

Electric vehicles (EVs) are not new. The first EV was launched in 1880 (Høyer, 2008). However, due to high costs, low battery capacity and range, and slow recharging, the interest in EVs declined, in favor of Internal Combustion Engine (ICE) vehicles.

Currently, carmakers are investing heavily in the development of EVs to achieve compliance with tightening European regulations (McKinsey & Company, 2017). Electric vehicles have the potential to reduce CO<sub>2</sub> emissions by using renewable energy. They are developed to prevent climate change as well as oil rarefaction (Richardson, 2013). Meanwhile, the main hurdles faced by EVs are the costs of production, battery autonomy, charging infrastructure and the fact that the absence of noise can cause accidents (Manzetti & Mariasi, 2015).

Poullikkas (2015) identified three main types of electric vehicles: “*the hybrid electric vehicles (HEVs), the plug-in electric vehicles (PHEVs) and the full electric vehicles (FEVs)*” (Poullikkas, 2015, p. 1278). The hybrid electric vehicle provides power with both an ICE and a battery pack. The battery is charged by a generator system turned by the ICE or through regenerative braking (Richardson, 2013). The plug-in electric vehicle has the same composition of an HEV, with both an ICE and a battery pack, but has in addition a “*battery storage system of 4 kW h or more, a means of recharging the battery from an external source and the ability to drive at least 16 km in electric mode*” (Poullikkas, 2015, p. 1280). Unlike HEV, PEV battery is not charged by the engine. Instead, it has a grid connection, which charges the battery by plugging the car into an electrical outlet, at home or at a charging station. Finally, the full electric vehicle does not have an ICE, like the HEV and PHEV. The only power source is an electric motor. Richardson (2013) goes further by making the distinction between battery electric vehicle (BEV) and fuel cell vehicles (FCV). The power source of a BEV is grid electricity, which is stored in a large battery although FCV’s power

source is electricity produced by fuel cell. Just like the PHEV, battery can be charged from the grid at home or at charging stations (Poullikkas, 2015; Richardson, 2013).

#### **2.3.4 Shared mobility**

As already explained in section 2.2, shared mobility includes a large set of services such as ridehailing, ridesharing, carsharing, bikesharing, microtransit, mobility-as-a-service, and shared autonomous vehicle (see appendix 2) (Center for Automotive Research, 2016). In a context of rapid urbanization, we expect mobility services to increase, as traffic jams and parking spaces will become major problems for big cities (Aboltins & Rivza, 2014).

Nourinejad and Roorda (2015) identified two shared mobility systems. The one-way system allows user to pick up the car and park it anywhere in the area of activity. In the two-way system, users have to return the car to a predefined position (Boyacı, Geroliminis, & Zografos, 2015; Nourinejad & Roorda, 2015).

The main goal achieved by shared mobility is transportation accessibility and convenience. Instead of “*buying a “one size fits all” type of product*”, they use a product adapted to their needs (Alt & Puschmann, 2016, p. 95). Shared mobility allows everyone to travel from one point to another, which is a need that tram, bus and trains cannot satisfy. Shared mobility is part of the product-service system, which promotes services instead of products (Chan & Shaheen, 2015). This would thus change the current model of private ownership into a model of usage (Alt & Puschmann, 2016). Other notable impacts are the decrease in greenhouse gas emissions and in parking spaces (Chan & Shaheen, 2015).

The major hurdles of car sharing are the deeply rooted behaviours and mentalities towards car ownership as well as the absence of car sharing in rural environment (Glenn, 2016; Grosse-Ophoff, Hausler, Heineke, & Möller, 2017).

## **2.4 Conclusion**

The automotive industry is a crucial sector for Europe, which has the highest number of vehicles in use compared to rest of the world. Its value chain is complex and involves many firms, comprising suppliers, car manufacturers, dealers, fleet providers, authorized and independent channels as well as new entrants such as connectivity companies and other stakeholders. This industry is in the midst of a fundamental change, influenced by four main trends, namely connected cars, autonomous cars, electric cars and shared mobility. These trends will refine existing technologies and the way the automotive industry currently works.

## Part 3: Qualitative research

### 3.1 The problem and research questions

This thesis aims to establish whether obsolescence is currently used in the automotive industry, and how it will evolve in the future, with respect to the four trends identified in section 2.3 (i.e. connected car, autonomous car, electric car and shared mobility). To conduct our research, we identified the following research questions to be analyzed in part 4.

- What is the current state of obsolescence in the automotive industry?
- How will obsolescence in the automotive industry evolve in the future, with regard to connected car, autonomous car, electric car and shared mobility?

### 3.2 Methodology

#### 3.2.1 Choice of qualitative approach

To determine if any forms of obsolescence are present in the automotive industry, we decided to carry out qualitative research, by way of conducting interviews. It is not our objective to measure a phenomenon but to get opinions from experts in the automotive industry to understand if some forms of obsolescence are there in this sector and explore how they will evolve in the future, from the respondent's perspective. We use a qualitative approach to "*take a holistic and comprehensive approach*" of this phenomenon as well as to "*explore areas not yet thoroughly researched*" (Corbin & Strauss, 2015, p. 5). Through this research, we aim at a deeper understanding of the current and future situation of obsolescence in this sector, and explaining the causalities (i.e. how and why). We endeavor to develop explanations and gain new insights into this problem based on arguments made in the interviews.

There is a variety of methods to collect qualitative data: one-to-one interviews, focus groups, observations, textual or visual analysis, and online research. In this thesis, we chose to conduct one-to-one interviews to collect the views on obsolescence of experts in various fields of the automotive industry. This type of interview allows us to have a comprehensive understanding of the current situation of obsolescence, by asking questions such as what forms of obsolescence would exist or not in the automotive industry and why. Also, with face-to-face interviews, we can go deeper into the subject, by asking for more explanations. Besides, one-to-one interviews allow collecting new insights from the respondents. It is thus

more appropriate for our thesis because we want to explore how the situation of obsolescence will evolve in the future. Finally, because obsolescence, and particularly, planned obsolescence is a sensitive topic, respondents feel more comfortable answering questions privately than in a group environment (Chadwick, Gill, Stewart, & Treasure, 2008).

### 3.2.2 Choice of sample

To evaluate obsolescence in the automotive industry and what is likely to happen in the future, we conducted individual interviews with a systemic approach. We considered many different actors that are already or will potentially be part of the automotive industry and could know whether some forms of obsolescence are present in this industry. Therefore, we identified twelve categories of actors in figure 7, which incorporates actors of the value chain analysis (see section 2.2). We only added the expert of obsolescence, who could also provide his opinion regarding the presence or absence of some forms of obsolescence in the automotive industry.

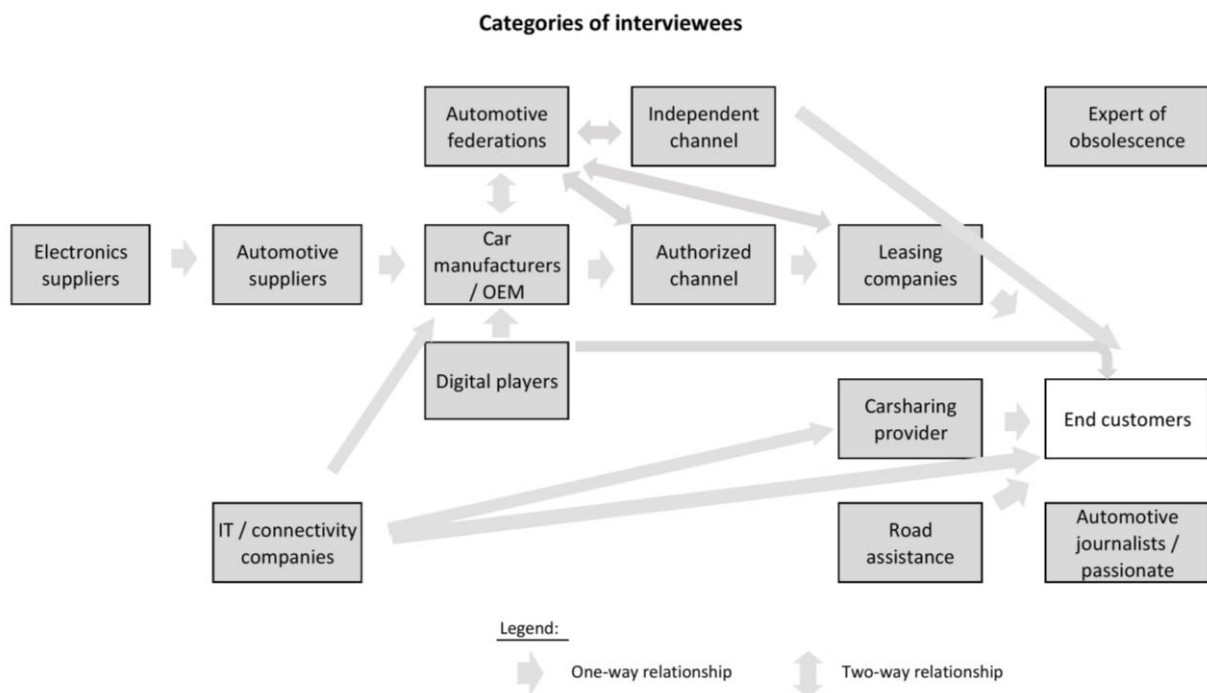


Figure 7: Categories of interviewees

In appendix 4, a table gathers all the categories of actors with the name of each person interviewed in this category, the company they belong to and the role they play in this company. Unfortunately, despite several attempts to reach digital players, we did not get any interview in that category. For instance, through the intermediary of a worker at *AGC Glass Europe*, we tried to contact an employee of *Apple* working on the autonomous car, in North America but he is bound by his non-disclosure agreement and is very busy.

In total, we conducted 35 interviews with different actors in the automotive industry. We interviewed at least two actors in each category to get a balanced point of view, except for the categories of road assistance, obsolescence expert and connectivity companies. We focused our analysis on the main value chain, which comprises the suppliers, car manufacturers and the independent and authorized channel. Automotive federations were also very interesting because of their figures, studies conducted each year, and their overall view of this sector.

### **3.2.3 Method of collecting information**

There are three types of one-to-one interviews: structured, semi-structured and unstructured interviews (Srivastava & Thomson, 2009). For this thesis, we chose to conduct semi-structured interviews that balance between the two other types of interview. On the one hand, structured interviews limit the interviewee to a pre-determined set of questions, and restrict his expression. On the other hand, unstructured interviews start with a very open and broad question and let the interviewee speak and digress. Interviewees are more in control of what they want to talk about and of the pace of the discussion (Corbin & Strauss, 2015). Semi-structured interviews are in between, being open-ended, with particular themes to cover. These themes are chosen based on the literature that we reviewed in the previous section. The questions mainly serve as a guide. They are not always asked in the same order, nor in the same way. This allows customization in a sense, modifying the questions as a function of the interviewee (Srivastava & Thomson, 2009). We believe that semi-structured interviews meet the objective of this qualitative research better. Indeed, we want to analyse what form of obsolescence exists in the automotive industry and how the interviewee thinks the future trends will impact obsolescence in this industry. Therefore, we do not want to restrict the interviewee, nor do we want him to digress from the subject too much.

Before starting the interview, we always asked if the respondent agreed to be recorded and if he wanted to remain anonymous. To ensure anonymity, we replaced every word in the transcript that might reveal his identity and addressed him by his profession.

The interview guides followed three main themes.

#### *1. Questions about his area of expertise.*

To make him feel in its comfort zone, we first asked questions related to his area of expertise. As an illustration, when talking with journalists, we talked at first about their articles and when interviewing repair shops, we mainly focused on the repair field. This means that the first part of the interview varied according to the interviewee.

## 2. *Obsolescence currently in the automotive industry.*

We asked questions about the different categories that we identified in section 1.3. Then, at the end of this theme, we showed and explained each respondent the table in figure 2, section 1.3, summarizing the different categories of obsolescence. We asked them which categories they think might or might not apply in the automotive industry and why. This allowed the interviewee to consider each category. Also, having all these categories in mind, we expected them to be able to answer better questions concerning the next theme, about future trends.

## 3. *The impact of the future trends in the automotive industry on obsolescence*

In the last part of the interview, we asked questions about the impact of the four future trends in the automotive industry that we identified in section 2.3, on the different categories.

After covering these three themes, we usually asked to the respondents if they wanted to add something and if they had any relevant documents or contacts to give. Finally, we thanked them for their time.

Furthermore, as obsolescence is a word that might be scary for some respondents, such as car manufacturers, we chose to replace the term ‘obsolescence’ with ‘the replacement rate’ of cars. We defined this replacement rate as the rate at which the customer decides or is constrained to replace its car for another.

When collecting information through interviews, we adapted our sample by adding or removing a category, for instance. This iterative approach allowed us to modify the sample according to the information we needed.

### **3.2.4 Method to analyze information**

Before analysing information from the interviews, we systematically transcribed the interviews recorded by way of voice recording. Transcribing is essential to remain faithful to the words of the interviewee and therefore, avoid any misunderstanding or interpretation. This is also useful to quote sentences with the exact words used by the interviewees. The 35 transcripts can be found in appendix 11 to 44, from page 106 to page 529 (total of pages: 423). The average duration of the interviews is 53 minutes.

To synthetize what comes out of the interviews, Mucchielli & Paillé (2016) propose different types of qualitative analysis, based on annotations in the text. The three types are phenomenological analysis, thematic analysis and analysis through conceptual categories. We



chose to use the thematic analysis, which consists in identifying sentences to a specific theme. Thanks to the delimitation of themes, it is easier to answer the research question gradually (Mucchielli & Paillé, 2016). This process also refers to what Lejeune (2014) called “indexation”. In his book, he explains that labelling consists in associating describing annotations to specific passages in the interview transcripts (Lejeune, 2014).

Due to the large number of interviews conducted yielding a large amount of data, we decided to use a web-based application called *Dedoose*. This tool facilitates the organisation and analysis of qualitative data by providing codes for instance. These codes were used to classify and interpret excerpts in the transcripts. This refers to the inclusion of themes in the text, as proposed by Mucchielli & Paillé (2016). Our analysis being divided into two main parts, the current and future situation of obsolescence in the automotive industry, we also divided the codes into these two different parts. The codes were structured according to the different categories of obsolescence identified in section 1.3 (see appendix 5). We identified each sentence or part of sentence that corresponded either to one category used currently in the automotive industry or to a positive or negative impact of one trend on a category of obsolescence. This helped us structure the large amount of data in order to better identify and analyze the variety of arguments made by the interviewees.

### **3.3 Conclusion**

To summarize, we conducted 35 semi-structured interviews with experts from different areas in the automotive industry. These respondents are classified into eleven categories, namely car manufacturers, automotive suppliers, electronics companies, independent channel, authorized channel, automobile federations, leasing companies, car-sharing providers, road assistance, automotive journalist/passionate, and connectivity companies. To analyze these 35 interviews, we used the software *Dedoose* to structure them with different codes. This coding facilitated the analysis provided in the following part, which confronts the literature with what we learned from the interviews.

## Part 4: Analysis of the results

This section presents the analysis of the current and future situation of obsolescence in the automotive industry.

We first analyze whether there is obsolescence in the automotive industry, based on the different arguments given by the respondents and the literature. Then we analyze the impact of the four trends, namely, connected car, autonomous car, electric car and shared mobility. We illustrate some paragraphs with excerpts from the interviews, which are the most representative, and which support the idea developed in the paragraph. These quotes are identified by the names of the respondents and the category they belong to (see appendix 4).

### 4.1 Current situation of obsolescence in the automotive industry

Firstly, we give an overview of the elements that would indicate the presence or absence of obsolescence in the automotive industry. Then we divide the analysis according to the PESTEL framework used in section 1.3 (see figure 8). This analysis revealed a fifth category of obsolescence, namely legal obsolescence (see section 4.1.6).

Dimensions	Economic	Social	Technological	Ecological	Legal
<b>Types of obsolescence</b>	<ul style="list-style-type: none"> <li>• Cost of repair</li> <li>• Purchase subsidy mechanism</li> </ul>	<ul style="list-style-type: none"> <li>• Psychological obsolescence due to the consumer</li> <li>• Marketing strategies</li> </ul>	<ul style="list-style-type: none"> <li>• Functional defect</li> <li>• Software obsolescence</li> <li>• Indirect obsolescence</li> <li>• Obsolescence by notification</li> <li>• Sophistication</li> </ul>	<ul style="list-style-type: none"> <li>• Ecological obsolescence</li> </ul>	<ul style="list-style-type: none"> <li>• Legal obsolescence</li> </ul>

Figure 8: PESTEL representing the categories of obsolescence analyzed in the automotive industry

#### 4.1.1 Indicators of the presence or absence of obsolescence

In this thesis, we limited our geographical scope to Europe, and especially to Belgium. This is because our interviews were conducted in Belgium and because, as mentioned by automotive historian Philippe Casse, there are significant differences between the European, US, Chinese, Japanese, South American and Asian automobile markets. As an illustration, Denis Flandre, professor at the *Université Catholique de Louvain* argued that, unlike Japanese car manufacturers, European carmakers are not developing their electronic components.

As we see in figure 9, from 2008 to 2012, new car registrations decreased in Europe, which is probably due to the economic crisis of 2008. However, since 2013, the number of passenger cars sold continues to rise from around 12 million units in 2013 to almost 15 million units in 2016 (European Automobile Manufacturers Association, 2017).

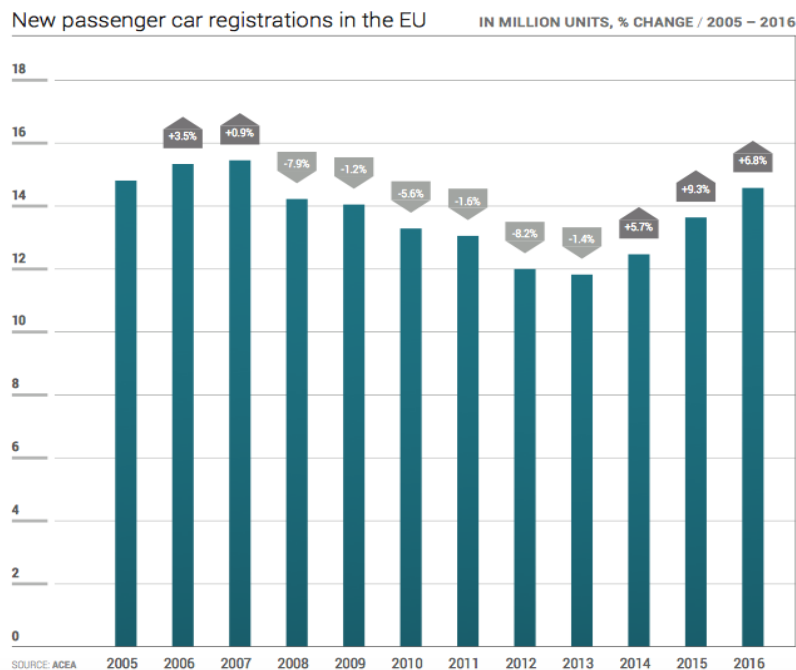


Figure 9: Registrations of European passenger cars in million units (European Automobile Manufacturers Association, 2017)

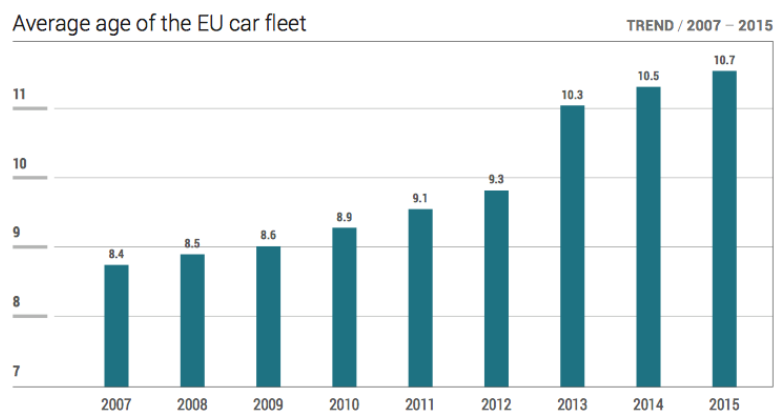


Figure 10: evolution of the average age of the European vehicle fleet (European Automobile Manufacturers Association, 2017)

Meanwhile, the majority of the interviewees agree on the fact that cars are more reliable and durable than in the past. In figure 10, we observe a steady increase of the average age of the European vehicle fleet. And, if we look at the average age of the vehicle fleet in Belgium, it increased from 7.9 in 2010 to 8.9 in 2016 (Febiac, 2017). Also, the expected average lifetime of cars is continuously increasing. As reported in a document provided by the director of an end-of-life vehicle recycling organization, fifteen years ago, the average age of end-of-life

vehicles was 12 years. In 2017, the average age was 15.8. The arguments given to justify this increase are the crisis that encouraged people to keep their cars longer as well as technological progress that prolonged the lifetime of vehicles. All these figures would indicate that the automotive industry is not quite concerned by the forms of obsolescence in figure 8. However, if the average age of cars is higher, we could expect a decrease in new vehicle registrations by inhabitant (all things being equal). Nevertheless, this proportion of new vehicle registrations by inhabitant was stable overall, between 2005 and 2016 (see appendix 6). It would thus indicate the presence of some forms of obsolescence.

