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Titel

Planned Obsolescence: Balancing Performance and Sustainability – A Systematic Literature Review

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I. Table of Contents:

II. List of Figures

III. List of Abbreviations

Abbreviation	Explanation
CO_2e	Carbon Dioxide Equivalents
E-waste	Electronic Waste
GWP	Global Warming Potential
HOP	Halte à l'Obsolescence Programmée; French for “Stop Planned Obsolescence”

1. Introduction

In December 2022, an investigation regarding planned obsolescence against Apple was started in France, triggered by a complaint by the French non-governmental organization Halte à l'Obsolescence Programmée (HOP; "Stop Planned Obsolescence" in English; Goodman, 2023). Famously, Apple was already fined 25 million euro by France's agency for consumer protection for throttling old iPhones and paid 113 million dollars in the US to settle similar allegations (BBC News, 2020; Dave & Nellis, 2020). Despite slow iPhones being the most prominent example, they represent just one of several cases where giant technology companies engaged in illegal business practices and made their old units obsolete intentionally. Similar lawsuits against the printer companies Epson, HP, Canon, and Brother were filed in France in 2017 and many companies are under suspicion to shorten their products' lifespans (Schrieberg, 2017).

The narrative of planned obsolescence transcends industries, from smartphones and laptops to household appliances and cars. A representative survey conducted in Germany showed that 90% of respondents believe many devices are built to malfunction after the warranty period ends (Jaeger-Erben & Hipp, 2018). In addition to allegations about lowering the physical lifespans of their products, firms are promoting shorter replacement cycles, motivating consumers to replace fully functional devices. For example, T-Mobile's marketing campaign *JUHU!* promoted yearly upgrading of smartphones and earned criticism for enabling environmentally harmful consumer behavior (Wieser, 2016). And these strategies seem to be impactful. The median smartphone replacement time in 2016 was found to be less than two years, compared to almost five years for mobile phones in the early 2000s (Bakker et al., 2014; Kantar Worldpanel, 2017).

The incentives for firms to exercise planned obsolescence seem obvious as markets are saturated and firms lack new customers to sell their products to (Cooper, 1994b). Making consumers replace their products more frequently increases demand and therefore improves performance. However, this reasoning might not be that unambiguous in today's economy. Planned obsolescence is being condemned as harmful to consumers, while also contributing to environmental problems. Increased energy consumption, resource depletion, and growing amounts of electronic waste (e-waste) can be attributed to planned obsolescence and pose major threats to the environment and human health (Bakhiyi et al., 2018). As consumers become more conscious of their consumption's environmental impact, engaging in unsustainable business practices might deter them from buying short-lived products and diminish the gains of more rapid replacements (Petersen et al., 2021).

In an era of increasing environmental concerns and shifting consumer sentiments, companies cannot ignore their environmental responsibility and need to balance their performance with sustainability. These arguments raise the question of whether planned obsolescence is still a valid business practice, suited for future developments, or whether unsustainability's negative effects outweigh replacement sales' positive effects.

Early research mainly discusses planned obsolescence in theoretical models and finds that firms are incentivized to shorten their products' lifespans deliberately (Bulow, 1986; Levhari & Srinivasan, 1969). However, more recent research emphasizes the environmental consequences and losses in the brand image of such behavior that can potentially harm performance (Bakker et al., 2014; Kuppelwieser et al., 2019).

There is currently no meta-analysis confronting the up- and the downside of planned obsolescence. This work will fill this gap. The objective of this paper is to give companies and governments clearance about the outcomes of planned obsolescence and suggest implications on how companies and governments should balance sustainability and performance.