*“They put, objectively, vehicles for sale that are more and more reliable and efficient. However, I mean, to continue to ensure their economic survival in a market that is pretty much saturated, they need to replace this type of vehicle more and more frequently.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

Another indicator is the average ownership of cars, which is five years in Belgium and nine years in France. This is far below the average age of end-of-life vehicles, which means that many customers replace their cars before the vehicle's end of life (European Automotive Manufacturers Association, 2017). This would also indicate the presence of obsolescence. We find it interesting to point out that, compared to other countries, Belgium has a relatively new vehicle fleet (see appendix 7). Frank Van Gool, general manager from *Renta*<sup>2</sup>, explained this with the large number of company cars that are replaced between 2 and 5 years. This rapid replacement of company cars is due to economic reasons. Leasing companies want to ensure a high resale value at the end of the leasing contract. This is also the reason why there are more premium cars in that segment than in the private market. Several respondents argued that vehicle lease accelerates the renewal of the vehicle fleet. Leasing forces customers to replace their cars at a predefined period, which results in obsolescence in the automotive industry.

*“Leasing and company cars as well as certain fiscal measures certainly influence the replacement rate.” (Eric Van den Heuvel, Car manufacturer, translated from appendix 13)*

*“But then, in the annual sales, company cars represent 50%. Well, it is cars that are replaced every 3 to 5 years. So, it helps automotive brands to make volume.” (Joost Kaesemans, Automotive federation, translated from appendix 30)*

A particularity of the automotive industry is that consumers and leasing companies can resell the product in the secondary market of used cars, instead of scrapping it. This is different

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<sup>2</sup> Renta is a Belgian federation of car rental companies, specialized in long- and short-term rentals. (Renta, n.d.)

from the smartphone industry, where the replacement of a smartphone leads to disastrous environmental consequences, with huge amounts of waste (see section 1.4.4). Besides, as a reminder, obsolescence could be beneficial as cars are constantly improved and supposed to respect the Euro emissions standards (further discussed in section 4.1.5).

*“Obviously, there is this consideration of obsolescence but with the particularity of the automotive economic model, which is one of the rare in which resell is possible.” (Thierry Libaert, expert of obsolescence, translated from appendix 11)*

All in all, the increased durability of cars would indicate an absence of technological obsolescence but the stability of new vehicle registrations per inhabitant would suggest other forms of obsolescence that induce people to buy new cars. Also, the average ownership period would mean that customers replace their cars before the vehicle's end of life. Finally, the leasing industry seems to increase the fleet renewal.

#### **4.1.2 Economic obsolescence**

Economic obsolescence is divided into two categories: costly repair, which makes the replacement more attractive, and purchase subsidy mechanisms inducing faster replacement.

##### **a. Cost of repair**

As a reminder, this category refers to the situation where customers find it more advantageous to replace the product than to have it repaired. This situation seems to apply to this sector, especially when the car becomes older. When going to repair shops, either independent or authorized, it appears that consumers sometimes decide to buy a new car instead of repairing the one they have because repair costs are too high compared to the car's residual value.

*“It is mostly when the vehicle starts needing maintenance and major repairs that the customer starts to think about replacing his car.” (Philippe Decrock, Automotive federation, translated from appendix 31)*

*“The berline or break that has 250 000 kilometers on which we have 2000 to 3000 euros in charges to put the car back on the road, it is no longer an attractive alternative since repair costs are higher than the market value of the car. So, in theory, it would be possible to keep this car longer but the owner is not motivated to do that.” (Laurent Vandievoet, Automotive journalist/passionate, translated from appendix 43)*

Besides, the disadvantages of old cars compared to newer ones incentivize the consumer to replace it. Some respondents argued that an old car uses more oil and energy, is less secure and more subject to breakdowns. Moreover, the resale value of a car decreases over time.

David Carlier, industrial engineer, montage manager at *Audi*, also mentioned that spare parts get more expensive as the car gets older. Furthermore, a garage owner gave the example of two customers that compared repair costs to vehicle buy back programs offered by car manufacturers during an auto show. These programs consist in giving financial advantages for trading their old car for greener vehicles. They generally commit to recycling the old car afterwards. This program influences the decision whether to repairing or replace the car, when the cost of repair is almost the amount given by the buy back program.

*“Because once you go further on like 5 years, 6 years, 7 years... your economical risk on the car becomes too high, because you know you will have more breakdowns, you know you will have more repairs and you know when you sell that when 7 or 8 years old, your car is becoming less attractive for second-hand buyers” (Sales & Marketing manager, Leasing company, appendix 37)*

In the past, a consumer could still repair the car himself. Now, due to sophistication (see section 4.1.4), it is not possible for the owner to repair the car on his own. This means that consumers are forced to go to a repair shop, which also results in an increase of repair costs.

Another factor increasing repair costs is the rise of car component prices, especially of electronic components (Aboltins & Rivza, 2014). Joost Kaesemans, communication director of *Febiac*<sup>3</sup> made a comparison with the printer industry that compensates the loss of money from printer sale with higher cartridge prices. He argued that car manufacturers have to compensate on repair costs because profit margins on car sales are low (i.e. generally less than 1%). However, this is not the view of Philippe Decrock, spokesperson of *Traxio*<sup>4</sup>, who argues that the spare part market is highly competitive. There are other manufacturers producing ‘pirates parts’, which are less expensive than original parts.

*“For a little piece of plastic, you pay 300, 500, 700, 1000 euros, only for a piece of plastic.” (Joost Kaesemans, Automotive federation, translated from appendix 30)*

Also, it emerged from the interviews that repair workers need to invest in new equipment (e.g. computers, software), often expensive, to diagnose where the problem comes from and be able to repair the broken component. Indeed, *“electronic components become more prevalent, and diagnosing problems requires more tools—and expensive ones—to access the necessary data. Smaller repair shops often choose not to invest in equipment, because they lack the scale needed to generate a positive return on the investment” (Frowein, Lang, Schmieg, &*

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<sup>3</sup> Febiac is a Belgian automotive federation representing car manufacturers and importers (Febiac, n.d.).

<sup>4</sup> Traxio is the Belgian Confederation of the automotive and related sectors. (Traxio, n.d.)

Sticher, 2014). What is more, each manufacturer has its own equipment and technology, which increases the costs for multi-make repairers.

Additionally, due to the increasing complexity of cars, manufacturers tend to produce modules rather than individual spare parts, which would increase the cost of repair (Aboltins & Rivza, 2014). The three electronics experts confirmed this trend by claiming that repairers generally replace the whole module rather than repair the broken component inside.

On the other hand, maintenance frequency decreased from every 15 000 kilometers in the recent past to 30 000 kilometers or even less with modern cars (Aboltins & Rivza, 2014; Frowein, Lang, Schmieg, & Sticher, 2014). Several respondents explained this declining need of maintenance by the increase of cars' reliability, components quality, and better production methods. This results in a decrease of repair costs over the total lifetime of a car.

According to David Carlier, car manufacturers ease the access to the most frequently broken parts to decrease the cost of repair and maintenance. As an illustration, engine sensors were positioned behind the engine, which required the repairer to unscrew but now, they are positioned in front at the right of the engine, to be more accessible.

The addition of electronics to the car also offers several advantages (e.g. regulation of ideal gasoline quantity; anticipations of breakdowns). Philippe Casse, automotive historian, gave the example of brake wear indicators. When brake pads are used, an electric wire comes in contact with the disk and a warning lights up on the dashboard. Thanks to diagnostic tools, it would also be easier to identify where the problem comes from. Then an electronic problem is quicker to solve and cheaper to repair. Moreover, many security systems were incorporated in the vehicle. This results in a decrease of car accidents and therefore less need to repair cars. Meanwhile, the addition of electronics increases the possibilities of breakdowns and would thereby increase total repair costs.

*"The more electric components there are, the higher the risk of breakdown, obviously. Now, as I said, the electric breakdown is easily detectable with computers that we can connect to the car. So, for me, the detection cost will not be high, but depending on the part to replace, costs can be significant." (David Carlier, Car manufacturer, translated from appendix 15)*

*"The cost is increasing due to lot of comfort items [...] like automatic gear bow, air conditioning but certainly also all the specific security items like breakdown control and full-rear control." (After-sales director, Car manufacturer, appendix 17)*

Other initiatives also decrease repair costs. For instance, a French tire manufacturer designed a puncture-proof tire. When the car runs over a nail, it fixes itself thanks to a flexible material (Rédaction Turbo, 2014). This would have a positive impact on repair costs and it shows the intention to design more durable goods.

In conclusion, there are situations where customers find the replacement of their car more advantageous than its repair, due to high repair costs.

Arguments that suggest high costs of repair are as follows:

- The decreased residual value due to disadvantages of old cars and buy-back programs.
- The impossibility to repair a car on our own.
- The need for new expensive equipment and trainings.
- The design of modules instead of individual parts.
- Addition of electronics increasing breakdowns' likelihood.

And, arguments suggesting low repair costs are as follows:

- Less frequent maintenance than before due to the increased reliability of cars.
- Assembling designed to facilitate repair and reduce costs.
- Diagnostic tools for electronics facilitating problem finding.

#### ***b. Purchase subsidy mechanisms***

Many respondents mentioned premiums given by the government and car manufacturers that would accelerate the replacement rate of cars. First, both government and carmakers offered *recycling premiums* (also called *scrapping premiums* or *buy-back programs*). It consists in giving financial and fiscal advantages for trading an old vehicle for a newer one. The government thereby tries to reduce CO<sub>2</sub> emissions because newer vehicles try to respect the new Euro standards (see section 4.1.6). In Belgium, according to a document given by the director of an end-of-life vehicle recycling organization, numbers normally fluctuated around 110,000. However, in 2010 and 2011, it rose to around 170,000 end-of-life vehicle registrations, partly due to environmental incentive schemes.

*“There are some brands that, every few years, especially French brands, offer for instance recycle premiums. So that is also, somewhere, to incentivize people who have old cars, saying “we give you a premium and then, it goes to a demolition yard and then, you receive a premium for the purchase of a new vehicle”.” (Philippe Decrock, Automotive federation, translated from appendix 31)*



There are also subsidies for greener vehicles. In 2017, 23 European countries offered electric vehicles incentives (see appendix 8) (European Automobile Manufacturers Association, 2017). Currently, according to advisors of *SPF mobilité*<sup>5</sup>, in Belgium, in the Flemish region, there are premiums of 4000 euros for buying electric and hydrogen cars. The government also induces people to buy greener cars by offering tax breaks. These subsidy mechanisms foster the replacement of cars for greener vehicles.

Furthermore, Hiep Le, a sales person at *Audi*, argued that car manufacturers encourage people to buy new cars by giving attractive financing rates and through reduction on the catalogue prices. According to Christophe Vloeberg, press relations of *Daimler*, these reductions increased from 3 or 5% ten years ago to 15-20% today.<sup>6</sup>

Finally, when defining purchase subsidy mechanism in section 1.3.1, we gave the example of telephone subscriptions combined with offering a smartphone at reduced prices. At the end of the subscription period, customers are induced to subscribe again, to get another smartphone. Private leasing can induce a higher replacement rate of cars similarly. Like company cars, private individuals lease their cars for a short period of 2 to 5 years. Then they get another car and do not bother reselling their cars if they want to change. Private leasing is a growing trend, “expected to grow almost tenfold by 2020” (Nextcontinent, 2016, p. 61).

*“You see a clear shift in people minds where they say “I no longer want to own a car and bear the financial risk myself but I just see a car as a service to me, like I have a mobile phone. I have a subscription with a telecom operator and I get the mobile phone with it [...] And, in fact, for OEMs that’s not so bad because normally, private customers remain with the same car for 7 years on average now in Belgium, 7 or 8 depending on the source. If they go to private lease, they will change after 4 or 5 years. So, that’s good because that’s more renewal volume in the market.” (Sales and marketing manager, Leasing company, appendix 37)*

In short, the interviews revealed three types of subsidy mechanisms:

1. Premiums offered by car manufacturers and the government for buying new and greener vehicles.
2. Car manufacturers also offer attractive rates to finance the cars or reductions on catalogue prices, so that people are more inclined to buy new cars.
3. Private leasing induces a higher car replacement rate.

<sup>5</sup> *SPF mobilité* is a federation specialized in politics on mobility and transport. (SPF mobilité, n.d.)

<sup>6</sup> This can also be explained with marketing strategies (Social obsolescence)

### 4.1.3 Social obsolescence

Social obsolescence refers to two categories: psychological obsolescence due to the consumer and marketing strategies, which make their products psychologically obsolete.

#### a. Psychological obsolescence due to the consumer

Advertising surrounds customers, showing new products and services continuously. This increases their desire for novelty. For some consumers, new technologies incorporated in the cars encourage them to replace their old car. New functionalities and features increase the perception that their current car is outmoded, and could lead to a premature replacement.

*“The word “nouveau, nieuw, new” is the best selling argument on the market.”  
(Philippe Casse, automotive historian, translated from appendix 42)*

*“We are always looking for new, new, new because shops always show us something new, new, new [...] You are continuously in contact with the novelty” (Delphine Awouters, Car manufacturers, translated from appendix 18)*

Cars can have a symbolic significance for customers, linked to their identity or even emotional aspects. Some drivers have an affectionate relationship with their car, and even perceive it as an expression of their social status (Déméné & Marchand, 2015). This has often been confirmed in the interviews, arguing that the car would be replaced faster than if it was only considered as an object to go from one point to another.

*“ [...] the automobile, it is not just a mode of transportation, of mobility, it is the prestige, the power, the imagination, the image we want to show to others.” (Thierry Libaert, Obsolescence expert, translated from appendix 11)*

*“ The car is really a status, a social symbol compared to the people around him.”  
(Nicolas Corluy, Roadside assistance, translated from appendix 44)*

Also, Pierre Courbe of *Inter-Environnement Wallonie*<sup>7</sup> argued that company cars reinforce the image of social achievement a car conveys. Someone's choice of the car category depends on his position in the company and is therefore associated with social achievement. Then, even if his mobility needs have not changed, he will choose higher-class cars, which are often bigger (Courbe, 2011).

On the other hand, a car being an expensive product, some respondents do not believe that customers would replace a product only because the current one is perceived as outmoded.

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<sup>7</sup> *Inter-Environnement Wallonie* is a federation for environmental protection.

Although it could influence the decision to replace the car, this argument alone would not be sufficient for people to decide to buy another car, except for wealthy individuals.

*“I think everybody wants to drive the newest and latest car possible. The thing is that a car is an expensive thing. So, they don’t have the buying power.” (Sales and marketing manager, Leasing company, appendix 37)*

Currently, the emotional tie with cars is evolving from a product associated with social achievement to a product only considered as a means of transportation among others (L'observatoire Cetelem, 2015). Some repair shops reported that customers tend to keep their car longer due to the financial investment a car represents but also due to the decrease in considering cars as conveying social status. This is consistent with a BCG report, which states *“the size of the aftermarket for cars more than eight years old grew the most since 2010, [...] as drivers held on to their old cars longer”* (Frowein, Lang, Schmieg, & Sticher, 2014, p. 7).

In brief, there are customers that would replace their cars faster due to emotional appeal and the social status that a car conveys but currently, a growing number of customers only consider the car as a means of transportation. Besides, as cars are expensive, willingness for new cars and technologies would not be a sufficient argument to replace a car but it might anticipate the decision to replace it.

### ***b. Marketing strategies***

The automotive industry seems particularly affected by heavy marketing strategies pushing people to trade their old cars.

Guiltinan (2009) considers that *“the rise of General Motors and its displacement of industry leader Ford was the first victory of fashion positioning over durability positioning among ‘hard goods’”* (Guiltinan, 2009, p. 20). This showed that *“consumers were willing to trade up for style, not just for technological improvements, long before their old cars wore out”* (Slade, 2006, p. 4). Introducing new technologies, options, and models fostered the replacement rate of cars (Archambeau, 2011).

*“[...] Marketing is the strongest point of the automotive industry, of course. It’s the advertising, finding people’s weaknesses so that they replace their cars more quickly.” (Hiep Le, Car manufacturer, translated from appendix 16)*

*“There is a huge marketing process behind the whole automobile market, which is to ensure that the client chooses this brand, this product and to make him want what is*

*new, innovative.” (Joost Kaesemans, Automotive federation, translated from appendix 30)*

Every few years, new automotive trends come out, which would reduce the perceived value of older cars. This year, the trend was towards Sport Utility Vehicles. According to the press relations of Daimler, the proportion of SUVs sold reached one-third of the total sales. Customers are thereby encouraged to trade their outmoded cars for new trendy ones, even if the old one is still functional. Car manufacturers promote this model not only to induce higher replacement but also because they have higher profit margins.

*“I think that SUVs fall in these two logics: both, the offering of new products that will conduct to a faster renewal of the vehicle fleet and the offering of more expensive products.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

Howleg & Kattuman (2006) distinguish three types of introductions of cars to the market: annual model changes, facelifts and new model generation. As an illustration, according to the press relations of Daimler, Mercedes has a car launch every month, and around 15 car launches a year. This refers to the rapid introduction of new models, leading to a reduction of the perceived value of the consumer's product, explained by Aladeojebi (2013) in section 1.3.2. By comparing the new models with their current product, they would be more likely to perceive their products as outmoded.

Firstly, every year, manufacturers plan the launch of new models so that it will make older ones obsolete. Annual model changes involve no technical improvements but rather minor changes to the cars' design (Waldman, 1993). These systematically decrease the perceived value of older models. It could also reduce the resale value, which makes them obsolete faster.

*“[...] Premium brands Mercedes, BMW,... regularly launch a new model or make an update of their new model to drive consumption, because it is a brand like Apple that ensures you will buy, actually.” (Delphine Awouters, car manufacturer, translated from appendix 18)*

Secondly, a well-known marketing strategy carmakers use is called *facelift*. It consists in introducing only major aesthetic upgrades, usually in the mid-model lifecycle, to make previous models less desirable (Hadhazy, 2016; Howard, 2010). Some respondents justify this rapid succession of facelifts as a way to stay fashionable, boost sales and attract customers with new features. It allows manufacturers to show it again in the auto show and advertise it again. By enhancing the product design, they make the previous model psychologically

obsolete and induce customers to replace their current car for more up-to-date models (Howleg & Kattuman, 2006).

*“When you launch a new model, there is a spike on the sales and then, it slightly decreases and then, to recapture the attention on this model, it is always good to have, after 3 years, 3 years and a half, a lifting, so that the model is in the focus of attention.”*  
(Christophe Vloeberg, Car manufacturer, translated from appendix 12)

*“So, if you add some new features, you have new things to talk about and people really always want the latest things that are available on the market. So it really prolongs the product life cycle of the car.”* (Product and pricing manager, Car manufacturer, appendix 14)

The last category of car introductions concerns new model generation, by changing not only the platform, but also the body shell (Howleg & Kattuman, 2006). Several respondents mentioned that brands extend their model range to help attracting people to buy new cars. Although they had niche markets in the past, they are now covering all the segments, from segment A to D. However, it could be argued that this type of introduction is real innovation, not only aesthetically but also technically.

*“Now, when you look at it, car manufacturers have wider and wider ranges. [...] They extend more and more. So, you really have this side... I would say, there is a marketing side, where you will have more and more new product introductions.”*  
(Laurent Vandievoet, Automotive journalist/passionate, translated from appendix 43)

The annual motor show also increases social obsolescence, by exhibiting all the current automobile models and innovations. It influences the purchase decisions of consumers, by reinforcing the positive image of a new car, and increasing consumers' desire for novelty.

*“Advertising pressure for new vehicle purchases, the motor show that is an extraordinary success in Belgium every year, all this contributes to maintaining the positive image of a new car, both as a technologically desirable object and as a social affirmation object. [...] This maybe the main factor in replacing the vehicle fleet.”*  
(Pierre Courbe, Automotive federation, translated from appendix 29)

Joost Kaesemans of *Febiac* pointed out that every car is reliable now and is even composed with the same basic equipment, supplied by *Bosch*, *Siemens* or *Valeo*. But still, consumers can spend a lot more money on a specific car brand. This brand image also has an impact on the resale value. This value is still generally high before the car is 4 years old, and starts to decrease faster after that, especially with mass brands. Therefore, Nicolas Corluy, product

manager at *Touring assistance*, believed that, like leasing companies, some private individuals would replace their cars when it reaches 4 years old.

On the contrary, Hiep Le pointed out that this relationship with the brand could also motivate people to keep a car longer. Old-timers and young-timers are very attractive to some people, as it gives a nostalgic feeling and is fashionable.

*“Yes, old-timer, it is very psychological. It is the nostalgic side. It is all the things vintage. Besides, today, it is very fashionable.” (Nicolas Corluy, Road assistance provider, translated from appendix 44)*

In summary, the perceived value of cars decreases with the following marketing strategies:

- New trends launched every few years.
- Introduction of new models (i.e. annual model changes, facelifts and new model generation), going from aesthetical changes to significant changes.
- The auto show, which attracts many customers each year.
- Impact of brand image on the resale value.

But, the relationship with brands also makes old-timers and young-timers attractive for consumers, which would encourage them to keep these cars.

#### **4.1.4 Technological obsolescence**

As a reminder, this type of obsolescence limits the functional lifetime of a car and is divided into five sub-categories: functional defect, software obsolescence, indirect obsolescence, obsolescence by notification and sophistication.

##### **a. Functional defect**

The existence of this form of obsolescence is a very controversial point. It is not surprising, as this form strongly relates to what is called planned obsolescence. Therefore, points of view vary from interviewee to interviewee.

The only category of interviewees asserting the presence of planned obsolescence is the independent repair channel. According to three of them, carmakers are now designing more fragile pieces. They even think that this could be intentional on the part of car manufacturers, to foster the replacement of their cars. Besides, an interviewee from *Garage wolu master car* observed an increase in the repair numbers that he explains with a decrease of quality. In his opinion, carmakers now choose cheap parts, impacting their quality negatively.

*“They cause breakdowns on purpose. It’s like washing machines.” (Garage Montald, Independent repair shop, translated from appendix 22)*

*“Airflow sensors, those are parts that we replace regularly. The valves that are supposed to be parts for pollution, and that we regularly replace, because they get dirty. For me, it’s parts that were designed for replacement.” (Benjamin Abeloos, Authorized repair shop, translated from appendix 24)*

*“We see an increasing decline of quality every year and sometimes, with obvious and simple things, like a tail light that is immediately taking on water or things like that, that never happened before...[...] We have been in business for 25 years and there are things breaking currently that never used to break down before.” (Garage wolu master car, Independent repair shop, translated from appendix 20)*

Rolf Gervelmeyer, who worked at *Philips* in the lighting industry, claimed that repair was sometimes rendered impossible to induce higher replacement. For instance, the replacement of one single LED required the replacement of the whole unit. This means that one broken component involves the replacement of the whole product.

*“You cannot replace one single LED, you have to replace the full unit. [...] So, the head lamp suppliers, the carmakers and the garage is earning money. They trained consumers to accept that and pay even more for these LED technologies.” (Rolf Gervelmeyer, Automotive suppliers, appendix 39)*

On the other hand, the major argument why this form of obsolescence would not apply to this sector is that of security. A car has to be safe, as it can be responsible for accidents that can injure people and even cause death. Therefore, many interviewees argued that car manufacturers would not risk security issues by introducing functional defects.

Also, they highlighted that cars are becoming more and more reliable and efficient, based in particular on vehicles’ extended lifetimes (see section 4.1.1). Two respondents specialized in microelectronics also claimed that electronics suppliers must follow strict rules to prove the quality level of their products. As an illustration, the probability of breakdown must be below one part per million. It means that on one million products, less than one component is allowed to break down. These norms are more and more strict due to the increasing number of electronics in a car, which automatically increases the probability of breakdowns. There is also a test qualification for integrated circuits called AEC Q100, which aims at *“determin[ing] that a device is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in the application”* (Automotive

Electronics Council, 2014). Another respondent from *Audi* claimed that their engines are tested and that a functional defect would be detected immediately. Therefore, he is convinced that these kinds of defect would be an exception. Finally, car manufacturers demand a high level of tractability, by knowing for instance all the actors involved in the value chain.

*“When they ask you to develop a component, they ask you that it sticks. In general, typically, in the automobile, it is 8000 operating hours, which corresponds to a vehicle lifetime of 10 years.” (Co-founder, Electronics company, translated from appendix 33)*

*“There are audits at least every year and everything [...], from the method of design, method of making, subcontractors, suppliers, must be absolutely traceable, documented, checked...” (Denis Flandre, Electronics company, translated from appendix 35)*

Automotive historian Philippe Casse also stressed that it could have disastrous consequences on the brand image of the car manufacturer if it gets out. At the same time, car manufacturers already mislead consumers in the Dieselgate, in 2015 (Transport & Environment, 2016).

*“Nobody thought that car manufacturers would manipulate the computer chips in their cars to mislead the consumer and the government.” (Sales and Marketing manager, Leasing company, appendix 37)*

Moreover, several respondents argued that car manufacturers initiate recall campaigns when a defect has been identified, which is very expensive. And, if people find out that they designed unreliable components, car manufacturers would be forced to make these expensive recall actions. That is also a reason why car manufacturers would not take the risk of introducing a functional defect. According to *Febiac* communication director Joost Kaesemans, the automobile sector is driven by engineers rather than marketers. In that case, engineers would not introduce functional defects, as they want to offer a well-functioning car.

Meanwhile, a functional defect does not necessarily mean that car manufacturers intentionally designed it. Electronics specialist Denis Flandre argued that a functional defect is always likely to occur, because of misuse or malfunction. He gave the example of electronics stress that happens when the temperature rises at the surface of the engine. The higher the temperature, the higher the stress.

<p>Overall, opinions are divided on the presence of functional defect in the automotive industry. Only independent repair shops asserted the presence of functional defect, by giving examples and even suggesting an intention from car manufacturers to cause this defect.</p>
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The arguments supporting the absence of this form of obsolescence are as follows:

- The potential risk on safety that they would not dare to take.
- The strict rules and tests regarding quality levels and tractability.
- The financial risk of recall campaigns.
- The negative image it would convey and the increased reliability of cars.

### ***b. Software obsolescence***

This kind of obsolescence does not seem to apply in the automotive sector, unlike in the smartphone industry, because cars are expensive and because it could destroy car manufacturers' brand image. Instead, Philippe Casse argued that car manufacturers carry out upgrades to improve their cars, rather than make them obsolete.

*“We do not replace a car every year or every year and a half like a smartphone and certainly not if the car is worth 35 or 40 000 euros.” (Laurent Demilie, Automotive federation, translated from appendix 28)*

*“When they realize that an improvement can be made to increase the reliability, they make it. It is even the contrary of planned obsolescence!” (Philippe Casse, Automotive journalist/passionate, translated from appendix 42)*

However, Hiep Le, marketing manager at Audi, claimed that software updates could be incompatible with an old car. It happened to John Quain, journalist of the New York Times, who could not enjoy Carplay or Android Auto in his old car, due to incompatibility issues.

*“If I wanted to put an infotainment system with Carplay and Android Auto into my older SUV, there was no way to do it because it had a single DIN, smaller in dash system. And all the new upgrades were double DIN and I couldn't fit it in the car.” (John Quain, Automotive journalist/passionate, appendix 41)*

The car being an expensive purchase and because of the negative impact it could have on the brand image, this industry does not seem strongly affected by software obsolescence. The only problem mentioned was the incompatibility between the smartphone and the car.

### ***c. Indirect obsolescence: availability of spare parts***

The majority of the respondents claimed that this form of obsolescence is not present in this industry. Firstly, several respondents stated that manufacturers must continue providing the spare parts for at least 10 years after a car model goes out of production. And, they usually stock spare parts for more than ten years, as the life expectancy of a car is higher. Also,

suppliers keep the part design plan to ensure they can rebuild it if needed. Besides, a multi-brand repair shop stated they never had the problem of a spare part being impossible to find.

*“You have to know that the service levels they want to have at the suppliers are about 97-98% of spare parts availability.” (Aftersales manager, Car manufacturer, appendix 17)*

*“Because the part manufacturer is always there. They build a new part but always have the older parts’ plans.” (David Carlier, Car manufacturer, translated from appendix 15)*

*“In general, we have all the fast movers, so all the filters, brake pads, all of these, we replace. We always have those in stock. The other parts, if we need them and if I order them before 5pm, I get them the following day.” (Benjamin Abeloos, Authorized repair shop, translated from appendix 24)*

Moreover, car manufacturers produce spare parts to preserve their brand’s heritage. Old- and young-timers are beneficial for their brand image.

*“ [...] Now, almost every brand, especially European, capitalizes heavily on its brand’s historical heritage [...] The first who did this was Volkswagen, which created a department designed to manufacture, remanufacture, find suppliers for the maintenance parts needed to keep its brand historic cars alive.” (Philippe Casse, Automotive journalist/passionate, translated from appendix 42)*

In addition, in the automotive aftersales market, there are not only the original spare parts but also spare parts manufactured by other companies. For instance, a worker at *Garage wolu master car* explained that there are big suppliers stocking huge amounts of pieces, providing a same day delivery and allowing them to find all the spare parts they need.

Besides, there are some actions in the automotive industry to ensure that spare parts can be found. As an illustration, instead of sending a car to the scrap yard directly, an automotive dismantler gave everyone the possibility to dismantle the car himself. All spare parts dismantled only cost 15€. Then, cars’ second-hand bumpers that generally cost around 100€ are sold at 15€. They give a second life for the spare parts that would be destroyed otherwise (TF1, 2017).

To sum up, it seems that this form of obsolescence does not apply to the automotive industry. Carmakers provide parts for at least ten years after the end of the model cycle, and usually continue providing the part. This can be explained by their intention to preserve their brand heritage through the old- and young-timers. Also, spare parts can always be found in the after-market, thanks to non-original parts provided by other manufacturers and scrap yards.

#### ***d. Obsolescence by notification***

As a reminder, obsolescence by notification refers to products that indicate when they have broken down and have to be replaced. Three examples from the interviews would indicate the use of this form of obsolescence in the automotive industry.

The first example comes from Yassin Korchi, co-founder of a telematics company. A notification appeared in the dashboard of a vehicle, warning the consumer that he had to replace the windscreen washer, although there was, in fact, still some liquid. This situation is closely related to the example of printers notifying users of the need to replace the ink cartridges although there is still enough ink to do the job (see section 1.3.3).

*“There is still some windscreen washer in your tank. Nevertheless, you will receive a push notice to incentivize you to fill it up in the first Mercedes or Renault center near you.” (Yassin Korchi, Connectivity company, translated from appendix 27)*

Secondly, Rolf Gervelmeyer, advanced design manager from AGC, claimed that car manufacturers are forcing people to replace the liquid in the braking system, although it could still work for a couple of months. Car manufacturers earn more money by using this strategy. As consumers are not able to verify themselves, they usually follow the instructions.

*“Most people just go to the garage and pay, because it is so easy to manipulate people. It is easy to integrate more and more of these warnings, asking people to drive to the carmakers’ garage.” (Rolf Gervelmeyer, Automotive suppliers, appendix 39)*

Finally, two respondents gave the same example. A notification on the display warns that the consumer must replace the pad, thanks to a sensor. The consumer will then replace it, although it is still functional.

*“So the sensor is sending a signal to the display “you need to replace the pad”. [...] In fact, if you check the thickness, you can spend several more months using the same pads. That’s just a positioning of sensors inside the pads, and you can increase your business by 10-20% easily.” (Rolf Gervelmeyer, Automotive suppliers, appendix 39)*

However, other respondents do not seem to share this opinion. Again, the main reasons mentioned for the absence of this type of obsolescence are the financial investment a car represents and the bad image it would have if it gets out.

In conclusion, three examples of this form of obsolescence were given, suggesting the presence of obsolescence by notification in the automotive sector. Again, the reasons for the absence of this type of obsolescence in this industry are the high prices of cars and the negative impact on brand image it would convey.

#### *e. Sophistication*

As a reminder, sophistication refers to the complexity of products, therefore more prone to breakdown and more difficult to repair.

By reviewing the literature, sophistication seems a big concern related to obsolescence in the automotive industry as the complexity of vehicles is rising continuously (Book, et al., 2012). This is partly because electronics parts are introduced more and more in cars. In 2014, cars had “*up to 50 control units and their number continues to grow*” (Aboltins & Rivza, 2014, p. 342). The system becoming more complex, in case of breakdown, it is more difficult to identify the cause of the failure and to fix it (Pagès, 2011). This was confirmed in several interviews. As already explained, it is now more and more difficult for someone to repair a car on his own because it requires specific tools to diagnose and repair. The car is not only mechanics anymore, composed of pistons and pumps. Almost all mechanical components are coupled with electronics, which increases the complexity. A repair worker gave the example of the water pump, which used to be only mechanical but is now controlled electronically.

*“A simple Golf is composed of more than 8000 components, and I consider the whole electronics box as one component, in which there are many other things, while a Coccinelle was only composed of 1200.” (Philippe Casse, Automotive journalist/passionate, translated from appendix 42)*

Again, points of view differ on the impact of electronics on repair time. Some repair shops reported that electronics could take hours of search to find the cause of the problem. For instance, when a lamp turns on, it is difficult to know what exactly goes wrong. However, other respondents are of the view that electronics facilitate the research process. When repairers plug the on-board diagnostic connector in, they see what is wrong and why.

*“They look for breakdowns but those are very difficult to find because they are electronic and sometimes it requires deeper diagnostic on the vehicle with a*

*diagnostic tool. [...] Very small electronics breakdowns can sometimes take two or three hours of research to find the real reason why the car stopped or...*” (Philippe Decrock, automotive federation, translated from appendix 31)

*“It is easier to find the problem, the breakdown. Why? Because it’s electronics. So, it is a diagnostic plug centralized in the dashboard. You will connect a device to it, and through this device, we will know which electronic component has a breakdown.”*  
(David Carlier, Car manufacturer, translated from appendix 15)

Besides, CO<sub>2</sub> emissions standards are becoming stricter all the time, forcing carmakers to incorporate new components. Repair shops claim that these new pollution control components cause many breakdowns. *Febiac* press relations director Joost Kaesemans confirmed that equipment such as motors with particle filters or regeneration systems are very complex.

Furthermore, repair and maintenance services require more specific tools, knowledge and expertise, especially with electronics and new materials introduction (Frowein, Lang, Schmieg, & Sticher, 2014). The interviews confirmed that repair workers need ongoing trainings to keep up-to-date. Their competencies have to be updated and diversified more quickly. It is thus more complicated for repair workers to be able to repair the car. And, as already explained in section 4.1.2, car sophistication requires more and more equipment (i.e. diagnostic tools) to repair the vehicles. Moreover, each car manufacturer has its own technology and diagnostic tools, which are very expensive. It is thus very difficult for multi-brand repair shops to survive.

*“A car today is very complex, requires continuous training and a quite significant level of specialization. [...] What do we do? Do we repair or replace? How can we access this part? How do I reinitiate the other systems in the car, if I reinstall this part, so that everything is always well settled? Yes, it is very complex.”* (Joost Kaesemans, Automotive federation, translated from appendix 30)

*“You must be in a dealership, because the dealership has the computer for each car. Yet, a mechanic doing multi-brand repairs does not have the computer for each car so, it’s already done. He cannot already repair those cars.”* (Vanderveken, Independent repair shop, translated from appendix 21)

Meanwhile, as explained earlier, cars are increasingly designed in a way that facilitates ease of repair, by giving access to the parts that are the most frequently broken down. Also, the European norm mentioned in section 1.6 forces car manufacturers to provide information on repair, which allows everyone to access a maintenance plan.

In summary, our research has revealed that vehicles seem to be more sophisticated, which would impact the ease of repair.

- The incorporation of electronics would increase breakdown probabilities but would make it easier to analyze through a connector.
- Pollution standards necessitate components more subject to failure.
- The complexity of vehicles requires more knowledge and equipment, which means that sometimes, it is possible that mechanics are not able to repair the cars.

#### **4.1.5 Ecological obsolescence**

This obsolescence consists in replacing a product for ecological arguments. However, replacing a product might be more polluting than keeping it, due to the production and recycling phase.

First of all, it has been reported that consumers are not influenced strongly by ecological arguments when it comes to cars. They consider financial and aesthetical aspects more than ecological ones. This would indicate that consumers are not replacing their old cars for ecological reasons.

*“Consumers are ecologically concerned through their wallets, that is, they would maybe buy an ecological car. Why? Because they pay less, they consume less gasoline and it costs less.” (Benjamin Abeloos, Authorized repair shop, translated from appendix 24)*

However, there are some incentives by the government and car manufacturers to replace cars faster, based on ecological arguments. We mentioned some of these incentives in the passage on purchase subsidies mechanisms, such as recycling premiums and subsidies for ecological vehicles (see section 4.1.2). There are also legislations that accelerate the replacement rate of cars, such as Euro standards and legislation banning old diesel cars from Antwerp and Brussels. These legislations will be analyzed in the following section. What we found interesting to mention here is that the government justifies these legislations with ecological arguments. However, opinions differ on how it really impacts the environment. As reported by a respondent from *SPF mobilité*, it is generally argued that a new vehicle is greener than an old one. This is because European emission standards are increasingly limiting the level of exhaust emissions for new cars. As an illustration, a diesel car equipped with a particle filter produces 95% less emission, according to Joost Kaesemans, communication director of *Febiac*. This is why some respondents found the replacement of old cars for newer cars

justified and even recommended. However, a mobility mission responsible at *Inter-Environnement Wallonie* argued that these premiums could be considered as greenwashing as they often resulted in bad environmental status reports. When taking the production and recycling into account, replacing an old car for a new one can have a higher environmental impact than keeping this old car until its end of life (Baron, 2013). Therefore, Jean-Pierre Raskin and Denis Flandre, professors of *the Université Catholique de Louvain*, recommended a deepened analysis of the car life cycle, by considering CO<sub>2</sub> emissions, energy consumption, the amount of resources needed for the production, cost of recycling, usage in terms of kilometers and location (e.g. city or countryside) and many more parameters. In fact, the environmental impact would be mainly caused when the car is used and not during the conception and recycling phases. Joost Kaesemans argued that production and recycling only account for less than 10% of the energy consumed. Besides, CO<sub>2</sub> emissions from production decreased from around 13 tons per unit produced in 2010 to less than 8 tons in 2016 (see appendix 9) (European Automobile Manufacturers Association, 2017). Moreover, cars can be recycled at 95% of their weight (Rolland, n.d.). This means that, at some point, it could be ecologically justified to replace a car with a newer one.

*“With, I would say, emphasizes on “the engine consumes less, it is better optimized” so, here, it is not necessarily a lie but we have to consider all the parameters as a whole. We need to take a systemic approach to make a wise choice and be sure that we do not fall into the trap of increasing the problem in the end rather than reducing it.” (Jean-Pierre Raskin, Electronics company, translated from appendix 34)*

Laurent Demilie of *SPF mobilité* claimed that the government favors EVs as a result of lobbying, although there are still uncertainties about the real environmental benefit of this technology (see section 4.2.3). To support his claim, Laurent Demilie gave the example of biofuels that were promoted by the European commission. They realized a few years later that in fact, it generated even higher CO<sub>2</sub> emission, instead of reducing it. Therefore, he promotes technology-neutral activities, such as an increase of CO<sub>2</sub> prices, instead of gasoline prices, or incentives for homeworking.

What is more, the automotive industry was accused of cheating in the lab test regarding the CO<sub>2</sub> emissions. In 2014, Volkswagen was picked up for using software to detect *“when they are tested, and emitting far less CO<sub>2</sub> than they did normally”* (Amabile, Conte, Siano, & Vollero, 2017, p. 30). Therefore, they mislead consumers by selling cars claimed to comply with the pollution emissions tests.

*“We saw with the dieselgate, for me, there’s clearly greenwashing when we sell a vehicle as conform to the European norms, although we know very well that in fact, it is going to be 7 times more polluting.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

All in all, our qualitative interviews findings suggest that there is ecological obsolescence in the automotive industry. Both car manufacturers and the government use ecological arguments to incentivize drivers through premiums, subsidies and legislations to replace their cars. However, opinions differ whether replacing an old car for a new one is more or less environmentally friendly. This would need a full life cycle analysis, based on many characteristics. Finally, car manufacturers cheated in emission tests, and sold cars as environmentally friendly, when in fact, they were not standard compliant.

#### **4.1.6 Legal obsolescence**

A fifth category of obsolescence also emerged from the interviews: that of legislations that increase the product replacement rate.

*“There is sometimes legislation that, to increase the competitiveness of certain sectors and the replacement rate, edit legislation acts offering additional possibilities.” (Libaert, Obsolescence expert, translated from appendix 11)*

Firstly, as explained in section 4.1.2, with purchase subsidies mechanisms, the government gave recycling premiums, when trading an old car. This, in its turn, increased the replacement rate of cars.

There are several cities such as London, Berlin and Antwerp that introduced Low Emission Zones (LEZ) (Cape, Fayolle, Forestier, Le Clercq, & Pouponneau, 2016). A recent example mentioned in several interviews is the law in Belgium that prohibits vehicles not meeting specific Euro standards. These standards define exhaust emission limits for new vehicles (see appendix 10). Under this law, diesel vehicles without a Euro standard and Euro 1-standard diesel vehicles will not be allowed in Brussels anymore, effective January 1 2018<sup>8</sup> (Biourge, 2017). And it all goes even further. According to Philippe Casse, in Belgium, the minister Céline Fremault said that they even decided to ban diesel cars by 2030. Frank Van Gool, general manager of *Renta* also argued that there are cities in Germany where all diesel cars are banned. Similarly, in Paris, there is an initiative that aims at banning diesel cars by the year 2025 (International Energy Agency, 2017).

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<sup>8</sup> This example could also have been considered as part of a legal obsolescence



Low Emission Zones have several impacts. First, they force people owning the cars affected by this legislation to replace them. Secondly, several respondents argued that it is causing a devaluation of diesel cars. And, even buying new diesel cars that are not affected by the Belgian LEZ scares makes people concerned about the resale value. This would also induce people owning diesel vehicles to replace their cars.

*“It pushes clients to shop faster than expected, for fear that they cannot enter Brussels or Antwerp, wherever, in their cars aged 6 years.” (Christophe Vloeberg, Car manufacturer, translated from appendix 12)*

*“So now, people are already preparing themselves. They anticipate. They change today so that they still get back some money for their current car, because within a few years, their cars will be worthless on the market.” (Eiffeling garage, Independent repair shop, translated from appendix 19)*

On the other hand, there are also legislations to reduce the obsolescence of cars. In Europe, for fair-competition reasons, car manufacturers are obliged to give access to technical data on the vehicle (see section 1.6). Another example given by the general manager of *Renta* is when car manufacturers were able to connect to the car remotely, and wanted to remove the On-Board Diagnostic connector. But then, independent repair shops could not have access to the information from the connector anymore and would be limited in making repair. Therefore, the European Parliament decided to oblige car manufacturers to eliminate this form of access.