To achieve that, a comprehensive literature review on planned obsolescence and adjacent topics has been conducted. The research reveals that shortening the physical lifespan of a product or regularly introducing product revisions to outdate old versions can increase the frequency of repurchases (Bellezza et al., 2017). However, the anticipation of fast obsolescence is harmful to the brand image and lowers consumers' willingness to pay (Kuppelwieser et al., 2019). Conversely, longevity can also nurture a positive brand image and therefore increase profits (Hartl et al., 2023). Furthermore, artificially shortened lifespans are unfavorable for the environment in all examined categories (Bakker et al., 2014). As more consumers care about their consumption's environmental impact, the effects of planned obsolescence on brand image and repurchasing behavior can become more adverse in the future (Gomes et al., 2023). In addition, extending lifespans, while benefiting the environment, would likely stimulate macroeconomic growth (Montalvo et al., 2016). The detriments to consumers and the environment necessitate government intervention and a cultural change to promote longer lifespans in all product categories.

After outlining the theoretical foundation and synthesizing the current state of the empirical literature, it will be discussed whether the gains for companies conducting planned obsolescence are worth the losses in brand image and environmental damages. Following, a discussion about the responsibility of planned obsolescence will be led and measures

that legislation can implement to support change and solve current issues will be discussed. Lastly, implications for management, research, and legislation will be stated and a conclusion will be drawn.

2. Research Method

The exploration of the introductory literature provided a starting point for the research. Subsequently, the University of Hamburg's economics databases were searched for papers in peer-reviewed academic journals with the term "planned obsolescence" and adjacent keywords like "product lifetimes", "durability", or "replacement purchases" in combination with either performance-related or sustainability-related keywords. A comprehensive literature search was conducted on platforms including Google Scholar, JSTOR, and SpringerLink with similar keywords. In addition, engineering and natural science databases from the University of Hamburg's database information system were searched in the same manner. After compiling scientific papers on planned obsolescence and its effect on performance and sustainability, a reverse search was conducted to find further relevant literature.

For the synthesis, papers were selected through the following criteria. First, the papers must empirically examine obsolescence, product lifespans, or repurchasing behavior. Second, the papers must be published in academic journals ranked B or better in the VHB-JOURQUAL3. Ultimately, 13 papers remained for the synthesis.

Unfortunately, no research regarding the effects of planned obsolescence on sustainability met these criteria. Either the research is not published in a journal ranked sufficiently high in the mentioned ranking or does not conduct any empirical research that fits the format of the synthesis. However, many practical findings, including case studies, will be included in the discussion. Generally, publications cited often in highly ranked journals were preferred and for lifespan data and sales numbers, the latest and most reliable data available was used.

3. Theoretical Foundation

3.1 What is (Planned) Obsolescence?

Planned obsolescence refers to the design of products with intentionally shortened lifespans, driving consumers to buy replacements more often (Kuppelwieser et al., 2019). It was lauded as an economic catalyst that could alleviate the economic depression in the US in the 1930s. The problem Bernard London (1932) stated was that consumers keeping

their items for a long time does not create demand, which leads to unused production capacities and unemployment. Planned obsolescence could solve this by creating steady and predictable replacement purchases and therefore stimulating the economy.

An early, still well-known historical example of planned obsolescence is light bulbs. In the 1920s, technological progress enabled manufacturers to build bulbs that could last substantially longer over time (Friedel, 2013). However, the companies saw that they would sell fewer light bulbs over time, the longer they lasted and colluded to form the Phoebus cartel, which ensured that no manufacturer would produce light bulbs lasting longer than 1,000 hours. A similar historic example can be found in fashion, where nylon stockings were modified to be more fragile (Rivera & Lallmahomed, 2016).

The described cases are examples of planned physical obsolescence. There are different ways manufacturers can plan for physical obsolescence. Among them is building in design flaws, like predetermined breaking points or overall weakened materials, to make sure a product is not as durable as it could be and wears out physically to become unusable or aesthetically unsatisfactory (Satyro et al., 2018). Another form of physical obsolescence is the design for limited repairability as often found in smartphones, which commonly use glue or soldering instead of screws, making repairs difficult and time-consuming to an extent, where buying a new product is often cheaper than changing a single component (Bakhiyi et al., 2018; Satyro et al., 2018). Relatively low durability will be treated as a form of planned physical obsolescence because it implies that a manufacturer deliberately chose to make a product less robust than it could be.