To conclude, the interviews revealed a fifth category, namely, legal obsolescence. Legislation on emissions (e.g. Low Emission Zones) and on EVs or alternative solutions would accelerate the replacement of cars. However, there are also legislations aimed at reducing obsolescence in areas such as repair ease and costs.

#### **4.1.7 Conclusion**

The aim of this research was to understand deeply the current situation of obsolescence. Therefore, we structured the analysis according to the different categories identified from the literature. Through this analysis, we analyzed information from the interviews in each category of obsolescence and we confronted these findings with the literature.

The qualitative research does not aim at making generalizations but rather at evaluating the different arguments explaining whether there is obsolescence in this industry. The table in figure 11 summarizes the arguments made in the interviews, according to the categories of obsolescence. It seems there are more arguments that would indicate the presence of

economic, social, ecological and legal obsolescence as well as sophistication. However, it appears that indirect and software obsolescence do not particularly apply to this industry. This was explained by high prices of cars, safety risks it incurs and the negative image it could convey. Concerning functional defect and obsolescence by notification, there are both arguments indicating the presence and absence of these forms of obsolescence.

		Presence	Absence
Economic	<i>Cost of repair</i>	Repair costs too high compared to the residual value Disadvantages of old cars and buy-back programs reduce the residual value Impossibility to repair the car by our own Spare parts expensive Need for expensive equipment & training Replacement of modules rather than individual parts Addition of electronic components increase possibilities of breakdowns	Highly competitive spare parts market Pirates parts Longer maintenance intervals Assembling conceived to facilitate repair and lower the costs Electronics diagnostic tools facilitate problem research
	<i>Purchase subsidies mechanisms</i>	Premiums offered by car manufacturers and government for new and greener cars Attractive rates given by car manufacturers Private leasing	
Social	<i>Psychological obsolescence due to the consumer</i>	Willingness for new cars and technologies Symbolic significance and emotional appeal Reinforcement of positive image of new cars due to leasing cars	Cars are expensive Evolution of the relationship with cars – seen as a means of transportation
	<i>Marketing strategies</i>	Influence of new trends Annual model changes Facelifts Broadening of the ranges of cars Motor show attracting customers and maintaining the positive image of new cars	Old-timers and young timers - motivation to keep the car longer
Technological	<i>Functional defect</i>	More fragile pieces Replacement of the whole unit - repair of the individual component is impossible	Safety issues Negative impact on the brand image Recall campaign cost Stric rules and tests
	<i>Software obsolescence</i>	Incompatibility between smartphones and cars	Negative impact on the brand image Cars are expensive Updates to improve
	<i>Indirect obsolescence</i>		Spare parts available at least 10 years after the end of the car model Suppliers keep the parts design plan Spare parts available for old-timers Pirates parts Automotive dismantler
	<i>Obsolescence by notification</i>	3 examples of real cases	Cars are expensive Negative impact on the brand image
	<i>Sophistication</i>	Increased number of components Electronics adds more probabilities of breakdowns	Diagnostics are easier with electronics

Legal Ecological		Pollution control components more complex and subject to breakdowns Require more equipments (specific to the car manufacturer) and trainings	
	<i>Ecological obsolescence</i>	Purchase subsidy mechanisms (recycling premiums and subsidies for electric vehicles) Legislations banning old diesel cars Dieselgate – cheating on lab tests	Consumers not strongly influenced by ecological arguments
	<i>Legal obsolescence</i>	Purchase subsidy mechanisms (recycling premiums and subsidies for EVs) Low Emission Zones	Legislation forcing car manufacturers to leave the car access with On-Board Diagnostic connector

Figure 11: Table summarizing the arguments given by the respondents for each category of obsolescence

Now that we have evaluated the current situation of obsolescence in the automotive industry, we will analyze the impact of the four trends that are the most likely to shape this industry, namely the connected car, autonomous car, electric car and shared mobility & service.

## 4.2 Future situation of obsolescence in the automotive industry

This section analyses the impact of the connected, autonomous and electric car as well as shared mobility on the different forms of obsolescence that we discussed in the previous section. We need to point out here that this analysis does not aim at showing the impact exactly, as we cannot predict what will happen. At the same time, we review the arguments made in the interviews that suggest an impact on the situation of obsolescence.

### 4.2.1 How will connectivity impact the situation of obsolescence?

The interviews revealed that connected car could have major impacts on the situation of obsolescence. We interviewed Yassin Korchi, co-founder of a telematics company that aims at connecting vehicles with a box placed on the dashboard. Thanks to this box, they can have access to many data such as driving behavior, performance and maintenance.

Thanks to car condition data, the connected car would enable predictive maintenance, with vehicle diagnostics predicting, detecting and warning about any problem (e.g. cracks, breakdown, missing piece...). Breakdowns could be detected and repaired faster, before they get worse, thereby avoiding collateral damage. It could even alert when “*a part is about to break down, thus avoiding car/part failure*” (Dhall & Solanki, 2017, p. 16). Maintenance services could then be proactive. Instead of periodic maintenance, sensors would analyze the condition of every part in the car. Then, repair workers would only deal with “*parts, which need to be replaced or serviced*” (Dhall & Solanki, 2017, p. 16). Also, the driver would be in direct contact with the OEM or the garage to fix an appointment, which Aboltins & Rivza call “*a connection car to manufacturer/workshop*” (Aboltins & Rivza, 2014, p. 348). In this

perspective, Aboltins & Rivza (2014) think that spare parts could be ordered by the car itself, without relying on humans, which would decrease delivery time. They could even make over-the-air repairs, which consist in fixing the problem remotely. Besides, security would be improved thanks to advanced driver assistance systems as well as V2V and V2I communication (see section 2.3). This would then decrease the number of car accidents, which means lower total repair costs during the lifetime of a vehicle. Another argument highlighted is the increase of transparency and information provided to customers. Currently, when a problem happens, the consumer does not know how much it will cost him until he goes to the repair shop. Thanks to connectivity, he would less depend on its repair shop. For instance, he would be able to know the market prices of this kind of repair. This would shift the decision power to customers' hands. Taking everything into consideration, connectivity would reduce search and repair time. The only negative impacts mentioned were a possible increase of computer problems and a rise of electronics inside vehicles (e.g. radars for advanced driver-assistance systems), which would require trainings for repair workers (Book, et al., 2012).

*“It might decrease the costs of repair because they can react quicker, because of the physical health check. A problem that is not repaired can get bigger problems. So, the sooner you go to the dealer, the less are the costs to get this repaired.” (Product and pricing manager, Car manufacturer, appendix 14)*

Based on the interviews, connectivity does not seem to impact social obsolescence strongly. Respondents do not believe that it would be a sufficient argument to buy a new car. They argue that connectivity features are more beneficial for companies to know their customers better. However, a study conducted by McKinsey & Company (2015) in Asia, Europe and North America revealed that consumer willingness to pay for connectivity is increasing, from 21 percent in 2014 to 32 percent in 2015. And, in 2015, 37 percent of consumers “would switch from their current OEM to another manufacturer they trust if it was the only one that offered a car with full access to apps, data and media” (McKinsey&Company, 2015, p. 16).

*“Because the connected car, actually, does not add very much for the consumer. It is rather for companies that it has benefits, because the connected car allows you to get information on your consumption, kilometers driven, when you need to do your maintenance...” (Nicolas Corluy, Roadside assistance, translated from appendix 44)*

As regards the technological dimension, as connectivity would provide more transparency, the co-founder of the telematics company believes that it would reduce obsolescence by

notification. However, Rolf Gervelmeyer, advanced design manager at *AGC Glass Europe* reminds that these connectivity features could also be misused.

*“So, we would give information back to consumers or the company by saying “the brake pads are still good for long. Today, they are working well so keep them. However, you should change them in 10 000 kilometers for your safety.” (Yassin Korchi, Connectivity company, translated from appendix 27)*

Concerning software obsolescence, the evolution of connected technologies could require new hardware. Automotive passionate Laurent Vandievoet gives the example of phones that were embedded in the vehicle in the past, but that are now connected to Bluetooth, which could also become obsolete in a few years. A study conducted by L’observatoire Cetelem (2016) showed that 8% of the people interviewed are also worried about quickly outdated functionalities. However, some respondents argue that car manufacturers could add new features through over-the-air updates, to follow innovation. Then, instead of having to replace the hardware to get the new functionalities, they could just change the software remotely. However, we could wonder how long these updates would be available.

*“Will the consumer realize that or will he fall into the trap and buy a n+1 car to get the new computer model, I mean dashboard? I don’t know.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

*“I think, there, the link with mobile phone, no. It’s not something from 500 or 1000 euros. We are speaking about, in terms of 40, 50, 60 0000 euros.” (After-sales manager, Car manufacturer, appendix 17)*

Regarding legal obsolescence, what emerged from the interviews is that legislations could force carmakers to incorporate connected features. At the same time, this would only concern connectivity that improves safety and not comfort. Yassin Korchi gives the example of the eCall, which is mandatory for new vehicles in Europe, as it calls the emergency in the event of an accident. He believes that this type of regulation will increase in the future. Frank Van Gool, from *Renta*, thinks that when cars without V2V communication will coexist with cars able to communicate with each other, legislations could impose this connectivity.

*“If some new technologies are promoted by continents, countries, regions and even cities, the consumer will decide according to these new parameters.” (Eric Van den Heuvel, Car manufacturer, translated from appendix 13)*

In conclusion, the connected car would impact the situation of obsolescence as follows:

- A decrease in repair costs, by providing information about cars' current state of health. The repair process would be optimized, and lengthen cars' lifetime.
- A decrease of sophistication thanks to information provided by the connected car.
- An increase of transparency would potentially reduce obsolescence by notification.
- The impact on software obsolescence is more debated.
- An increase of legal obsolescence for connected features that improve safety.

#### **4.2.2 How will autonomous cars impact the situation of obsolescence?**

In this section, we review only the case of private autonomous cars, to only analyze the impact of this new technology (see section 4.2.5 for the case of autonomous shared vehicles).

Regarding obsolescence, some respondents believe that the autonomous car would be used more intensively. When a customer decides to take his car, he usually considers the travel time and possibilities to park the car. However, with a self-driving car, these two main obstacles would be removed since it relieves drivers of the task of driving and hunting for parking spots. Furthermore, people not allowed to drive (i.e. disabled, children, elderly) would use these self-driving cars. It would then reduce the lifetime of cars, by increasing vehicle-miles traveled.

*“We could imagine that the mileage would increase because everyone would have their own private autonomous car and we could do whatever we want in the car. [...] Also, as it could park wherever we want, it could look for a place to park for half an hour, because we are not sitting in it.” (Laurent Demilie, Automotive federation, translated from appendix 28)*

Designing self-driving cars aims at improving road safety since human errors are responsible for almost 90% of car accidents (Fagnant & Kockelman, 2015). When looking at the repair cost structure, as shown in a report from BCG, in 2013, around 40 per cent of European repair revenues come from accidents (Frowein, Lang, Schmieg, & Sticher, 2014). By reducing this number, we might expect a decrease of repair needs, as suggested in a report of McKinsey & Company (Gao, Kaas, Mohr, Möller, & Wee, 2016). This is also the opinion of several respondents. The reduction of minor accidents due to automated collision prevention would especially decrease the work at auto body shops. Besides, autonomous cars would be driven more efficiently and smoothly than those driven by humans, thereby reducing maintenance costs. On the other hand, Jean-Pierre Raskin, specializing in electronics, mentions that sensors

used for the autonomous car are more fragile and sensible to the atmospheric pressure. Benjamin Abeloos from *AB Automotive* also argues that it would add more electronics and thereby increase the possibilities of breakdowns. Meanwhile, in the end, he believes that the decrease of repair costs due to the reduction of accidents would compensate for this increase.

*“And, effectively, regarding accidents, the evolution will be very positive because those cars... it will make a huge difference, also with regards to repair. Those cars will have a driving efficiency incomparable with what we know currently. So, there will be less maintenance, less bodywork...” (Frank Van Gool, Automotive federation, translated from appendix 36)*

With regards to social obsolescence, Nicolas Colruy of *Touring* is of the opinion that autonomous cars could induce consumers to replace their cars, especially for those who love technology features. However, he also believes that some people would still want to drive their car. He gives the example of people that still drive with a manual transmission although they could switch to automatic change gearbox, which is easier to drive. Hiep Le, marketing manager at *Audi*, mentions a strategy used by insurers, which consists in offering a reduction with security options (e.g. eCall, adaptive cruise control, emergency brake assist, lane keeping assistance, blind spot warning, fatigue detection) (AG Insurance, n.d.). Similarly, insurers could promote autonomous cars with fee reductions as it reduces the risk of accidents<sup>9</sup>.

Designing autonomous cars seems to imply a high level of sophistication, comprising a number of radars, sensors and control systems, which would increase obsolescence (repair time and costs). There are many components to be added to the car that repair workers would need to be able to repair. They would thus need to go to trainings. An independent repair shops even states that they would not repair these systems and leave them to authorized repair shops. Moreover, automotive journalist John Quain gives the example of radar in the windshield for keeping distance as a feature that adds to complexity. Instead of only replacing the windshield, they also had to recalibrate the radar. Repair would then become more complex, which would increase repair time and cost.

*“So, as a repair worker, you have to be able to work on GPS, sensors or radar in cars. There are always new entities or technical aspects added to the car, which means that the car becomes a more sophisticated product.” (Philippe Decrock, Automotive federation, translated from appendix 31)*

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<sup>9</sup> This could also be considered in the purchase subsidies mechanism category

Regarding software obsolescence, automotive historian Philippe Casse argues that carmakers would not make software updates that slow down the hardware because these cars must remain secure. However, John Quain claims that this incompatibility is bound to happen.

*“In a matter of how many times they update software, there’s a hardware limitation.”*

*(John Quain, Automotive journalist/passionate, appendix 41)*

Concerning legal obsolescence, Dominique Coster, a manager at AGC Europe refers to an article from *USA Today*, about a new proposition by the regulators in the United States. To avoid road accidents, it would oblige car manufacturers to include a crash-avoidance system that works by communicating with other cars (Bomey, 2016). Some respondents also mentioned the possibility of legislations restricting specific lanes for self-driving cars or specific areas only accessible for vehicles equipped with intelligent speed adaptation. Laurent Demilie from *SPF mobilité* even makes the comparison with low emission zones, where non-autonomous cars could be banned, to improve safety. All these legislations would induce customers to trade their cars for autonomous vehicles.

*“I can imagine [...] the government says “there are a lot fewer accidents with these cars, they use less fuel because they drive at a certain speed, and they don’t exceed the speed limit” and allowing only those cars in a special lane. And, that would again push people to sell their cars, buy new cars much sooner than it would have otherwise.” (John Quain, Automotive journalist/passionate, appendix 41)*

All in all, autonomous cars would have the main following impacts:

- Decrease in repair costs due to a car accidents’ decrease and optimized driving style.
- Increase of sophistication, due to the addition of sensors, radars and control systems.
- Increase of social obsolescence through marketing strategies such as reductions offered by insurers for autonomous cars, fostering the replacement of cars.
- Increase of legal obsolescence. For safety issues, there could be legislations incentivizing the replacement for self-driving vehicles.

#### **4.2.3 How will electric vehicles impact the situation of obsolescence?**

The electrification trend is already increasing significantly, and could have several impacts on the different forms of obsolescence.

First, it could decrease sophistication because there are fewer mechanical and rotary components to repair. However, repair workers are used to dealing with Internal Combustion Engine (ICE) vehicles and currently lack the necessary skills to repair electric engines. They



thus need trainings to be able to repair EVs. Besides, EVs require a certificate to work on them because they are more dangerous due to high voltage circuits. This is the reason why some repair shops such as *Garage Montald* even decided not to repair EVs.

*“This is a Tesla when we remove the body structure. So, you see that it is not more complicated. It is actually simpler. There are far fewer parts.” (Dominique Coster, Automotive suppliers, translated from appendix 40)*

*“But the problem is that they are more dangerous. The high voltage batteries...you need to have certificates. You need to know what to do if you are working on a high voltage vehicle because you can be killed.” (After-sales manager, Car manufacturer, appendix 17)*

Electrification could also reduce economic obsolescence. Fully electric vehicles do not have engine components that need frequent repairs or replacements such as oil drains and particle filters. Because they do not have thermal-mechanical problems as in an ICE, they would have less friction and mechanical stress, which makes them more reliable. Philippe Decrock, spokesperson of *Traxio*, expects a 40% decrease of repair costs on the total lifetime of the vehicle. Also, because it would be less subject to wear, it is expected to significantly increase the lifetime of electric cars. In fact, some carmakers are worried about a profitability decrease due to electric vehicles, because cars are sold with low margins and they used to recoup on vehicle maintenance services. The only arguments that could raise repair costs are the need for new equipment and training as well as battery. As soon as a battery's capacity drops below 80%, it has to be replaced. However, a battery upgrade costs more than 10,000 euros according to Philippe Decrock, which represents almost one third of the vehicle price. Fortunately, these batteries could be reused for other purposes, such as energy storage.

*“For electric cars, for example, you will not have these high maintenance costs because electric engines don't need maintenance. [...] You don't have oil changes, which is the most impactful for the engine [...] I was at a meeting at Daimler, Mercedes-Benz, [...] and they said “this is one of our biggest concern at this moment. How will we make all these dealerships [...] profitable if we do electric cars?”” (Aftersales manager, Car manufacturer, appendix 17)*

As mentioned in section 4.1.5, there are financial incentives initiated by the government to encourage consumers to trade their cars for EVs, and this could increase in the future. For instance, in Norway, EVs benefit from a tax exemption and waivers on road tolls and ferries that make them more attractive (International Energy Agency, 2017).

According to the interviews, the impact of electric cars on psychological obsolescence does not seem very strong. The only impact it would create is a significant increase of vehicle launches. As an illustration, until 2022, Daimler will launch 10 fully electric vehicles, in line with new Euro standards. The value of older models would thus depreciate faster, and customers will be incentivized to trade their cars for those new EVs. Also, this new technology could appeal to a segment of the population, attracted by newness.

*“There is obviously a whole segment of the population, relatively affluent people, enjoying fashionable trends. Therefore, in my opinion, a whole segment of the population will switch to electric vehicles in the foreseeable future.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

Regarding legal obsolescence, a report of the International Energy Agency (2017) suggests several measures that could increase EV sales and encourage consumers to buy EVs.

- Restriction of the number of license plates of ICE vehicles.
- Restriction of the access to a specific area for electric vehicle, which was also envisioned by Laurent Demilie, from *SPF mobilité*.
- *“Exemptions from usage fees for specific portions of the road network (e.g. parking fees, road tolls and other fees incurred from vehicle use)”* (International Energy Agency, 2017, p. 16)
- Dedicated parking lots, and availability of public charging infrastructure.
- Lane access restricted to EVs, also suggested by automotive journalist John Quain.

Another regulation mentioned in an interview was the introduction of EVs quotas for OEMs. These legislations would encourage customers to trade their vehicles for electric cars, which would lead to a higher car replacement rate, and thereby increase legal obsolescence.

*“We are about to revise the regulation 443 2009 on the CO<sub>2</sub> target of new vehicles and so, in this context, we will fix electric vehicle sales quotas for car manufacturers. Furthermore, depending on the size of the quotas, the effect or the absence of the effect on the vehicle fleet renewal will be more or less evident.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

Financial incentives and legislations that promote electric vehicles are based on ecological arguments. However, the environmental impact of EVs is strongly debated. As recommended by Denis Flandre, it is essential to look at the product life cycle, to compare the environmental impact of EVs with that of internal combustion engine (ICE) vehicles over their entire life cycle.

The life cycle of a car comprises the following elements:

1. *“Car production (raw material extraction, material transformation and car assembly)*
  2. *Replacement and spare parts production (tyres, battery, lubricants and refrigerants)*
  3. *Fuel transformation process upstream to fuel consumption (well-to-tank - WTT)*
  4. *Fuel consumption for car driving (tank-to-wheel - TTW)*
  5. *Car disposal and waste treatment (end-of-life - EOL)”*
- (Leduc, Mongelli, Nemry, & Uihlein, 2008)

A life cycle analysis comparing EVs with ICEs was conducted in a study in 2013. It showed that, although an electric vehicle is less impactful during operation than an ICE, *“the production phase of EVs proved substantially more environmentally intensive. [...And], it is counterproductive to promote EVs in regions where electricity is produced from oil, coal, and lignite combustion”* (Hawkins, Majeau-Bettez, Singh, & Strømman, 2013, p. 61). Similarly, Dominique Coster refers to an article from *L’Echo* that illustrates two scenarios. In the first one, the EV is more ecological than the ICE vehicle because the energy comes from renewable energies while in the second one, it is more polluting as the energy is produced in coal plants (Scharff, 2017).

*“An electric car is not as ecological as claimed. You need to see how it produces electricity that we put in cars. [...] And, there is not that much renewable energy in Belgium. [...] It demonstrates that politicians do not always know very well what they are doing.”* (Christophe Vloeberg, Car manufacturer, translated from appendix 12)

Manufacturing power trains and batteries also requires the extraction of rare resources. Some respondents argued that there would not be enough of these rare resources to support the increase of EVs. Besides, battery recycling is not sufficiently developed. Fortunately, as explained earlier, these batteries could be reused in stationary energy storage applications lowering their environmental footprint. Also, Philippe Decrock from *Traxio* reports that car manufacturers take recycling into account when producing electric cars. He gives the example of the BMW i3 composed of material 90% of which comes from reuse.

*“I talked at Salar de Uyuni, the biggest deposit of lithium [...] I talked with scientists there, who said, “the automotive industry is crazy! If the 85 million new vehicles were all electric, within 2 years, we will not have lithium”.”* (Philippe Casse, Automotive journalist/passionate, translated from appendix 42)

If battery production and recycling, as well as clean energy production improve in the future, it could justify the incentives for EVs. However, now, based on life cycle analysis, there are

conditions where the promotion of electric vehicles is not environmentally justified. Furthermore, in Belgium, the share of renewable energy only reaches 16.8% (SPF Économie, PME, Classes moyennes et Énergie, 2017). It could thus foster the replacement of cars for EVs based on ecological arguments, although it could have a negative environmental impact. It would require further investigation to measure the environmental impact in each country.

To conclude, electric vehicles would mainly impact the situation of obsolescence as follows:

- Reduce repair costs and sophistication. An electric car has fewer complex components and would thus require less maintenance.
- Increase in purchase subsidy mechanisms.
- Slight increase of social obsolescence: attraction for new EVs and many launches.
- Increase of legislations favoring the replacement of cars for EVs.
- Increase of ecological obsolescence, as the environmental impact of EVs could be negative. This depends on many factors (e.g. battery recycling, energy source).

#### **4.2.4 How will shared mobility & service impact the situation of obsolescence?**

An increase in shared mobility would likely result in a decrease of ownership of private vehicles and a reduction of new vehicle launches, as “1 carsharing vehicle replaces 9-13 vehicles” (Chan & Shaheen, 2015). We could then expect a reduction of the vehicle fleet size. However, several respondents argue that those cars would be more intensively used, as the service provider would maximize its occupation rate. Currently, a car is not used around 95% of the time, but in the sharing system several people would use the same car (International Transport Forum, 2015). Then, there would be fewer cars but used more intensively.

*“L: It is clear that if cars are shared, it will reduce the number of vehicles needed.*

*D: Yes, but then, the use would become higher and the replacement rate could increase.” (Laurent Demilie and David Schoenmakers, Automotive federation, translated from appendix 28)*

Many articles promote shared mobility for ecological reasons. Indeed, “new technological mobility systems may provide significant societal and environmental benefits by reducing the number of cars used for personal travel and improving the utilization of available seat capacity” (Novikova, 2017, p. 29). But, the interviews also revealed that users of shared mobility services were mainly people that used to take public transport or other alternatives. This would thus increase the total number of kilometers driven in cars and also ecological obsolescence, as public transport is more environmentally friendly than cars.

*“You take them from public transport and you create kilometers that didn’t exist before.” (Philippe Casse, Automotive journalist/passionate, translated from appendix 42)*

Regarding economic obsolescence, we could expect higher repair costs because many different drivers use the car and have different driving behaviours. And, because customers are not the owner anymore, they would be less careful with these cars.

*“I drive my 20 kilometers, I drop it. And I will see this car never again. So, I don’t care about repair, and what happen with the car itself. And also, I expect that this car is used more severely and that it might be damaged earlier. So, I expect repair costs will increase because of having hundreds of different users.» (Rolf Gervelmeyer, Automotive suppliers, appendix 39)*

As the driver would not own the car in this system, several respondents believe that it could weaken the relationship with brands and the importance of brand image. They would only use a car for a travel and then, they would never see it again. As it would be seen more as a means of transportation, the connection with the brand would be weaker. Nevertheless, some respondents still imagine that there would be key differentiators. For instance, there could be different offers in terms of product range (e.g. luxury or basic car). Overall, we could expect a decrease in social obsolescence.

*“A link that is very strong today. There are many customers ready to pay more for a specific brand. [...] And, if the car becomes only a product to travel in, with all this sexy touch, individual feeling and commitment that is lost, where are we going to earn money?” (Joost Kaesemans, Automotive federations, translated from appendix 30)*

To evaluate the impact of this trend on the different forms of obsolescence, we interviewed Sven Heyen, corporate development manager at *Drive Now* and Morena Kcmar, marketing and communication manager at *Drivy*. These two companies belong to two different forms of car sharing: business-to-consumer and peer-to-peer (Cohen & Kietzmann, 2014). *Drive Now* is a one-way sharing mobility provider, which owns the vehicles shared on the platform. *Drivy*, on the other hand, is a two-way peer-to-peer car-sharing platform, which connects private owners of a vehicle with drivers. The two models have very different implications.

In the case of *Drive Now*, owned by *BMW*, while selling sustainable goods implies an incentive to increase repeat purchase frequency, *“companies that offer the product-service have the incentive to produce or use efficient product-services (as they are paid by the result)*

*and to extend the product's lifetime (when they remain the product's owner)"* (see section 1.6) (Dimache & Roche , 2009, p. 6). Likewise, several respondents argue that car manufacturers who offer this use-oriented system would be incentivized to design cars that last longer because they would only bring money when driven. In the current business model, the majority of the revenues comes from the sales of vehicles. But with this system, revenues would come from product longevity instead of product replacement. They would then redesign cars so that they would need less maintenance and reduce overall costs. This would suggest a reduction of economic and technological obsolescence. A report by McKinsey & Company (2017) suggests the introduction of purpose-built vehicles that would be less sophisticated, with *"lower levels of complexity; less powerful engines; simpler, easier-to-clean interiors; less complicated assembly processes; and lower distribution costs"* (Grosse-Ophoff, Hausler, Heineke, & Möller, 2017). In addition, in this B2C model, customers would not choose to replace the car nor repair it anymore. Then, because car ownership would be transferred from customers to OEMs, we could expect an overall decrease of obsolescence.

*"So, with all the technology, we have cars that work quite well. And they will be much more durable so that they are available quite a lot of minutes per day. So that's for... as a service product and not really as a product once sold to the customer."* (Sven Heyen, Carsharing provider, appendix 25)

*"One more reason to offer reliable products. Because where do we lose money? It's the time the vehicle is not available, when we need to work on it and we need to replace parts. However, when do we earn money? It is, when we can convince the highest number of users to use our mobility service, our product as often as possible."* (Joost Kaesemans, Automotive federation, translated from appendix 30)

Concerning *Drivy*, in this case, consumers would still less own a car in the future, because they could rely on sharing platforms. However, *Drivy* does not own the vehicles, which means that they cannot impact the lifetime of cars or repair ease and costs.

Overall, shared mobility would have the following impacts:

- Decrease of social obsolescence. Shared mobility would result in a decrease of ownership, which would probably weaken the brand image of OEMs.
- Decrease of economic and technological obsolescence by shared mobility providers who own cars such as *Drive Now*. Because their revenues come from product use and not product sales anymore, they are motivated to increase the lifetime of cars.

- Impact on ecological obsolescence is debated. Sharing cars would likely reduce the environmental impact, but, as a proportion of customers using shared mobility used to take public transports before, it could have detrimental effects on the environment.

#### **4.2.5 Interdependencies between trends**

When analyzing the interviews, we discovered interdependencies between the four trends. Indeed, these trends will not develop separately but will rather reinforce one another. In this section, we do not provide a comprehensive analysis, as we only review the different interdependencies revealed in the interviews.

As already explained in section 2.3.1, the connected vehicle would support the development of autonomous cars, by collecting real-time information on its surroundings. As an illustration, V2V and V2I communication is helpful to avoid car accidents, optimize trips, and receive information from street signs and traffic lights (Coppola & Morisio, 2016). Advanced driver assistance systems could bring many implications such as “*blind spot object and pedestrian detection*” and parking assistance (Habeck, et al., 2014, p. 4). According to Frank Van Gool, general manager at *Renta*, connectivity would also facilitate the access to shared cars in the future, which fosters the development of shared mobility. He also claims that autonomous cars could potentially slow down the adoption of shared mobility because it would eliminate the two main drawbacks of the private car (i.e. parking search and travel time) (see section 4.2.2). At the same time, many respondents believe that autonomous cars would reinforce the shift from personal-mobility to shared mobility. Autonomous cars could be part of a use-oriented product-service system. And finally, electric cars would allow a better arrangement of autonomous cars.

*“As long as cars are autonomous, what will happen is that cars could drive autonomously, even empty, in the streets. And then, a bit like today, we say “hep, taxi!” [...] A shift in mentality will occur, and it will make the private car obsolete.”*  
(Nicolas Corluy, Road assistance provider, translated from appendix 44)

Both autonomous and connected cars would significantly reduce the number of accidents, which would lead to a reduction of repair costs. The connected and autonomous car would detect when a component is about to break down and drive itself to the repair shop when needed. This could centralize repair shops. Also, autonomous and connected cars would drive smoother compared to cars driving by humans thanks to V2V and V2I communications. This would decrease repair costs and increase reliability of cars.

*“The autonomous car, it is also what we call 0 accident, because in fact, the car becomes smart enough to communicate with other cars, the infrastructure, which implies that mechanical damages will ultimately be gone, which means that body repair will decrease significantly.” (Philippe Decrock, Automotive federation, translated from appendix 31)*

*“In my opinion, vehicles will be less frequently loaded when they are autonomous than when driven by humans because it would be a smoother driving. [...] They will be connected in a smoother way, so, in my opinion, it will increase reliability.” (Co-founder, Electronics companies, translated from appendix 33)*

In the context of shared autonomous vehicles, customers would not own the product anymore but rather pay to use a car. Some respondents compared this service with self-driving cabs that could be booked through smartphone applications, and they could drive customers to their destination. Another respondent envisions autonomous cars as part of a transport service integrated with public transport, which refers to mobility-as-a-service.<sup>10</sup> This could solve the first-mile and last-mile problem faced by public transports. As already explained in section 4.2.4, this would reduce the need for individual ownership of vehicles and reduce the size of the vehicle fleet. The use-oriented system would also incentivize manufacturers who provide shared autonomous cars to increase the life expectancy of these cars. Finally, it could reduce social obsolescence, as it would be considered as cabs and public transport.

*“The autonomous vehicle would be shared and developed as a complement of public transport, which could indeed somehow reduce individual ownership needs and thus, somehow, reduce the vehicle fleet size.” (Pierre Courbe, Automotive federation, translated from appendix 29)*

*“[Brand image] is perhaps something that will disappear in the future when there will be more autonomous cars, because then, brands would play a less important role, as long as the vehicle drives you from point A to point B. [...]» (Philippe Decrock, Automotive federation, translated from appendix 31)*

To summarize, the four trends are complementary and would support each other's development. However, in order to evaluate their combined impacts on the situation of obsolescence precisely, we recommend a deeper analysis and measurements.

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<sup>10</sup> Mobility-as-a-service is a “holistic provision of integrated on-demand multimodal services enabled and accessed via powerful digital platforms that eliminates the need for multiple tickets and payments for subscribers, helps users to optimise their transport choices, provides access to real-time journey information” (Nikitas & Kougias & Alyavina & Tchouamou, 2017, p.14)



#### 4.2.6 Conclusion

This second part of the analysis evaluated the impact of the four major trends that would influence the future of the automotive industry. Figure 12 summarizes the different arguments that would increase (+) or decrease (-) the forms of obsolescence in each trend. This table is not exhaustive, as it only gathers arguments made in the interviews.

To give another point of view, we structured this conclusion according to the different forms of obsolescence. We analyze below the main impacts of the four trends:

- Regarding **economic obsolescence**: cost of repair would be impacted both positively and negatively by the four trends. And purchase subsidies mechanisms are likely to increase due to autonomous and electric vehicles.
- **Social obsolescence** would be reduced by shared mobility, due to the decrease of car ownership. But autonomous and electric cars would mainly increase it due to financial incentives and the desire for new technologies.
- **Technological obsolescence** is likely to decrease due to the connected car, autonomous car and shared mobility. In a use-oriented system provided by carmakers, these carmakers would have the incentive to minimize functional defect to maximize their revenues based on consumers' use. Concerning sophistication, connected and electric cars would impact it both positively and negatively, while autonomous cars will likely increase sophistication.
- Electric cars are likely to increase **ecological obsolescence**. Justifications for legislation and subsidies favoring EVs are based on ecological arguments but its environmental impact is strongly debated. The impact of shared mobility is more debated.
- Regarding **legal obsolescence**, there could be legislation favoring the three technologies (i.e. connected, autonomous, electric). This would foster the replacement rate of cars.

Impact of trends on obsolescence	Connectivity		Autonomous		Electrification		Shared mobility & Service	
Economic	+	-	+	-	+	-	+	-
Cost of repair	Possible computer problems More information and trainings	Predictive and remote maintenance Accident prevention More transparency and decision power shifted to customers	More intensive use Addition of fragile components More electronics	Fewer accidents Optimised driving style	Batteries replacement Training and new equipment needed	Less repair needs Less friction and less subject to wear and tear	Intensive use Different driving behaviors Customers less careful	Use-oriented system by carmakers (e.g. Drive Now)
Purchase subsidies mechanisms			Financial incentive from insurers		Subsidies given for EVs			
Social								
Psychological obsolescence due to the consumer		Not a sufficient argument	Willingness for this new technology	Willingness to drive the car himself	Attracted by newness			
Marketing strategies			Financial incentive from insurers		Increase of vehicle launches			Brand image weakened
Technological								
Functional defect								Use-oriented system by carmakers (e.g. Drive Now)
Software obsolescence	Upgrades not compatible with hardware	Over-the-air updates		Safety issues				Use-oriented system by carmakers (e.g. Drive Now)
Indirect obsolescence		Spare parts ordered by the car itself						Use-oriented system by carmakers (e.g. Drive Now)
Obsolescence by notification	Possible misuse	Transparency given to customers						Use-oriented system by carmakers (e.g. Drive Now)
Sophistication	Addition of components	Diagnostics indicate problem origin	Addition of components Training needed to repair		Training needed to be able to repair	Fewer components		Use-oriented system by carmakers (e.g. Drive Now)
Ecological								
Ecological obsolescence					Ecological arguments foster replacement but environmental impact discussed		Users taken from public transports	Reduction of cars and better use
Legal								
Legal obsolescence	Legislation regarding safety features		Legislation regarding safety improvements		Legislation enforcing the use of EVs			


Legend:  No arguments from the interviews  
 + Increase obsolescence  
 - Decrease obsolescence

Figure 12: table summarizing the impacts of each trend on the different forms of obsolescence

### 4.3 Case study: XYT

In the automotive industry, we found an interesting initiative, aiming at customizing an electric vehicle based on the customers' needs and designed to be continuously upgradable.

*France Craft*, recently called *XYT*, is a French automotive constructor that differentiates himself from the competition by offering a modular solution (Ezratty, 2016). The real added value of this company is that they do not only consider the vehicle as a moving means but they go beyond, by seeing the car as a space that creates value. Indeed, thanks to its modularity, they propose solutions that use the vehicle, even when stationary. Their point of view is supported by the fact that cars are unused 96% of their lifetime. The car is thus brought to correspond to each customer's need (XYT, n.d.).

Simon Mencarelli, founder of *XYT*, claimed that they are aiming at extending the lifetime of their vehicles, by being able to disassemble the car and then, repair or replace the broken parts (Mencarelli, 2018). These vehicles can be upgradable and then, keep pace with continual technological improvements. In this perspective, they chose electric engines because it could have an almost endless life, provided that they change the battery module.

*"It is important to think about the electric vehicle life cycle because we need to extend the lifetime of those vehicles. We will perhaps scrap them less than we used to. Vehicles are perishable goods, let's say. We really work on the extension of this lifetime."* (Simon Mencarelli, translated from Terra Terre, 2018)

Being modular, *XYT* facilitates repair services. These EVs are only composed of 600 parts, whereas a traditional car contains around 10,000 components. This significantly decreases sophistication and repair costs. The car is even delivered in separate components, made to assemble easily (XYT, n.d.).

This example shows that there are good initiatives in the automotive industry, which could lengthen the lifetime of vehicles.

### 4.4 Conclusion

This section had two main objectives: the analysis of the current and future state of obsolescence in the automotive industry. We analyzed the arguments given in the interviews with articles found in the literature. In this conclusion, we only review the main arguments but the reader can refer to figure 11 and 12 that summarize the comprehensive analysis.

### **Economic obsolescence**

Currently, the costs of repairing an old car are sometimes higher than the residual value of the car itself. Several factors increased repair costs, such as the addition of components, increase of spare part prices for old cars, need of trainings and new equipment to be able to repair as well as the impossibility to repair the car on one's own. However, in the future, we could expect a decrease of repair costs. The connected car would improve diagnostics. Electric cars would have fewer components. When carmakers provide shared mobility, they will try to reduce these costs because otherwise they will burden their budgets. Finally, autonomous cars would lead to a decrease of repair costs by decreasing the number of car accidents, but it would also potentially increase them by adding components more subject to breakdown.

Currently, there are already purchase subsidy mechanisms to replace the old car with new and electric ones. These subsidies for EVs could increase in the future and there could also be financial incentives for the purchase of autonomous cars, by insurers for instance.

### **Social obsolescence**

This form of obsolescence is divided into customers' desire for newness and the marketing strategies used to convince customers to replace their products. Car manufacturers launch many new models every year, including new models and facelifts, which decrease the perceived value of old cars. Customers also used to associate themselves with the brand and the social status it conveys. However, it seems that customers see the car more and more as only a means of transportation. Similarly, as shared mobility will decrease car ownership, we could expect a decrease of social obsolescence. However, private autonomous and electric cars could incentivize customers to replace their existing cars, due to the desire for new technologies.

### **Technological obsolescence**

This category is divided into five subcategories.

Firstly, some respondents of the independent channel gave current examples of functional defects. However, others do not believe that these problems could happen, due mainly to the safety risks a car incurs. The presence or absence of this form would be mainly impacted by shared mobility provided by carmakers. As the car manufacturer wants to maximize its cars' availability, it would be incentivized to design cars that do not become obsolete quickly. Cars would last longer, incur fewer repairs and minimize or even eliminate functional defects.

It seems that indirect obsolescence and software obsolescence are currently not present in this sector. The only trend that could potentially raise software obsolescence is connectivity.

Three respondents gave examples that would indicate the presence of obsolescence by notification. However, this could potentially convey a bad image that would discourage car manufacturers from using this form of obsolescence. Besides, the connected car is expected to decrease this type of obsolescence, by providing more transparency to customers.

Finally, it appears that cars are more and more sophisticated, due to the addition of components (e.g. electronics, anti-pollution, software...). This would likely decrease with connected and electric cars, as connectivity would provide more information and electric cars would have fewer components. However, autonomous cars would be more sophisticated.

### **Ecological obsolescence**

Purchase subsidy mechanisms and legal obsolescence are both justified by ecological arguments. However, this needs a whole life cycle analysis to evaluate the real environmental impact of scrapping an old car for a new one. In the future, we could expect an increase of this obsolescence due to the trend of electrification. These electric vehicles are often promoted with ecological arguments but their environmental impact is strongly debated.

### **Legal obsolescence**

Currently, there are regulations that incentivize the replacement of cars such as Low Emission Zones, recycling premiums and subsidies for EVs. In the future, there could be legislations that would promote connected and autonomous cars, based on safety arguments. Besides, some regulations currently foster the adoption of electric vehicles, and this is expected to increase in the future.

All in all, it seems that currently, there are some forms of obsolescence that apply to this sector (i.e. economic, social, sophistication, ecological and legal). In the future, these forms of obsolescence would be strongly impacted by the four trends, both positively and negatively. Overall, we could expect a decrease of economic and technological obsolescence, but an increase of ecological and legal obsolescence. As regards social obsolescence, it is difficult to estimate if the final impact would be positive or negative. Finally, there are initiatives such as XYT that demonstrate the intent to increase vehicle lifetime in the future.

# Conclusion

## Summary of the thesis

This master thesis aims at understanding and describing the obsolescence in the automotive industry, both currently and in the future. The thesis is divided into four parts.

In the first part, we review the literature about obsolescence that we define as all the techniques inducing a higher product replacement rate. We present a table summarizing ten categories in four main dimensions (i.e. economic, social, technological and ecological). In the economic dimension, we identify the situation where repair costs exceed the residual value of the product, which makes the replacement more attractive than its repair. Also, purchase subsidy mechanisms reduce the real price of the product to induce faster replacement. Social obsolescence refers to consumers' attraction to new products and marketing strategies that render the product psychologically obsolete. On the technological side, there are five categories comprising functional defects, obsolescence by notification, indirect obsolescence, software obsolescence and sophistication. Finally, ecological obsolescence refers to ecological arguments given to incentivize the replacement of the product. After that, we identify both positive and negative consequences of obsolescence and several solutions that could reduce the negative consequences.

The second part analyzes the automotive industry and its value chain, which comprises many actors. We describe four main trends that are likely to transform this industry in the future. These trends are Connected car, Autonomous car, Shared mobility and Electric car (CASE).

To analyze the current and future state of obsolescence in this sector, we conducted 35 semi-structured interviews to collect different points of view. We classify the respondents into eleven groups of actors in the automotive industry, based on value chain analysis.

Finally, the fourth part of this thesis is the qualitative analysis, divided into two sub-analyses.