Another way to make old units obsolete is psychological obsolescence, which occurs when something is still fully functioning but no longer satisfies the customer (Cooper, 2004). This can be achieved by style changes that make old units look outdated even though they have equal functionality as the latest product, or by introducing new products with technologically enhanced features older models cannot match (Satyro et al., 2018). An example of psychological obsolescence is the upgrade cycle of smartphones. New models are released yearly, with some technological advancements and at least a slightly changed appearance to make last year's model appear outdated. In addition, software updates are only provided for a couple of years, making old units unable to keep up with the latest devices, despite having no physical impairments.

A third form of obsolescence is economic obsolescence, which occurs when a new product is available that makes the old one financially not worth keeping (Cooper, 2004). An

example of economic obsolescence would be the availability of a new washing machine that is so efficient with water and energy that it would be more expensive to hold on to the old model. However, as physical and psychological obsolescence are more common business practices, economic obsolescence will not be discussed as deeply.

3.2 Performance and Sustainability

Performance consists of multiple criteria in the context of this work. Besides quantifiable factors like profit and sales, customer loyalty and brand image will also be included.

Sustainability will be examined in the form of environmental impact, which can be assessed by adding the effects from manufacturing, distribution, use phase, and disposal (van Nes & Cramer, 2006). Different types of products have different patterns of impact. Static goods require most of their energy in production and less or no energy during their use, e.g., a chair, while dynamic goods use the most energy in their use phase, e.g., a car (Rivera & Lallmahomed, 2016). This differentiation is important to assess the environmental damage that can be attributed to planned obsolescence as for certain dynamic products, a premature breakdown might be environmentally favorable due to the efficiency gains of new products.

Next to the emission of carbon dioxide equivalents (CO_2e) and the corresponding global warming potential (GWP), e-waste has been recognized as an escalating environmental problem. Global production surged 20% from 2014 to 54 Megatons in 2019 with an anticipated 75 Megatons by 2030 (Forti et al., 2020). While most of the e-waste is produced in developed countries, the adverse effects are often translocated to developing countries (Bakhiyi et al., 2018). Toxic substances from e-waste not only bear the potential to be environmentally harmful if mishandled but also pose a threat to human health (Bakhiyi et al., 2018; Forti et al., 2020).

3.3 Legal Groundwork

An EU directive from 2008 aims to decrease the environmental hazards of waste production (Directive 2008/98/EC). An important facet of the directive is the Waste Hierarchy. It puts the prevention of waste as the priority, followed by reuse, recycling, recovery, and lastly, disposal. This order is relevant as planned obsolescence prevents the prolonged use of products and is therefore impossible to reconcile with the priorities of the directive.

Given the severe potential detriments of planned obsolescence for the environment and consumers, some legislators have started to take targeted actions. In 2015, France became

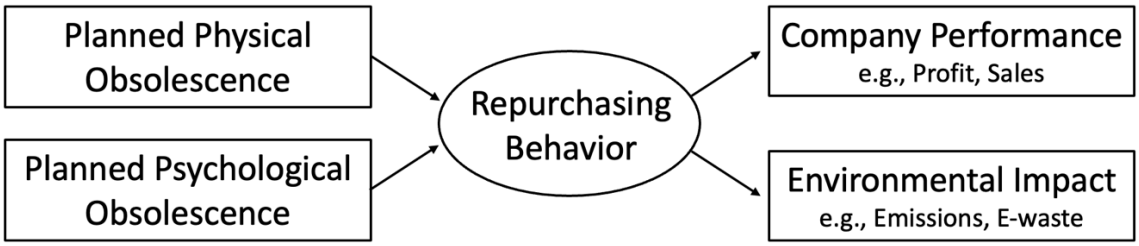
the first country to introduce a law to make planned obsolescence illegal (France, 2015). The law includes punishments of up to two years in prison and up to 5% of average annual revenue. A challenge that legislators are faced with is that it is hard to unambiguously prove that obsolescence is planned. Other laws take different approaches that indirectly affect obsolescence. For example, the EU has put a two-year minimum guarantee in place to protect consumers against premature obsolescence without directly outlawing planned obsolescence (Your Europe, 2022).