Firstly, we give different arguments suggesting the presence or absence of the forms of obsolescence in the automotive industry. A fifth dimension, legal obsolescence, comes up, adding an eleventh category of obsolescence. The analysis indicates that economic, social, ecological and legal obsolescence would be present in the automotive industry while the technological dimension is more debated. Indeed, the price of repair can discourage customers to repair their cars. Recycling premiums and subsidies for greener cars are also a form of economic obsolescence that incentivizes the replacement of cars. Concerning social

obsolescence, consumers' desire for new cars and marketing strategies seem to be strongly present in the automotive industry. Rapid launches of new models and facelifts depreciate the value of the older models more quickly and annual motor shows contribute to the desire for new products. A stronger example of ecological obsolescence is the cheating of carmakers in lab tests measuring CO<sub>2</sub> emissions. Other examples are the promotion of new vehicles and electric vehicles although the environmental impact could be negative, depending on the situation, as well as greenwashing used by car manufacturers. With regards to legislations, there are regulations fostering a higher replacement rate of cars such as Low Emission Zones and laws promoting EVs, but there are also regulations favoring competition in the aftermarket. The only technological obsolescence that seems to be present in this industry is sophistication, due to the addition of components. Examples of functional defect and obsolescence by notification were given but these types are more controversial due to safety regulations and reputational risks. Finally, we want to remind that obsolescence is not always negatively connoted. It fosters innovations and technological improvements. Also, it can be justified to replace a functional car if it is more environmentally friendly. Besides, in the automotive industry, customers generally resell their vehicles in the second-hand market instead of scrapping them.

The second analysis enabled us to suggest impacts of the four trends on the situation of obsolescence. Overall, we expect a decrease of economic and technological obsolescence but an increase of legal obsolescence with regulations fostering the development of connected, autonomous and electric cars. We think that the major impact on social obsolescence would be due to shared mobility, by reducing car ownership and weakening brand image. The ecological dimension would be mainly impacted by the advent of electric vehicles but it needs further research to measure its environmental impact in each country.

### **Recommendations**

Based on this analysis, we would recommend individuals to move towards sharing mobility systems (e.g. P2P or B2C), as this could potentially reduce obsolescence. Then, we would recommend regulators to conduct an in-depth life-cycle analysis when introducing subsidies or legislations fostering the replacement rate of cars, based on ecological arguments. For instance, when pushing the development of EVs, they should evaluate the production, recycling and energy sources used. Also, as the four trends are likely to decrease economic and technological obsolescence, regulators should promote the development of these trends. However, instead of inducing a higher replacement rate by promoting a specific technology,

we believe that, for instance, technology-neutral policies could more accurately favor environmentally friendly technologies. Regulators could also incentivize carmakers to provide sharing mobility systems, as it is likely to decrease economic and technological obsolescence. Besides, they could favor initiatives such as modular cars that facilitate repair (e.g. XYT). Finally, with the advent of autonomous cars, the government could integrate them with public transports into a seamless mobility.

### **Limitations**

This thesis has some limitations. First, even if transcribing interviews tried to limit the degree of interpretation, there could still be subconscious bias when analyzing the transcripts. Also, there is always a part of interpretation when translating the transcripts quoted in this thesis. However, we tried to remain true to the words of the respondents. Besides, unfortunately, we did not have the possibility to interview digital players, who would play a role in the future automotive value chain and who could have given another point of view. Furthermore, this analysis was conducted mainly in Belgium, but it would be interesting to collect opinions at the European level. Also, conducting qualitative research does not allow us to generalize the findings. At the same time, our analysis aimed at developing new insights and understanding better the current and future situation of obsolescence in the automotive industry, which would not have been possible with quantitative research.

### **Further research**

In our view, this thesis could be considered as a preliminary analysis requiring further research. Our study could be complemented by quantitative research that would confirm or refute the arguments put forward, by measuring the presence of obsolescence or the impact of each trend on the different forms of obsolescence. For instance, quantitative research could be conducted to collect data about the replacement rate of cars and study the main reasons for car replacement or discard. Another quantitative survey could measure the impact of shared mobility on social obsolescence or the impact of connected cars, based on forecasts, on repair costs and the residual value of the car. Researchers could also identify different types of consumers and evaluate how belonging to one type or another influences their decision to replace their cars or not. Another study could thoroughly address the impact of leasing on the replacement rate of cars. Besides, there could be studies about the different initiatives (e.g. XYT) that might reduce obsolescence. Finally, it could be interesting to compute the optimal replacement rate of cars, based on a whole life cycle analysis.



## Bibliography

6 AVRIL 2010. - *Loi relative aux pratiques du marché et à la protection du consommateur*. (2010, April 6). Consulté le August 7, 2017, sur <http://www.wipo.int/edocs/lexdocs/laws/fr/be/be102fr.pdf>

Aboltins, K., & Rivza, B. (2014). The car aftersales market development trends in the new economy. *Procedia - Social and Behavioral Sciences*, pp. 341-352.

Adam, S., Bücker, C., Desguin, S., Madsen Vaage, N., & Saebi, T. (2017). *Taking part in the circular economy: four ways to designing circular business models*. Consulté le January 7, 2018, sur SSRN: <https://ssrn.com/abstract=2908107>

ADEME. (2012). *Etude sur la durée de vie des équipements électriques et électroniques*.

AG Insurance. (n.d.). *Aide à la conduite ? Primes d'assurances réduites !* Consulté le May 23, 2018, sur AG Insurance: <https://www.portalpack.aginsurance.be/sites/IBP2/SiteCollectionDocuments/BrokerDocuments/00792460600F.pdf>

Aladeojebi, T. (2013). Planned obsolescence. *International Journal of Scientific & Engineering Research*, 4, 1504-1508.

Alt, R., & Puschmann, T. (2016). Sharing economy. *Business & Information Systems Engineering*, 58 (1), pp. 93-99.

Alyavina, E., Kougias, I., Nikitas, A., & Tchouamou, E. N. (2017). How Can Autonomous and Connected Vehicles, Electromobility, BRT, Hyperloop, Shared Use Mobility and Mobility-As-A-Service Shape Transport Futures for the Context of Smart Cities? *Urban Science*, 1 (36), pp. 1-21.

Amabile, S., Conte, F., Siano, A., & Vollero, A. (2017). "More than words": Expanding the taxonomy of greenwashing after the Volkswagen scandal. *Journal of Business Research*, 71, 27-37.

Angwin, D., Fréry, F., Johnson, G., Regnér, P., Scholes, K., & Whittington, R. (2014). *Stratégique* (éd. 10e édition). Pearson France.

Archambeau, O. (2011). Le rôle structurant de l'industrie automobile dans l'émergence des nouveaux acteurs de la mondialisation. (The structuring role of the auto industry in the emergence of new actors in globalization). *Bulletin de l'Association de géographes français*, 88 (3), 258-278.

Automotive Electronics Council. (2014, September 11). *Failure mechanism based stress test qualification for integrated circuits*. Consulté le May 2, 2018, sur Automotive Electronics Council: [http://www.aecouncil.com/Documents/AEC\\_Q100\\_Rev\\_H\\_Base\\_Document.pdf](http://www.aecouncil.com/Documents/AEC_Q100_Rev_H_Base_Document.pdf)

Baron, S. (2013). Eco-conception, durabilité et analyse du cycle de vie: quelle réalité ? . Dans A. Diemer, C. Figuiere, & M. Pradel, *Ecologie politique vs écologie industrielle: quelles stratégies pour le développement durable?* Editions Oeconomia.

Biourge, C. (2017, November 28). *Véhicules diesel interdits à Bruxelles dès le 1er janvier 2018, période de tolérance prévue*. Récupéré sur RTBF:

[https://www.rtb.be/info/regions/detail\\_vehicules-diesel-interdits-a-bruxelles-des-le-1er-janvier-2018-periode-de-tolerance-prevue?id=9774965](https://www.rtb.be/info/regions/detail_vehicules-diesel-interdits-a-bruxelles-des-le-1er-janvier-2018-periode-de-tolerance-prevue?id=9774965)

Blandin, M.-C. (2016). *100 millions de téléphones portables usagés : l'urgence d'une stratégie*. Récupéré sur Sénat: [http://www.senat.fr/rap/r15-850/r15-850\\_mono.html#toc82](http://www.senat.fr/rap/r15-850/r15-850_mono.html#toc82)

Bomey, N. (2016). *Feds: Cars must be able to talk to each other*. Récupéré sur USA Today: <https://www.usatoday.com/story/money/cars/2016/12/13/self-driving-cars-vehicle-to-vehicle-technology-v-to-v-nhtsa-autonomous-cars-v2v/95367310/>

Book, M., Ellul, E., Ernst, C., Frowein, B., Kreid, E., Rilo, R., et al. (2012, July). *The European Automotive Aftermarket Landscape*. Récupéré sur The Boston Consulting Group: <https://www.bcg.com/documents/file111373.pdf>

Boumphrey, S., & Brehmer, Z. (2017). *Megatrend analysis: putting the consumer at the Heart of Business*. Euromonitor International.

Boyacı, B., Geroliminis, N., & Zografos, K. (2015). An optimization framework for the development of efficient one-way car-sharing systems. *European Journal of Operational Research* , 240 (3), 718-733.

Brönneke, T. (2017). Premature Obsolescence: Suggestions for Legislative Counter-measures in German and European Sales & Consumer Law. *Journal for european environmental & planning law* , 14 (3-4), pp. 361-372.

Brouillat, E. (2015). Live fast, die young? Investigating product life span and obsolescence in an agent-based model. *Journal of Evolutionary Economics* , 25, 447-473.

Campbell, C. (1992). The desire for the new. *Consuming technologies: Media and information in domestic spaces* , 48-63.

Cape, F., Fayolle, D., Forestier, B., Le Clercq, G., & Pouponneau, M. (2016). *Les zones à faibles émissions (Low Emission Zones) à travers l'Europe : déploiement, retours d'expériences, évaluation d'impacts et efficacité du système*. ADEME.

Capgemini consulting. (2010). *The Aftermarket in the Automotive Industry How to Optimize Aftermarket Performance in Established and Emerging Markets*. Consulté le May 22, 2018, sur Capgemini: [https://www.capgemini.com/wp-content/uploads/2017/07/tl\\_The\\_Aftermarket\\_in\\_the\\_Automotive\\_Industry.pdf](https://www.capgemini.com/wp-content/uploads/2017/07/tl_The_Aftermarket_in_the_Automotive_Industry.pdf)

Cathles, E., Corwin, S., Kelly, E., & Vitale, J. (2015). *The future of mobility*. Récupéré sur Deloitte: [https://www2.deloitte.com/content/dam/Deloitte/br/Documents/manufacturing/Future\\_of\\_mobility.pdf](https://www2.deloitte.com/content/dam/Deloitte/br/Documents/manufacturing/Future_of_mobility.pdf)

Cathles, E., Corwin, S., Kelly, E., & Vitale, J. (2015). *The future of mobility: How transportation technology and social trends are creating a new business ecosystem*. Deloitte.

Center for Automotive Research. (2016). *The Impact of New Mobility Services on the Automotive Industry*. Cargroup, Ann Arbor.

Centre Européen de la Consommation. (2013). *L'obsolescence programmée ou les dérives de la société de consommation*.

- Centre permanent pour la Citoyenneté et la participation. (2013). *L'obsolescence programmée: portrait robot*. (A. quotidien, Ed.) From file:///C:/Users/BE105141/Downloads/obsolescenceprogrammee.pdf
- Centre Permanent pour la Citoyenneté et la Participation. (2014). *STOP à l'obsolescence programmée! Mode d'emploi*. Récupéré sur <http://www.cpcp.be/medias/pdfs/publications/obsolescenceprogrammee2.pdf>
- Chadwick, B., Gill, P., Stewart, K., & Treasure, E. (2008). Methods of data collection in qualitative research: Interviews and focus groups. *BDJ*, 204 (6), pp. 291-295.
- Chambre des représentants de Belgique. (2012, February 12). *Proposition de loi modifiant la loi du 6 avril 2010 relative aux pratiques du marché et à la protection du consommateur, concernant l'information des consommateurs en matière d'obsolescence des biens de consommation*. Récupéré sur Lachambre: <http://www.lachambre.be/FLWB/PDF/53/2060/53K2060001.pdf>
- Chan, N., & Shaheen, S. (2015). *Mobility and the sharing economy: impacts synopsis*. Transportation Sustainability Research Center.
- Cohen, B., & Kietzmann, J. (2014). Ride On! Mobility Business Models for the Sharing Economy. *Organization & Environment*, 27 (3), pp. 279-296.
- Cooper, T. (2010). *Longer Lasting Products: Alternatives To The Throwaway Society*. Gower Publishing.
- Coppola, R., & Morisio, M. (2016, October). Connected car: technologies, issues, future trends. *ACM Computing surveys*, 49 (3), pp. 1-36.
- Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: techniques and procedures for developing grounded theory* (éd. 4th edition). Los Angeles: Sage.
- Courbe, P. (2011). *Voitures de société: oser la réforme!* Namur, Belgique: Fédération Inter-Environnement Wallonie.
- Dalhammar, C., & Maitre-Ekern, E. (2016). Regulating Planned Obsolescence: A Review of Legal Approaches to Increase Product Durability and Reparability in Europe. *Review of European, Comparative & International Environmental Law*, 25 (3), pp. 378-394.
- Dejong, M. (2014). *Stop à l'obsolescence programmée !* Centre Permanent pour la Citoyenneté et la participation.
- Déméné, C., & Marchand, A. (2015). L'obsolescence des produits électroniques: des responsabilités partagées. *The Ethics Forum*, 10 (1), 4-32.
- Dhall, R., & Solanki, V. (2017). An IoT Based Predictive Connected Car Maintenance Approach. *International Journal of Interactive Multimedia and Artificial Intelligence*, 4 (3), 16-22.
- Dimache, A., & Roche, T. (2009). Implications of the Transition to a Product-Service System on the Business Model. *16th CIRP International Conference on Life Cycle Engineering*.
- Dirlea, R., Huang, L., Inampudi, S., Kaas, H.-W., Laverty, N., Newman, J., et al. (2014). *Connected cars: exploring infotainment trends*. Consulté le Februari 15, 2018, sur McKinsey & Company: <http://autoassembly.mckinsey.com>

- Duvall, L., McIntyre, K., & Opsomer, T. (2016). *Empowering repair*.
- European Automobile Manufacturers Association. (2017). *The automobile industry pocket guide*. Consulté le February 20, 2018, sur ACEA:  
[http://www.acea.be/uploads/publications/ACEA\\_Pocket\\_Guide\\_2017-2018.pdf](http://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2017-2018.pdf)
- European Automotive Manufacturers Association. (2017). *ACEA Report Vehicles in use Europe 2017*. Consulté le February 22, 2018, sur Acea:  
[http://www.acea.be/uploads/statistic\\_documents/ACEA\\_Report\\_Vehicles\\_in\\_use-Europe\\_2017.pdf](http://www.acea.be/uploads/statistic_documents/ACEA_Report_Vehicles_in_use-Europe_2017.pdf)
- European automotive manufacturers association. (n.d.). *Euro standards*. Récupéré sur ACEA:  
<http://www.acea.be/industry-topics/tag/category/euro-standards>
- European commission. (2018). *Automotive industry*. Consulté le 05 15, 2018, sur European commission: [https://ec.europa.eu/growth/sectors/automotive\\_fr](https://ec.europa.eu/growth/sectors/automotive_fr)
- Eurostat. (2017). *Population and population change statistics* . Consulté le February 22, 2018, sur Eurostat: [http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population\\_and\\_population\\_change\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_population_change_statistics)
- Ezratty, O. (2016). *Rapport du CES 2016*. International CES.
- Fabre, M., & Winkler, W. (2010). *L'obsolescence programmée, symbole de la société de gaspillage. Le cas de produits électriques et électroniques*. Les amis de la Terre.
- Fagnant, D., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A* , 77, pp. 161-181.
- Fairphone. (n.d.). *The modular phone that's built to last*. Récupéré sur Fairphone:  
<https://www.fairphone.com/en/>
- Febiac. (2017). *Datadigest 2017*. Récupéré sur Febiac:  
<http://www.febiac.be/public/statistics.aspx?FID=23>
- Febiac. (n.d.). *Qui est Febiac?* Consulté le May 10, 2018, sur Febiac:  
<http://www.febiac.be/public/infos.aspx?FID=11&lang=FR>
- Frost & Sullivan. (n.d.). *World's Top Global Mega Trends To 2025 and Implications*.
- Frowein, B., Lang, N., Schmieg, F., & Sticher, G. (2014, July). *Returning to growth*. Récupéré sur The Boston Consulting Group.
- Gao, P., Kaas, H.-W., Mohr, D., Möller, T., & Wee, D. (2016, January). *Automotive revolution –perspective towards 2030*. Récupéré sur McKinsey & Company:  
<https://www.mckinsey.com/~media/mckinsey/industries/high%20tech/our%20insights/disruptive%20trends%20that%20will%20transform%20the%20auto%20industry/auto%202030%20report%20jan%202016.ashx>
- Glansdorff, F., & Legros, P. (2014). *Liber Amicorum*. Bruxelles: Bruylant.
- Glenn, D. (2016). *TechZulu: The autonomous Car: Bringing you Luxury, Convenience and... Obsolescence ?* Retrieved 2017 йил 8-july from Newstex Trade & Industry Blogs:  
<http://techzulu.com/autonomus-car-luxury-convenience-obsolescence/>

Grosse-Ophoff, A., Hausler, S., Heineke, K., & Möller, T. (2017). *How shared mobility will change the automotive industry*. Retrieved 2017 йил 17-July from McKinsey & Company: <http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry>

Gultinan, J. (2009). Creative Destruction and Destructive Creations: Environmental Ethics and Planned Obsolescence. *Journal of Business Ethics* , 19-28.

Høyer, K. (2008). The history of alternative fuels in transportation: The case of electric and hybrid cars. *Utilities policy* , 16 (2), pp. 63-71.

Habeck, A., Hehensteiger , M., Hölz, J., Kaas, H.-W., Kässer, M., Newman, J., et al. (2014). *The impact of connected cars on OEM Market Shares*. From McKinsey & Company: [https://autoassembly.mckinsey.com/ourknowledge/industry/Automotive+Retailing/view/The\\_Impact\\_of\\_Connected\\_Cars\\_on\\_OEM\\_Market\\_Shares](https://autoassembly.mckinsey.com/ourknowledge/industry/Automotive+Retailing/view/The_Impact_of_Connected_Cars_on_OEM_Market_Shares)

Haber, J.-P., & Libaert, T. (2013, October 13). *Opinion of the European Economic and Social Committee on Towards more sustainable consumption: industrial product lifetimes and restoring trust through consumer information (own-initiative opinion)*. Consulté le August 2, 2017, sur European Economic and Social Committee: <http://www.eesc.europa.eu/resources/docs/qe-02-13-764-en-c--4.pdf>

Hadhazy, A. (2016). *Here's the truth about the 'planned obsolescence' of tech*. Consulté le January 3, 2018, sur BBC: <http://www.bbc.com/future/story/20160612-heres-the-truth-about-the-planned-obsolescence-of-tech>

Hawkins, T. R., Majeau-Bettez, G., Singh, B., & Strømman, A. H. (2013). Comparative environmental life cycle assessment of conventional and electric vehicles. *Journal of Industrial Ecology* , 17 (1), 53-64.

Heineke, K., Kampshoff, P., Mkrtchya, A., & Shao , E. (2017, May). *Self-driving car technology: When will the robots hit the road?* Consulté le February 2018, sur McKinsey & Company: <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/self-driving-car-technology-when-will-the-robots-hit-the-road>

Hodges , A., & Taylor, P. (2005). Science and technology law review. *The Columbia Science and Technology Law Review* , VI.

Howard, B. C. (2010). *Planned Obsolescence: 8 Products Designed to Fail*. Consulté le January 4, 2018, sur Popular Mechanics: <http://www.popularmechanics.com/technology/g202/planned-obsolescence-460210/?slide=7>

Howleg, M., & Kattuman, P. (2006). *Dynamic determination of the residual value product: Empirical evidence from the automotive industry*. Récupéré sur <https://www.pomsmeetings.org/confpapers/004/004-0144.pdf>

Insurance Europe. (2015, November). *European Motor Insurance Markets*. Consulté le May 5, 2018, sur Insurance Europe: <https://www.insuranceeurope.eu/sites/default/files/attachments/European%20motor%20insurance%20markets.pdf>

International Energy Agency. (2017). *Global EV Outlook 2017*.

International Transport Forum. (2015). *Urban Mobility System Upgrade How shared self-driving cars could change city tra c*. Consulté le May 20, 2018, sur Itf-oecd: [https://www.itf-oecd.org/sites/default/files/docs/15cpb\\_self-drivingcars.pdf](https://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf)

Jo, K., Kim, J., Kim, D., Jang, C., & Sunwoo, M. (2014, December). Development of Autonomous Car—Part I: Distributed System Architecture and Development Process. *IEEE Transactions on industrial electronics* , 61 (12), pp. 7131-7140.

KPMG International. (2014). *Future state 2030: the global megatrends shaping governments*. .

KPMG International. (2012). *KPMG's Global Automotive Executive Survey 2012*.

Leduc, G., Mongelli, I., Nemry, F., & Uihlein, A. (2008). *Enrionmental Improvement of Passenger Cars (IMPRO-cars)*. JRC Scientific and Technical Reports.

Legifrance. (2015). *LOI n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte (1) – Article 99*. Retrieved 2017 йл 19-July from [https://www.legifrance.gouv.fr/eli/loi/2015/8/17/DEVX1413992L/jo/article\\_99](https://www.legifrance.gouv.fr/eli/loi/2015/8/17/DEVX1413992L/jo/article_99)

Lejeune, C. (2014). *Manuel d'analyse qualitative: analyser sans compter ni classer*. Louvain-la-Neuve: De boeck.