However, recent developments in the EU loom a trend of tighter regulations in the future. An EU motion from 2017 demanded a clear definition of planned obsolescence, better protection for whistleblowers, more encouragement of durable products, and a need for upgradable products (Durand, 2017). In May 2023, the European Parliament voted in favor of a draft legislation including a ban on design features that make products malfunction prematurely, which opens communication with EU member states for final laws (Europa.eu, 2023a). The latest proposal by the EU's Environment Committee additionally includes the obligation to make more software updates and spare parts available to consumers, as well as the concept of a "product passport", making information about the environmental impact, repairability, and recycling accessible to consumers (Europa.eu, 2023b). Different possible legislative measures will be discussed in a later section.

3.4 Framework

The framework aims to visualize the examined effects. Planned physical and planned psychological obsolescence both aim to manipulate the repurchasing behavior by either physical wear-out or decreased perceived value. Repurchasing behavior is at the center of the model because planned obsolescence does not have any effect if it does not trigger replacements. The repurchasing behavior affects the companies' performances through demand and creates an environmental impact through the production of new goods. Whether these effects are positive or negative will be part of the synthesis and discussion.

Figure 1: Framework that Maps the Effect of Obsolescence on the Environment and Performance



Source: Own Presentation

4. Current State of Literature

Bernard London's (1932) pamphlet is one of the first to mention planned obsolescence. The topic itself and related topics like durability and product lifespans have since been discussed in multiple disciplines. The earlier research was almost solely focused on the economic perspective (Bulow, 1986; Levhari & Srinivasan, 1969; Swan, 1970, 1972). In contrast, later research puts growing emphasis on the environmental effects. While the topic is still being researched in business journals, with expanding focus on consumer behavior, journals focusing on environmental science and engineering have also addressed obsolescence (Cherry et al., 2018; Kuppelwieser et al., 2019; Rivera & Lallmahomed, 2016). Furthermore, there has been research examining the legal sphere (Malinauskaite & Erdem, 2021). In addition to publications in academic journals, insightful research on the impact of product lifespans has been conducted on behalf of government actors like the German Federal Environment Agency (Prakash et al., 2012, 2016).

Still, there are few high-quality empirical studies regarding the effects of planned obsolescence on the environment. A substantial amount of research, especially for the life cycle assessments of certain products, is done in the form of case studies. For example, lifetime-extending concepts like modular smartphones have been studied for their environmental potential with no empirical data to back it up yet (Proske & Jaeger-Erben, 2019). The practical findings of case studies will be utilized in the discussion.

4.1 Theoretical Models

A meaningful share of literature on planned obsolescence is merely postulating theoretical models and does not conduct any empirical research. These models are still relevant to this work because they can give explanations about the behavior of market players. According to Levhari and Srinivasan (1969), a profit-maximizing monopolist will produce goods that are less durable than a firm in a competitive environment would. In direct response, Swan (1970) proposed a different model with the conclusion that durability in a monopolistic and competitive regime will be equal because in both cases the manufacturer aims to minimize their production costs. He later added that monopoly exploitation can be better achieved by manipulating price rather than durability (Swan, 1972).

Most other theoretical models disagree with Swan. Bulow (1982, 1986) states that monopolists generally have an incentive to produce inefficiently short product lives because the monopolist does not have to compete against their old products if they become obsolete. If old products do not become obsolete, the monopolist is forced to sell at lower

prices in the long run. Waldman (1996) agrees with the time inconsistency problem a monopolist faces when selling in multiple periods. His model shows that maximizing current profit does not maximize overall profit. Furthermore, he concludes that this is also true for psychological obsolescence and that the incentives for a monopolist to introduce style changes are too high from its own standpoint (Waldman, 1993). Fishman and Rob (2000) are in line with that and state that a monopolist can capture the most value when he does not have to compete with old units. They suggest that this can be achieved by renting instead of selling, offering discounts or buy-backs to repeat customers, or reducing the lifespan of the product.

While according to Rivera and Lallmahomed (2016), monopolists can use physical obsolescence to compete against their own products, oligopolists compete with psychological obsolescence to make their own products obsolete before a competitor does. In contrast to monopolists, depending on the market structure, oligopolists have an incentive to produce either uneconomically long or short product lifetimes, according to Bulow (1986). If the oligopolist faces a possible competitor entering the market in a subsequent period, the oligopolist will produce uneconomically long lifespans to deter entry. On the other hand, oligopolists have an incentive to collude and gain the same benefits from decreasing product lifetimes as the monopolist would. A firm facing perfect competition, however, will output efficient durability (Bulow, 1986).

4.2 Empirical Evidence for the Existence of Planned Obsolescence

Regardless of the extent of planned obsolescence being controversial, there is empirical evidence supporting its existence. One of them is from the seed industry, where the yield of plants increased while the age of plant varieties significantly decreased between the 1960s and the 1990s (Rangnekar, 2002). The author attributes this fall in lifespan to planned physical obsolescence. He explains that plant breeders decreased the lifetime of their plants to keep their market share. Another empirical study from the textbook industry finds that the timing of new releases is significantly related to the market share of used textbooks (Iizuka, 2007). The author suspects that publishers release new versions to kill off old units. This pattern suggests the existence of planned psychological obsolescence.

Despite other industries lacking empirical evidence, there are indicators for the existence, making the examination relevant for various industries. Decreasing lifetimes in household appliances and periodical product releases in electronics are examples of business practices that imply a form of planned obsolescence (Huisman et al., 2012).

* p ≤ 0.1; ** p ≤ 0.05; *** p ≤ 0.01; n.s.: not significant													Independent Variables										Mod-erators	Mediators
													Physical Factors					Psychological Factors						
Type of Obsolescence	Author	Data Source						Type of Data	N	Methodology	Region	Industry	Dependent Variable	1 Wear-out	2 Product Age	3 Repairability	4 High Durability	5 Low Durability	6 Price Paid/Luxury Good	7 New Product Introduction	8 Frequent Introductions	9 Marketing Variables	10 Desire for Style Change	Brand Association with Innovativeness	Perceived Performance Gain
		Primary			Secondary																				
		Survey	Lab Experiment	Web Crawling	Field Data	Panel Data	Market Data																		
Physical Obsolescence	Bayus and Gupta (1992)					x		Mixed	407	Chi-square	USA	Household Appliances	Replacement Intention	+***											
	Van Nes and Cramer (2006)	x						Interviews	21	Provisional Model of Factors	Unspe-cific	Unspecific	Product Replacement	+											
		x						Quantitative Data	253																
	Makov and Fitzpatrick (2021)			x				CPU Perfor-mance Scores	3541556	Descriptive Statistics	Global	Electronics	Product Performance		n.s.										
							x	Web Traffic	12	Regression Analysis	Global	Electronics	Lifespan			n.s.									
	Yan et al. (2017)	x					x	Sales Data and Likert Scale	1163	Regression Model	USA	Electronics	Manufac-turer's Profit				+***	+***							
		x					x	Sales Data and Likert Scale	425	Regression Model	USA	Electronics	Reseller's Profit				+***	+***							
Physical and Psychological Obsolescence	Sun et al. (2021)	x	x					Choice Data	162	Conjoint Analysis	USA	Fashion	Perceived Utility				+***	–***							
		x	x					Likert Scale	421	Logistic Regression	USA	Fashion	Willingness to Buy				+***								
		x	x					Count Data	340	ANOVA	USA	Fashion	Length of Planned Ownership						+***						
		x	x					Likert Scale	340	Chi-square	USA	Fashion	Intention to Dispose Sustainably						+***						
	Grewal et al. (2004)	x						Likert Scale	1157	Weibull Model	USA	Automotive, Electronics, Fashion, Household Appliances	Interpurchase Interval	+***					–***						