Les amis de la terre. (n.d.). *Vite acheté vite à jeter: conséquences*. Récupéré sur [http://www.amisdelaterre.be/obsolescence\\_programmee/consequences.html](http://www.amisdelaterre.be/obsolescence_programmee/consequences.html)

Libaert, T. (2015). Consommation et controverse: le cas de l'obsolescence programmée. *Hermès* , 73, pp. 151-158.

Libaert, T., & Haber, J.-P. (2013). *Opinion of the European Economic and Social Committee on 'Towards more sustainable consumption: industrial product lifetimes and restoring trust through consumer information*. From Eur-Lex: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013IE1904>

L'observatoire Cetelem. (2015). *Marché automobile mondial: de belles perspectives de croissance*.

L'observatoire Cetelem. (2016). *Voiture autonome: les automobilistes prêts à lâcher le volant pour la Silicon Valley*.

*Loi relative aux normes de produits ayant pour but la promotion de modes de production et de consommation durables et la protection de l'environnement*. (1998, December 21).

Récupéré sur Ejustice:

[http://www.ejustice.just.fgov.be/cgi\\_loi/change\\_lg.pl?language=fr&la=F&cn=1998122141&table\\_name=loi](http://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=fr&la=F&cn=1998122141&table_name=loi)

London, S., Padhi, A., & Tschiesner, A. (2017, December). *How the auto industry is preparing for the car of the future*. Consulté le January 8, 2018, sur Mc Kinsey & Company: <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-the-auto-industry-is-preparing-for-the-car-of-the-future>

Manzetti , S., & Mariasi, F. (2015). Electric vehicle battery technologies: From present state to future systems. *Renewable and Sustainable Energy Reviews* , 51, pp. 1004-1012.

Maycroft, N. (n.d.). *Consumption, planned obsolescence and waste*. University of Lincoln.

- McKinsey & Company. (2017). *Electrifying insights: How automakers can drive electrified vehicle sales and profitability*.
- McKinsey&Company. (2015). *Competing for the connected customer - perspectives on the opportunities created by a car connectivity and automation*. Advanced Industries.
- Mencarelli, S. (2018, March 29). La voiture électrique, moins polluante? (W. Bouchard, Intervieweur)
- Meunier, E. (2017, December 8). *Pour un véritable accès aux informations sur la réparation et l'entretien des véhicules*. Récupéré sur Halte à l'obsolescence: <https://www.halteobsolescence.org/veritable-acces-aux-informations-reparation-lentretien-vehicules/>
- Mucchielli, A., & Paillé, P. (2016). *L'analyse qualitative en sciences humaines et sociales* (éd. 4th edition). (A. Colin, Éd.)
- Nextcontinent. (2016). *Automotive finance study 2016: the European market and its future challenges*. Consulté le May 23, 2018, sur Nextcontinent: <http://www.nextcontinent.net/publications/automotive-finance-study-2016/download>
- Nies, P., & Vanhaelewyn, J. (2017). 6000 fois trop vite usé. Dans T. Achats, *Les ratés des grandes marques* (pp. 20-23).
- Nourinejad, M., & Roorda, M. J. (2015). Carsharing operations policies: a comparison between one-way and two-way systems. *42* (3), 497-518.
- Novikova, O. (2017). The Sharing Economy and the Future of Personal Mobility: New Models Based on Car Sharing. *Technology Innovation Management Review* , 7 (8), pp. 27-31.
- ONU. (2017). *Déchets électroniques : face à une hausse de 8%, l'ONU appelle à un meilleur recyclage*. Récupéré sur Centre d'actualités de l'ONU: <http://www.un.org/apps/newsFr/storyF.asp?NewsID=40660#.WnAuyajiZPY>
- Pagès, E. (2011). *L'obsolescence programmée de l'automobile?* Consulté le January 11, 2018, sur Automobile et sécurité routière: <http://auto-et-sociologie.over-blog.fr/article-l-obsolescence-programmee-de-automobile-71566020.html>
- Pope, K. (2017). *Understanding planned obsolescence: unsustainability through production, consumption and waste generation*. Great Britain: Kogan Page Limited.
- Poullikkas, A. (2015). Sustainable options for electric vehicle technologies. *Renewable and Sustainable Energy Reviews* , 41, pp. 1277-1287.
- Proposition de loi modifiant le Code civil et le Code de droit économique, visant à lutter contre l'obsolescence programmée.* (2016, January 22). Consulté le August 9, 2017
- Proposition de loi relative à l'obsolescence programmée.* (2016, April 20). Consulté le August 9, 2017, sur <http://www.dekamer.be/FLWB/PDF/54/1783/54K1783001.pdf>
- PWC. (2018). *Five trends transforming the Automotive Industry*. Consulté le May 24, 2018, sur European Innovation Partnership on Smart Cities and Communities: <https://eu-smartcities.eu/sites/default/files/2018-03/pwc-five-trends-transforming-the-automotive-industry.compressed.pdf>

- RDC environnement. (2017). *L'obsolescence programmée : politiques et mesures belges de protection du consommateur*.
- Rédaction Turbo. (2014, November 26). *Technologie: Le pneu increvable de Michelin (Emission Turbo du 23/11/2014)*. Récupéré sur Turbo: <http://www.turbo.fr/videos-voiture/458409-technologie-le-pneu-increvable-de-michelin-emission-turbo-du-23-11-2014.html>
- Renta. (n.d.). *A propos de Renta*. Récupéré sur Renta: <http://www.renta.be/fr/propos-de-renta>
- Richardson, D. B. (2013). Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration. *Renewable and Sustainable Energy Reviews*, 19.
- Rolland, P. (n.d.). *L'éco-conception et le recyclage du véhicule automobile*. Récupéré sur Dupuis62.free: <http://dupuis62.free.fr/doc3eme/P-Rolland-Renault.pdf>
- Samsung Electronics Co. (2015). *The connected vehicle comes of age*. Samsung.
- Scharff, C. (2017, November 5). *"Encourager massivement la voiture électrique est tout à fait prématuré"*. Récupéré sur L'Echo: <https://www.lecho.be/entreprises/auto/Encourager-massivement-la-voiture-electrique-est-tout-a-fait-premature/9950128>
- Sénat de Belgique. (2011, October 11). *Proposition de résolution en vue de lutter contre l'obsolescence programmée des produits liés à l'énergie*. Consulté le August 2, 2017, sur Senate: <http://www.senate.be/www/?MIval=/publications/viewPub&TID=83889730&LANG=fr>
- Slade, G. (2006). *Made to Break: Technology and Obsolescence in America*. Harvard University Press.
- Society of Automotive Engineers. (n.d.). *Automated driving*.
- SPF Économie, PME, Classes moyennes et Énergie. (2017). *Rapport complémentaire électricité*.
- SPF mobilité. (n.d.). *A propos*. Récupéré sur SPF mobilité: <https://mobilit.belgium.be/fr/apropos>
- Srivastava, A., & Thomson, S. B. (2009). Framework analysis: a qualitative methodology for applied policy research. *JOAAG*, 4 (2).
- TF1. (2017, May 5). *15 € l'unité : une casse automobile brade des pièces détachées le temps d'une journée*. Récupéré sur LCI: <https://www.lci.fr/societe/15-eur-l-unite-une-casse-automobile-brade-des-pieces-detachees-le-temps-d-une-journee-2051082.html>
- The European Parliament. (2017, July 4). *European Parliament resolution of 4 July 2017 on a longer lifetime for products: benefits for consumers and companies*. Consulté le August 8, 2017, sur European Parliament: <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2017-0287+0+DOC+XML+V0//FR&language=FR>
- The European Parliament and of the Council of European Union. (2011, October 25). *Directive 2011/83/EU on consumer rights*. Récupéré sur Eur-Lex: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011L0083>



The European Parliament and the Council of the European Union. (2006, September 6). *Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC (Text with EEA relevance)*. Récupéré sur Eur-Lex: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0066>

The European Parliament and the Council of the European Union. (2008, November 19). *Directive 2008/98/EC on waste and repealing certain*. Récupéré sur Eur-Lex: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098>

The European Parliament and the Council of the European Union. (2009, October 21). *Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products*. Récupéré sur Eur-Lex: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF>

The European Parliament and the Council of the European Union. (2007, June 20). *Regulation (EC) No 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information*. Récupéré sur Eur-Lex: <http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32007R0715>

Transport & Environment. (2016, September). *Dieselgate: Who? What? How?* Consulté le May 23, 2018, sur Transport & Environment: [https://www.transportenvironment.org/sites/te/files/2016\\_09\\_Dieselgate\\_report\\_who\\_what\\_how\\_FINAL\\_0.pdf](https://www.transportenvironment.org/sites/te/files/2016_09_Dieselgate_report_who_what_how_FINAL_0.pdf)

Traxio. (n.d.). *Qui sommes-nous?* Récupéré sur Traxio: <http://www.traxio.be/fr/qui-sommes-nous/>

Vasseur, L. (2017). *La société du futur?* Récupéré sur Halte à l'obsolescence programmée: <https://www.halteobsolescence.org/quelle-societe-du-futur/>

Waldman, M. (1993). A new perspective of planned obsolescence. *The Quarterly Journal of Economics* , 108 (1), 273-283.

Waldman, M. (2003). Durable Goods Theory for Real World Markets. *Journal of Economic Perspectives* , 17 (1), 131-154.

Wieser, H. (2016). Beyond planned obsolescence: Product lifespans and the challenges to a circular economy. *GAIA - Ecological Perspectives for Science and Society* , 25 (3), pp. 156-160.

XYT. (n.d.). XYT. Consulté le July 18, 2017, sur XYT: <http://www.xyt.fr/>

# Appendix

## Appendix 1: Legislation regarding obsolescence

### *a. Laws regarding obsolescence at the European level*

Although the majority of these directives and regulation do not restrict the use of planned obsolescence, it tries to act somehow against it, and reduce its negative consequences.

Glansdorff & Legros (2014) believe that the directive 2005/29/EC on unfair B2C practices used by companies is a way to protect consumers against planned obsolescence, even if this term is never mentioned in the text. The absence of information on the artificial reduction of product lifetime could be considered as an unfair practice.

In 2006, the directive on batteries, accumulators, waste batteries, accumulators and repealing tries to reduce the environmental impact of batteries. Therefore, it fixed objectives of reaching at least 25% collection rate by 2012 and 45% by 2016. Furthermore, this law acts against the use of non-detachable batteries (Glansdorff & Legros, 2014). The article 11 of the directive 2006/66/CE states that “*Member States shall ensure that manufacturers design appliances in such a way that waste batteries and accumulators can be readily removed*” (The European Parliament and the Council of the European Union, 2006).

In the automotive sector, the regulation 715/2007 aims at facilitating vehicle repair. As stated in article 6 of this regulation, “*manufacturers shall provide unrestricted and standardised access to vehicle repair and maintenance information to independent operators through websites*” (The European Parliament and the Council of the European Union, 2007). However, in practice, the European Commission has discovered that manufacturers do not observe this regulation. None of them has created a website that provides repair and maintenance information. Only independent workers provide incomplete information at excessive prices. Repair workers face thus some issues to identify the spare parts needed. This makes repair more costly (Meunier, 2017).

The directive 2008/98/EC aims at reducing the amount of waste through waste management. According to article 8, Member States are allowed to take some measures to ensure an extended producer responsibility (e.g. take back the remaining waste of a spent product), to incentivize product designs that “*reduce their environmental impacts and the generation of waste*” as well as promoting repair and reuse activities (The European Parliament and the Council of the European Union, 2008).

One year later, the European Parliament and the Council of the European Union launched another directive, related to eco-conception. To reduce pollution, this directive establishes a framework for product requirements (The European Parliament and the Council of the European Union, 2009).

In 2011, a directive concerning consumer rights was introduced. The article 5 mentions that the trader has to provide information to its customers, such as the characteristics of the product, before being bonded by a contract (The European Parliament and of the Council of European Union, 2011).

Finally, more recently, on July 4, 2017, the European Parliament passed a resolution to lengthen product lifetimes. This resolution is comprised of seven parts. The first part is about the design of robust, high-quality and long-lasting products, by for instance encouraging modularity. The second is about facilitating repair and maintenance. Then, it aims at promoting economic models based on usage and better inform consumers (The European Parliament, 2017). They also call on the Commission to introduce measures for planned obsolescence and to “*propose [...] an EU-level definition of planned obsolescence for tangible goods and software*”. Moreover, they want consumers to be informed about the legal guarantee of conformity. The last part concerns the obsolescence of software for which transparency is needed concerning the evolution and updates (The European Parliament, 2017).

#### ***b. Laws regarding obsolescence in Belgium***

It started in December 21, 1998, with the introduction of a law regarding product standards. In the article 4 of this law, it requires the design of products in such a way that it does as little waste as possible (Loi relative aux normes de produits ayant pour but la promotion de modes de production et de consommation durables et la protection de l'environnement, 1998). Aforementioned, planned obsolescence is responsible for the increase in amounts of waste. Therefore, Glansdorff & Legros (2014) suggest that this article could be used as a basis to ban planned obsolescence.

The law on 6 April, 2010 deals with the loyalty of manufacturers, who have to provide the right information to customers. More particularly, the 88<sup>th</sup> article concerns misleading commercial practices with information including repair services and replacement parts (6 AVRIL 2010. - Loi relative aux pratiques du marché et à la protection du consommateur , 2010). A proposition in 2012 was introduced to modify the law on 6 April 2010, by adding an

article 18/1. This article states that every seller has to display the normal period of use on the product. Then the consumer could be properly informed before making his choice (Chambre des représentants de Belgique, 2012).

Furthermore, Belgium was considered as a pioneer in battling planned obsolescence due to a proposition made by Muriel Targnion in 2011 to fight against planned obsolescence of energy-related products (Centre Européen de la Consommation, 2013; Sénat de Belgique, 2011). In this document, after explaining the development of planned obsolescence, she proposed to the government to “*adopt a royal decree based on the law of 21 December 1998 [...] that would impose the display of the product lifetime and repair features*” [Our translation] (Sénat de Belgique, 2011). At the European level, she also wanted the discouragement of irreparable products (Sénat de Belgique, 2011). In 2012, the senate modified the proposition and finally adopted it. However, it had no significant impact since there is no prohibition (Déméné & Marchand, 2015). The European Economic and Social Committee reunited a lot of experts to address this issue. They finally voted an opinion on 13 October, 2013 that “*calls for a total ban on planned obsolescence*” (Haber & Libaert, 2013).

In 2016, three propositions have been submitted to fight against planned obsolescence. In January, the cdH proposed to extend the guarantee period but also to display product lifetime and reparability features. On 11 April, Ecolo also introduced a proposition and only nine days after, the PS followed the path (RDC environnement, 2017). In their propositions, they go further by mentioning penalties and sentences (Proposition de loi relative à l’obsolescence programmée, 2016; Proposition de loi modifiant le Code civil et le Code de droit économique, visant à lutter contre l’obsolescence programmée, 2016).

To prevent planned obsolescence proactively, in 2017, RDC Environment (2017) developed an action plan for Belgium divided into three objectives as shown on figure 13, namely ecoconception, better use and repair of products.

As illustrated on figure 13, actions promoted by RDC Environment, are divided into three specific measures. The first one being informative, it includes measures regarding the display of information. The second category concerns normative measures, which is related to the possibilities in terms of norms or laws. The third category includes economic measures

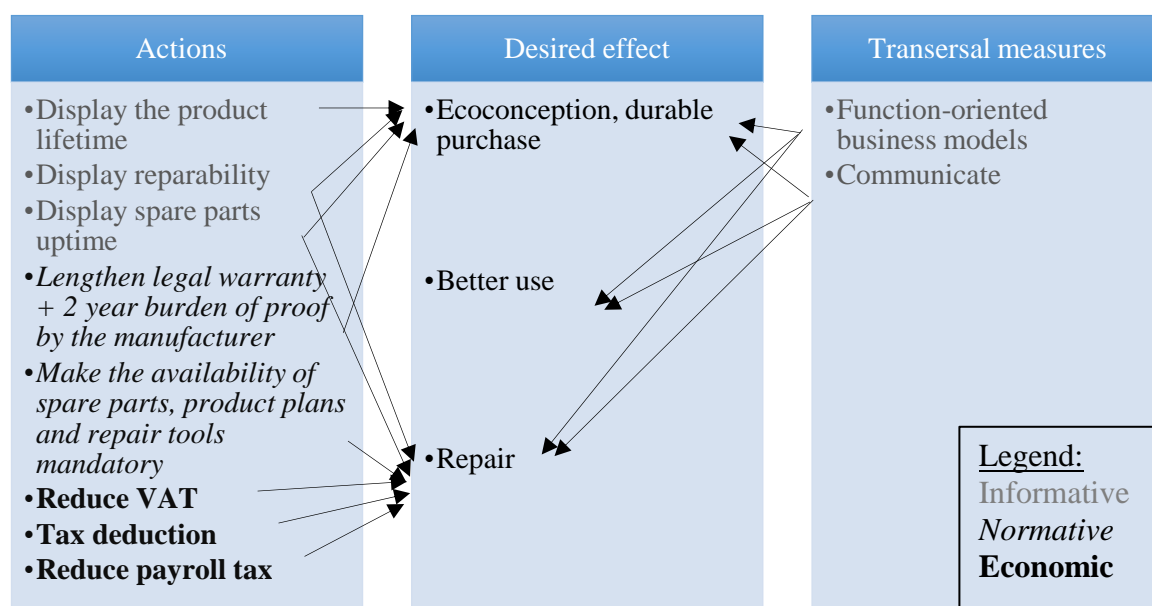


Figure 13: Action plan in Belgium, adapted from RDC Environment, 2017

Regarding informative measures, by giving more information to consumers, they could knowingly make their product choice, regarding the lifetime of product, ease of repair and uptime of spare parts. They could, for instance, consider the lifetime of the product as a criterion and choose long-lasting products, even if the price is higher (RDC environnement, 2017). To measure the lifetime of the product, those related to the usage of the product (e.g. number of washes of a washing machine) would be the most representative criteria (Centre Permanent pour la Citoyenneté et la Participation, 2014).

Products prices are not real indicators of their durability. By giving more information about product lifetime, consumers would be incentivized to consider this as a purchase criteria when making their decision. However, there are risks related to this, as consumers may buy durable products but still prematurely get rid of them. Also, prices could be higher, becoming an obstacle to their purchase since consumers are getting more and more accustomed to cheap products. Moreover, no universal methodology exists to estimate product lifetime, making it difficult for manufacturers to display lifetime reliably (Déméné & Marchand, 2015).

Then, concerning normative measures, RDC Environment suggests the lengthening of the two-year legal warranty and the burden proof. Currently, between six months and two years, it is the consumer who has to prove that the defect was present before purchasing it and not due to a misuse. Another measure is to “*guarantee the availability of spare parts, products*’

*technical descriptions and tools necessary for repair*” [Our translation] (RDC environnement, 2017, p. 90). This measure would facilitate repair to extend the product lifetime.

Finally, economic measures involve the reduction of VAT and payroll tax at the European level and tax deduction to facilitate repair activities. The idea is that consumers could deduct their repair costs from their taxes, and the reduction of VAT and social security contributions would decrease repair prices (RDC environnement, 2017).

As regards the transversal measures, instead of selling a product, function-oriented business models consist in selling a service offered by the product. The effect of this economic model will be discussed in section 1.6. Communication will also help to reach desired effects by raising awareness to consumers about these practices (RDC environnement, 2017).

However, one has to wonder if consumers will be responding to these actions. For instance, will the consumer pay attention to the label displaying availability of spare parts, product lifetime and reparability? Will he really bring the product back for repair? When consumers are considering the purchase of a product, this decision is influenced by a number of factors such as the price, brand, social norms and others. Will they include product lifetime in their set of criteria?

## **Appendix 2: Mobility service providers definition**

The following definitions are taken from a report undertaken by the Center for Automotive Research (Center for Automotive Research, 2016).

- a. Ridehailing services (e.g. Uber) rely on smartphone apps to connect paying passengers with drivers who provide rides (for a fee) in their private vehicles.
- b. Ridesharing (e.g. Blablacar) is a type of carpooling that uses private vehicles, arranging shared rides on short notice between travelers with a common origin and/or destination.
- c. Carsharing (e.g. . Zipcar, Car2go) is a short-term car rental, often by the hour. Electronic systems allow unattended access to the vehicles. Gasoline and insurance are included in this type of service. These characteristics distinguish carsharing from traditional car rental. Carsharing can be round-trip, one-way, free-floating or station-based.
- d. Bikesharing (e.g. Motivate) is a system that provides free or affordable access to bicycles for short-distance trips, mostly in urban areas. Most programs are organized either by local non-profit organizations or by public agencies.
- e. Microtransit (e.g. Bridj) is a wide category encompassing various private transit services that use small buses and develop flexible routes or schedules (or both) based on customer demand.
- f. Mobility-as-a-service (MaaS) (e.g. MaaS Global) is a mobility distribution model in which a person's transportation needs are met over one interface and are offered by a service provider.
- g. Shared autonomous vehicles (SAVs) are fully self-driving vehicles that do not need human operation, other than providing information regarding the destination of the trip.