* p ≤ 0.1; ** p ≤ 0.05; *** p ≤ 0.01; n.s.: not significant														Independent Variables										Mod-erators	Mediators
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		Primary			Secondary																				
		Survey	Lab Experiment	Web Crawling	Field Data	Panel Data	Market Data																		
Psychological Obsolescence	Iizuka (2008)					x		Sales Data	2561	Descriptive Statistics	USA	Textbook	Demand for New Revision							+					
	Stock and Zacharias (2013)	x						Mixed	180	Hierarchical Regression Analysis	Unspe-cific	Electronics, Machinery, Service, Software, Utilities	Customer Loyalty							–***				8↓**	
	Bellezza et al. (2017)		x					Consumption Data	670	ANOVA	USA	Consumables	Wasteful Consumption							+***					
			x					Mixed	92	Chi-square	USA	Consumer Goods	Product Neglect							+***					
					x			Lost Phone Reports	2840	Regression Model	Global	Electronics	Lost Phones							+***					
		x						Mixed	602	Regression Model	USA	Electronics	Product Neglect							+***					
	Wieser and Tröger (2018)	x						Likert Scale	988	Mann-Whit-ney U Test	Austria	Electronics	Premature Replacement							+***					
	Boone et al. (2001)	x	x					Count Data	120	ANOVA	USA	Unspecific	Perceived Performance Gain								–***				
		x	x					Count Data	120	Logistic Regression	USA	Unspecific	Purchase Delay								+**				8–M–DV –***
	Bayus (1988)	x						Mixed	50000-70000	Multiplica-tive Regres-sion Model	USA	Electronics	Premature Replacement									+***			
	Bayus (1991)	x						Mixed	3123	t-Test	USA	Automotive	Premature Replacement									+***	+***		

5. Synthesis

Looking at physical factors first, Bayus and Gupta (1992) find that the intention of replacing a household appliance is significantly affected by physical wear-out. Hence, making appliances wear out faster can increase demand, making planned physical obsolescence potentially effective to increase revenue. However, the study's findings cannot be generalized as the survey was only conducted in Arkansas, USA, in the early 1990s. Similarly, van Nes and Cramer (2006) find that wear and tear is the primary product characteristic that leads to a replacement, regardless of product category. This supports the findings from Bayus and Gupta (1992) that wear-out is the dominant reason for replacements. However, both studies do not research if consumers intend to repurchase from the same brand but rather replacements in general. Therefore, both studies do not provide sufficient insight into customer loyalty to conclude that accelerated wear-out benefits a company.

Grewal et al. (2004) find that interpurchase intervals for forced replacements are longer than for unforced ones. Consequently, replacement cycles can be manipulated easier by psychological factors than by wear-out. This finding partly opposes Bayus and Gupta (1992) and emphasizes the relevance of psychological obsolescence on replacements. The distinctions can likely be explained by the differences in examined products.

Next, Makov and Fitzpatrick (2021) find that contrary to popular belief, objective smartphone performances stay constant. Yet, interest in repairs diminishes with the device's age. This provides evidence that the CPU's performance of smartphones does not wear out and objective performance is not responsible for smartphone replacements. Furthermore, despite the number of examined models being small, the authors find that repairability does not correlate with the lifetime of a smartphone. The study about decreased interest in repair over time is limited in the sense that it does not allow for a shrinking installed base for older smartphones and that it takes traffic on a repair manual website as a proxy for interest in repair. This does not take repairs happening in shops into account but only the interest in self-repair. However, the results imply that if smartphone manufacturers want to prolong the lifetime of their devices, physical longevity is inferior to psychological obsolescence. The distinctions to the findings from Bayus and Gupta (1992) and van Nes and Cramer (2006) are likely due to the different product categories. The findings are in line with Grewal et al. (2004).

Yan et al. (2018) examined the effects of durability on manufacturers' and resellers' profits. They find that intermediate durability is worse for the profits of both parties compared

to sufficiently low or sufficiently high durability. Low durability is beneficial because customers need to replace their products more frequently and therefore, sales are increased. High durability can increase output price and hence, the profit per sale. An empirical analysis of the US x86 computer server market provides evidence that their predictions are valid. Therefore, deliberately lowering durability can increase performance. However, the empirical findings are only from one, very specific market and it is unclear whether the findings can be generalized to consumer electronics or other products.

A study in the fashion industry has shown that high durability increases the perceived value of a product (Sun et al., 2021). A conjoint analysis reveals that consumers' perceived utility is significantly higher for coats with high durability compared to low- or mid-level durability. Even though style is by far the most important attribute, with over 40% average importance, price and durability are almost equally important, both at about 20%, more than color and sustainability. However, the examined product was a coat from a high-end fashion brand which makes it hard to generalize these findings to mass-market items. Still, the findings imply that high-fashion brands should emphasize high quality.

Another study from Sun et al. (2021) supports this by finding that making high durability salient elevates the willingness to buy high-end sweatshirts. Yet, price seems to be pivotal for output quantity. Even though the salience of durability significantly increases the willingness to buy, about 70% of participants still chose the less durable sweater, compared to 84% when it is not salient. Therefore, while marketing durability can increase performance for high-priced fashion brands, low prices are generally more favorable for sales.

Regardless of durability, Sun et al. (2021) find that the price paid plays a significant role in the attachment to a fashion item. The planned length of ownership for high-end products is significantly higher compared to low-end products. Additionally, the plan for sustainable disposal is significantly elevated for high-end products. This implies that marketing high-quality goods can foster longer product lifetimes and eco-friendlier consumer behavior. However, the sample was limited to women in the United States with a mean annual income above 120 thousand dollars. Furthermore, the study examined women's bags and shoes, which limits the study's results to more hedonic clothing items.

The findings from Grewal et al. (2004) partly oppose the findings of extended ownership for high-priced items. They find that replacement cycles for luxury goods performing utilitarian functions are replaced more frequently than non-luxury goods. The differences can be attributed to the different samples and the examined product categories.

Introducing new products is another way to make old units obsolete. Iizuka (2007) finds that the launch of textbook revisions depends on the market share of used textbooks. By introducing a new textbook, the content of the old versions becomes outdated, and consequently, old books become obsolete. The introduction of a new textbook increases the demand for new textbooks and simultaneously decreases the demand for older versions. The regular release of revisions can therefore be performance-enhancing for publishers.

Stock and Zacharias (2013) also studied the effects of new product introductions and find that they can negatively affect customer loyalty. Product newness can create uncertainty among existing customers about the compatibility with their existing products and workflows. On the other hand, the superiority of a new product over the last version can enhance customer loyalty. Additionally, the negative effects of product newness are moderated by brand association with innovation. Higher perceived innovativeness mitigates the possible losses in customer loyalty triggered by product newness. Consequently, firms should reduce product newness for product revisions if their brand is not associated with innovativeness and only launch meaningful upgrades.

Bellezza et al. (2017) discovered that the mere availability of an upgrade encourages product neglect and wasteful consumption. When a nicer-looking mug was available, participants were more willing to endanger their mug than a control group without upgrade availability. Similarly, the consumption of nondurable products sped up when the participants were made aware of an upgrade. The consumption was tested for various nondurable goods and the results show that the change in consumption was more salient for more hedonic goods like perfume than for utilitarian goods like toothpaste. This behavior is also evident in smartphones. Bellezza et al. (2017) analyzed the number of lost iPhones over time and find that owners are less likely to look for their old smartphone if an upgrade is available. The authors replicated this behavior in a survey and find that consumers are less willing to repair their devices if an upgrade is on the market and they are willing to upgrade. Besides the availability of an upgrade, the paid price, the book value of the current phone, and the owner having to fully pay for a new phone influence the willingness to repair the smartphone. In line with that, Wieser and Tröger (2018) find that smartphones are replaced significantly earlier if the reason for the replacement is a new product introduction. While the duration of smartphones is about three years on average, replacements justified by the release of a newer model last only 1.8 years. This adds up with the findings from Bellezza et al. (2017) that a new smartphone release prompts psychological obsolescence and encourages careless consumer behavior.