## Appendix 3: European aftermarket landscape

### EXHIBIT 2 | Overview of European aftermarket landscape Aftermarket divided into authorized and independent channels

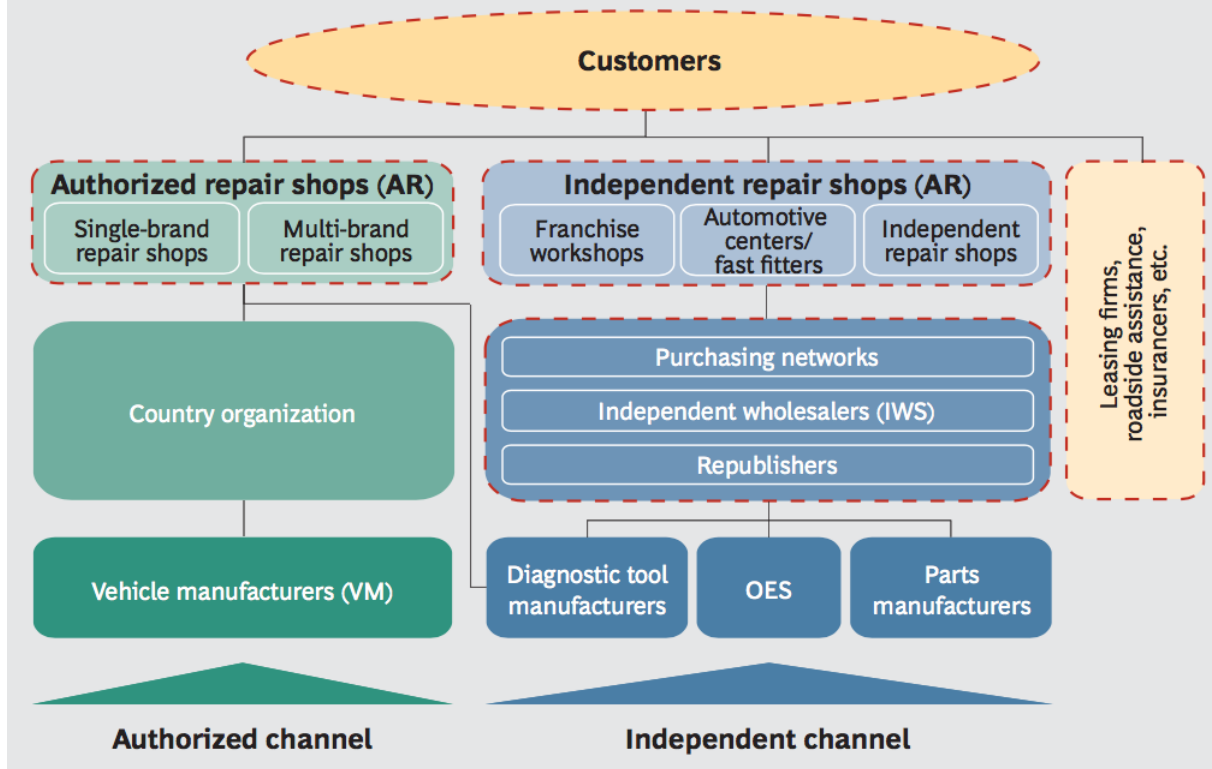


Figure 14: European aftermarket landscape (Book, et al., 2012)



## Appendix 4: Categories of experts interviewed and information about interviewees

	Name of experts	Company	Function
<b>Obsolescence expert</b>	Thierry Libaert	Comité Economique et Social Européen	Member
<b>Car manufacturers</b>	Christophe Vloeberg	Daimler	Press relations
	Erik Van den Heuvel,	Smart	Former marketing manager
	Anonym	Car manufacturer	Product and pricing
	David Carlier	Audi	Industrial Engineering Montage
	Hiep Le	Audi	Sales people
	Anonym	Car manufacturer	After-sales manager
	Delphine Awouters	Subaru	Marketing manager
<b>Independent channel</b>	Frédéric	Eiffeling garage	Independent repairer
	Anonym	Wolu master car	Independent repairer
	Anonym	Vanderveken	Old-timer repairer
	Anonym	Garage Montald	Independent repairer
<b>Authorized channel</b>	Anonym	CarWolu, Opel authorized repairer	Worker
	Benjamin Abeloos	AB automotive, Ford dealership	Dealer
<b>Car-sharing companies</b>	Sven Heyen	Drive-Now	Manager Corporate Development
	Morena Kcmar	Drivy	Marketing & Communication manager
<b>Connectivity companies</b>	Yassin Korchi	Waykonect	CEO, co-founder
<b>Automobile federations</b>	Laurent Demilie,	SPF mobilité	Advisor in sustainable mobility
	David Schoenmakers	SPF mobilité	Advisor in the automotive industry
	Pierre Courbe	Inter-Environnement Wallonie	Mobility mission responsible

	Joost Kaesemans,	Febiac	Communication director
	Philippe Decrock	Traxio	Spokesperson, senior company lawyer, new mobility
	Anonym	End-of-life vehicle recycling organization	Director
<b>Electronics companies</b>	Anonym	High temperature electronic company	Co-founder
	Jean-Pierre Raskin	UCL	Professor specialized in microelectronics
	Denis Flandre	UCL	Professor specialized in microelectronics
<b>Vehicle leasing companies &amp; association</b>	Frank Van Gool	Renta	General manager
	Anonym	Leasing company	Sales & Marketing Manager
<b>Automotive suppliers</b>	Thierry Jupsin	Bridgestone	Brand marketing
	Rolf Gervelmeyer	AGC Glass Europe	Advanced design manager
	Dominique Coster	AGC Glass Europe	New project manager, specialized in electric vehicle
<b>Journalists / automotive passionate</b>	John Quain	New York Times	Reporter
	Philippe Casse	/	Automotive historian
	Laurent Vandievoet	AGC Glass Europe	Car passionate
<b>Roadside assistance</b>	Nicolas Corluy	Touring	Senior product manager

## Appendix 5: Codes used in *Dedoose*

Currently - Consumer willingness for novelty  
 Currently - Cost of repair  
 Currently - Ecological obs  
 Currently - Functional defect  
 Currently - Indirect obs  
 Currently - Legal obs  
 Currently - Marketing strategies  
 Currently - Obso by notification  
 Currently - Purchase subs  
 Currently - Software obs  
 Currently - sophistication  
 Car recycling  
 Electronic  
 Leasing  
 Obsolescence of cars  
 Political obsolescence  
 Private leasing  
 Unnecessary

### Autonomous

Aut - consumer willingness for novelty  
 Aut - Consumer willingness for novelty -  
 Aut - Consumer willingness for novelty +  
 Aut - cost of repair  
 Aut - cost of repair -  
 Aut - cost of repair +  
 Aut - ecological obs  
 Aut - Ecological obs -  
 Aut - Ecological obs +  
 Aut - functional defect  
 Aut - Functional defect -  
 Aut - Functional defect +  
 Aut - indirect obs  
 Aut - Indirect obs -  
 Aut - Indirect obs +  
 Aut - legal obs  
 Aut - Legal obs -  
 Aut - Legal obs +  
 Aut - Marketing strategies  
 Aut - Marketing strategies -  
 Aut - Marketing strategies +  
 Aut - obso by notification  
 Aut - Obso by notification -  
 Aut - Obso by notification +  
 Aut - purchase subs  
 Aut - Purchase subs -  
 Aut - Purchase subs +  
 Aut - Software obs  
 Aut - Software obs -  
 Aut - Software obs +  
 Aut - sophistication  
 Aut - sophistication -  
 Aut - sophistication +

### Connected

Con - consumer willingness for novelty  
 Con - Consumer willingness for novelty -  
 Con - Consumer willingness for novelty +  
 Con - cost of repair  
 Con - cost of repair -  
 Con - cost of repair +  
 Con - ecological obs  
 Con - Ecological obs -  
 Con - Ecological obs +  
 Con - functional defect  
 Con - Functional defect -  
 Con - Functional defect +  
 Con - indirect obs  
 Con - Indirect obs -  
 Con - Indirect obs +  
 Con - legal obs  
 Con - Legal obs -  
 Con - Legal obs +  
 Con - marketing strategies  
 Con - Marketing strategies -  
 Con - Marketing strategies +  
 Con - obso by notification  
 Con - Obso by notification -  
 Con - Obso by notification +  
 Con - purchase subs  
 Con - Purchase subs -  
 Con - Purchase subs +  
 Con - sophistication  
 Con - sophistication -  
 Con - Sophistication +  
 Con - Software obs  
 Con - Software obs -  
 Con - Software obs +

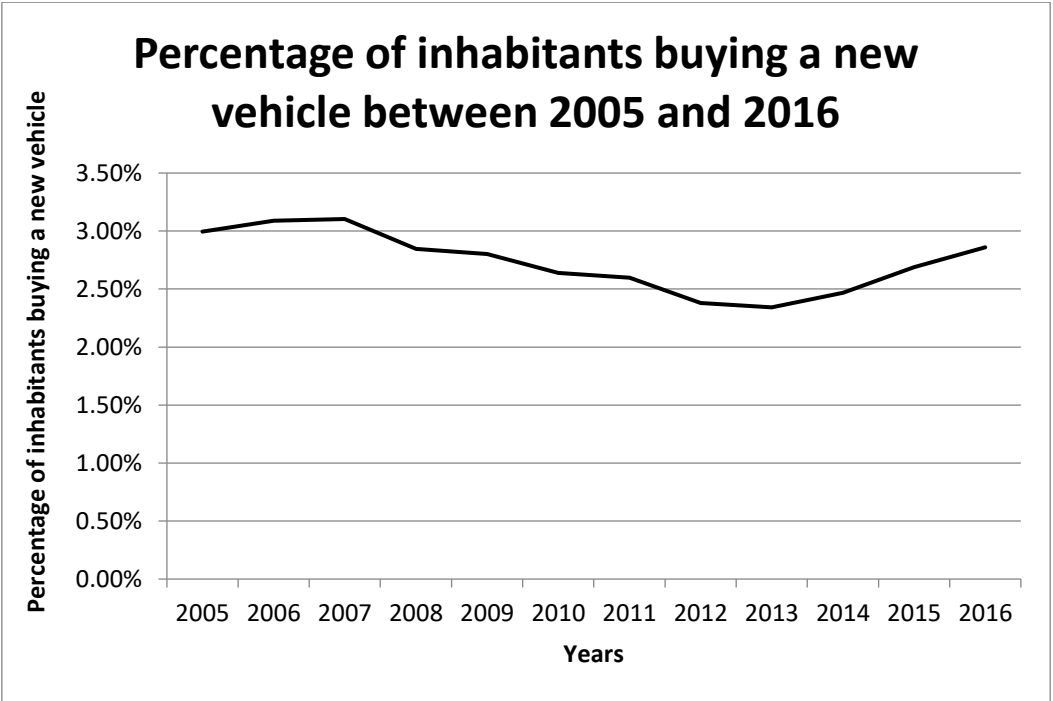
**Electric**

Elec - consumer willingness for novelty  
 Elec - Consumer willingness for novelty -  
 Elec - Consumer willingness for novelty +  
 Elec - cost of repair  
 Elec - cost of repair -  
 Elec - cost of repair +  
 Elec - ecological obs  
 Elec - Ecological obs -  
 Elec - Ecological obs +  
 Elec - functional defect  
 Elec - Functional defect -  
 Elec - Functional defect +  
 Elec - indirect obs  
 Elec - Indirect obs -  
 Elec - Indirect obs +  
 Elec - legal obs  
 Elec - Legal obs -  
 Elec - Legal obs +  
 Elec - Marketing strategies  
 Elec - Marketing strategies -  
 Elec - Marketing strategies +  
 Elec - obso by notification  
 Elec - Obso by notification -  
 Elec - Obso by notification +  
 Elec - Purchase subs  
 Elec - Purchase subs -  
 Elec - Purchase subs +  
 Elec - software obs  
 Elec - Software obs -  
 Elec - Software obs +  
 Elec - sophistication  
 Elec - sophistication -  
 Elec - sophistication +

**Shared mobility**

Shared - consumer willingness for novelty  
 Shared - Consumer willingness for novelty -  
 Shared - Consumer willingness for novelty +  
 Shared - cost of repair  
 Shared - cost of repair -  
 Shared - cost of repair +  
 Shared - ecological obs  
 Shared - Ecological obs -  
 Shared - Ecological obs +  
 Shared - Functional defect  
 Shared - Functional defect -  
 Shared - Functional defect +  
 Shared - Indirect obs  
 Shared - Indirect obs -  
 Shared - Indirect obs +  
 Shared - legal obs  
 Shared - Legal obs -  
 Shared - Legal obs +  
 Shared - Marketing strategies  
 Shared - Marketing strategies -  
 Shared - Marketing strategies +  
 Shared - obso by notification  
 Shared - Obso by notification -  
 Shared - Obso by notification +  
 Shared - Purchase subs  
 Shared - Purchase subs -  
 Shared - Purchase subs +  
 Shared - Software obs  
 Shared - Software obs -  
 Shared - Software obs +  
 Shared - Sophistication  
 Shared - sophistication -  
 Shared - sophistication +

**Appendix 6: Percentage of inhabitants buying a new vehicle between 2005 and 2016.**



*Figure 15: Percentage of inhabitants buying a new vehicle between 2005 and 2016 (figures taken from European Automobile Manufacturers Association, 2017 and Eurostat, 2017)*

Appendix 7: Average age of the European vehicle fleet by country in 2015



Figure 16: average age of the European vehicle fleet in 2015, retrieved from (European Automobile Manufacturers Association, 2017)

## Appendix 8: Purchase and tax incentives for electric vehicles in the European Union

### Overview of purchase and tax incentives for electric vehicles (EVs) in the EU

COUNTRY	INCENTIVES
Austria	EVs exempt from fuel consumption tax and monthly vehicle tax. Deduction of VAT applicable for zero-emission cars.
Belgium	EVs pay lowest rate for annual circulation tax; deductions on company car tax for zero-emission cars (all regions). Incentives to companies for the purchase of EVs, PHEVs and FCEVs (Brussels). EVs and PHEVs exempt from registration tax; incentives for EVs and hydrogen cars (Flanders).
Bulgaria	EVs exempt from annual circulation tax.
Cyprus	Vehicles emitting less than 120g CO <sub>2</sub> /km are exempt from registration tax.
Czech Republic	EVs, HEVs and other AFVs exempt from road tax.
Denmark	Hydrogen and FCEVs exempt from registration tax up to 2018.
Finland	Pure EVs pay the minimum rate of the CO <sub>2</sub> -based registration tax.
France	Regions can provide exemption from registration tax (total or 50%) for AFVs. EV buyers benefit from a premium (CO <sub>2</sub> -based). EVs and HEVs exempt from company car tax.
Germany	EVs exempt from circulation tax for ten years. Bonus granted for BEVs, FCEVs, PHEVs and EREVs.
Greece	Electric and hybrid vehicles exempt from registration tax, luxury tax and luxury living tax. Electric and hybrid cars exempt from annual circulation tax (based on cylinder capacity).
Hungary	EVs exempt from registration tax, annual circulation tax and company car tax.
Ireland	EVs, PHEVs, hybrids and other AFVs benefit from registration tax relief. EVs pay the minimum rate of the road tax.
Italy	EVs exempt from annual circulation tax for five years (75% reduction for the following years).
Latvia	EVs pay the lowest amount of the company car tax.
Luxembourg	EVs and FCEVs benefit from tax allowances on registration fees. EVs also pay the minimum rate of the annual circulation tax.
Netherlands	EVs exempt from registration tax. Zero-emission cars exempt from annual circulation tax.
Portugal	Pure EVs exempt from registration tax, while PHEVs benefit from a reduction.
Romania	EVs exempt from the annual circulation tax.
Slovakia	Pure EVs pay the lowest rate for registration tax and are exempt from annual circulation tax. Hybrid and CNG vehicles benefit from a 50% reduction on the annual circulation tax.
Slovenia	Financial incentives are granted for the purchase of pure EVs and PHEVs.
Spain	Main city councils are reducing the annual circulation tax for electric and fuel-efficient vehicles. Reductions on company car tax apply for BEVs/PHEVs (30%); HEVs and LPG/CNG vehicles (20%).
Sweden	Five-year exemption from annual circulation tax for EVs and PHEVs. A premium is granted for the purchase of new EVs and PHEVs. Reduction of company car taxation for EVs and PHEVs.
United Kingdom	EVs exempt from annual circulation tax, while other AFVs receive a discount. Pure EVs are exempt from the company car tax, while cars with low emissions pay 5%.

SOURCE: ACEA TAX GUIDE 2017

AFV Alternative fuel vehicle  
BEV Battery electric vehicle  
EREV Extended range electric vehicle

EV Electric vehicle  
FCEV Fuel-cell electric vehicle  
HEV Hybrid electric vehicle

LPG liquefied petroleum gas  
CNG Compressed natural gas  
PHEV Plug-in hybrid electric vehicle

Figure 17: Purchase and tax incentives for electric vehicles in the European Union, retrieved from (European Automobile Manufacturers Association, 2017)

Appendix 9: CO<sub>2</sub> emissions from production from 2007 to 2016

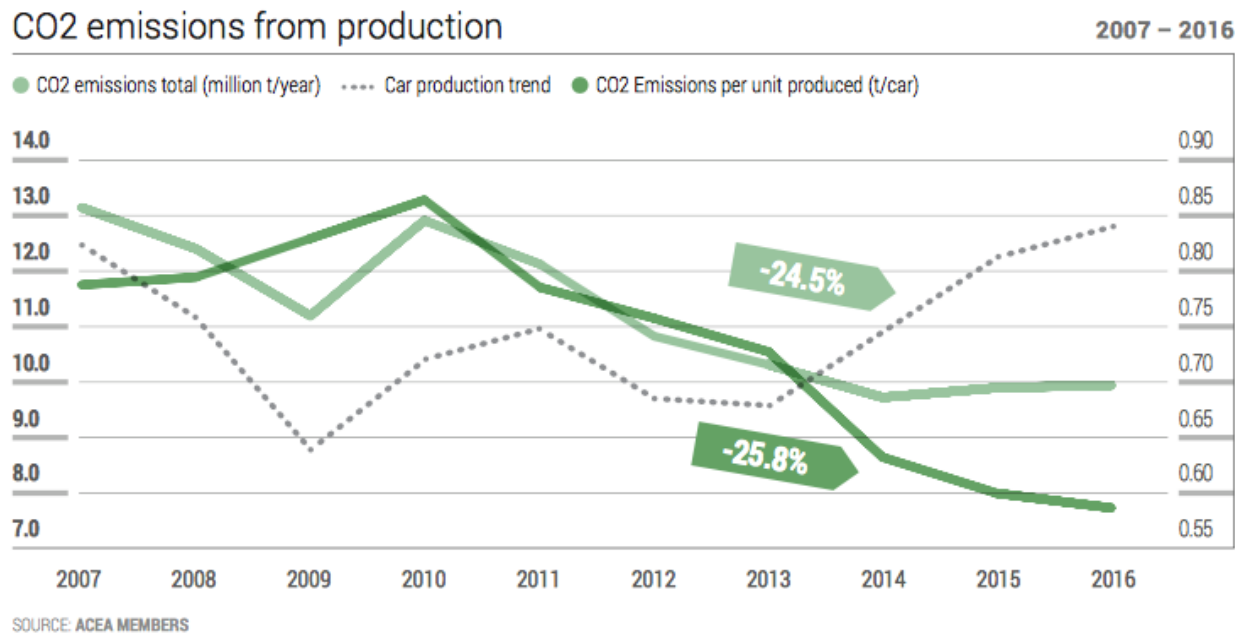


Figure 18: CO<sub>2</sub> emissions from production from 2007 to 2016, retrieved from (European Automobile Manufacturers Association, 2017)



## Appendix 10: Euro standards

Euro standard	Introduction dates		Petrol		Diesel		Petrol & Diesel
	New approvals	All new registrations	NOx (g/km)	Mass of particles (g/km)	NOx (g/km)	Mass of particles (g/km)	Number of ultra-fine particles per km
<b>Euro 1</b>	1 July 1992	31 December 1992	0.97 <sup>(1)</sup>	-	0.97 <sup>(1)</sup>	0.14	-
<b>Euro 2</b>	1 January 1996	1 January 1997	0.5 <sup>(1)</sup>	-	0.9 <sup>(1)</sup>	0.1	-
<b>Euro 3</b>	1 January 2000	1 January 2001	0.15	-	0.5	0.05	-
<b>Euro 4</b>	1 January 2005	1 January 2006	0.08	-	0.25	0.025	-
<b>Euro 5</b>	1 September 2009	1 January 2011	0.06	0.0045 <sup>(2)</sup>	0.18	0.0045	6 × 10 <sup>11</sup> (3)
<b>Euro 6</b>	1 September 2014	1 September 2015	0.06	0.0045 <sup>(2)</sup>	0.08	0.0045	6 × 10 <sup>11</sup> (4) (5)

<sup>(1)</sup> Expressed as HC+NOx.  
<sup>(2)</sup> Applicable to direct injection petrol engines.  
<sup>(3)</sup> Applicable to diesel engines only.  
<sup>(4)</sup> Limit of 6 × 10<sup>12</sup> in the case of direct injection petrol engines.  
<sup>(5)</sup> Common limit of 6 × 10<sup>11</sup> for direct injection petrol engines and diesel engines from September 2017/September 2018.

Figure 19: Euro standards, retrieved from (European automotive manufacturers association, n.d.)

## **Appendix 11-44: Transcripts**

For the sake of environmental protection, we decided not to print the transcripts of the interviews (total number of pages: 423). The reader can find these transcripts in the electronic version (pdf).



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