Boone et al. (2001) find that frequent product launches can harm sales. Consumers' timing of replacement purchases depends on the perceived benefit of buying a new version. This can be manipulated by the release frequency of a new product. Therefore, purchase delay is mediated by perceived performance gain. The perceived rate of change positively influences the likelihood of purchase and must be considered for replacement cycles. Consequently, categories with fast technological progress can introduce new products more frequently than firms in categories with slow technological progress without lowering their demand. This is in line with Stock and Zacharias (2013).

Combining these findings emphasizes that a correlation between upgrade availability and replacements transcends industries and is also applicable to product categories with slow technological progress. Making consumers aware of an upgrade can therefore be an effective measure to induce psychological obsolescence and possibly boost sales. Possible negative effects on customer loyalty must be considered when introducing new products.

Bayus (1988, 1991) demonstrates that marketing variables can trigger consumers to replace their durables prematurely. For example, price promotions can cut the replacement cycle of televisions by a full year (Bayus, 1988). Style changes and new features can shift the average replacement timing by about nine months each, whilst advertising shortens the replacement timing by less than six months. Similar effects can also be observed for cars (Bayus, 1991). Consumers, who replace their cars early, are more susceptible to promotional offers than late replacers. In addition, the desire for stylistic changes is significantly stronger among early replacement buyers. Notably, these consumers typically gather less information than late replacers. The findings of these two studies indicate that firms can effectively use marketing mix measures, like promotional discounts, to induce premature replacements. This can be particularly effective if the firm can target consumers prone to replace early. The consistency in findings in televisions and cars may stem from both being viewed as hedonic goods and status symbols by some consumers. This is in line with the implications from Grewal et al. (2004) that replacement cycles of hedonic goods are more influenced by psychological factors than utilitarian goods.

Combining the findings from the studies reveals that the effects of obsolescence factors vary across product categories. High durability increases the willingness to buy high-priced products but it may not resonate in mass markets. While replacements for utilitarian products are mostly induced by wear-out, firms selling hedonic goods can manipulate replacement purchases with upgrades but must be cautious with frequent releases.

6. Discussion

6.1 Should Firms Plan Obsolescence?

Planned obsolescence is meant to boost replacement sales. However, as worked out in the synthesis, the effects are not plainly positive but can potentially harm the company's performance while also being possibly disadvantageous for the environment and consumers. The following section will discuss whether planned obsolescence is a strategy worth pursuing or whether the drawbacks outweigh the benefits in certain industries.

Demonstrated in the x86 computer server market, Yan et al. (2018) highlighted that sufficiently high or low durability yields more profit for manufacturers and resellers than intermediate durability. Hence, in cases where durability is moderate, reducing durability deliberately is a profitable strategy for server manufacturers, backed by strong empirical support. Increasing durability was shown to be a profitable choice as well but comes at a cost that customers might not be willing to pay if they expect their device to become outdated before it breaks anyway. Most salient in electronics, technological obsolescence plays a huge role in replacements. Because upgradability is not part of most electronic products, promoting durability might therefore be counterproductive (Cooper, 2004).

Using an example in consumer electronics, Apple's iPod, Strausz (2009) explains that a low product lifespan does not correspond with a bad reputation but enables firms to emphasize other quality attributes. The iPod did not have an easily replaceable battery, which still holds true for the latest iPhones, and is called a "symbol of planned obsolescence within the electronics industry" (Strausz, 2009, p. 1418). Still, Apple's devices remain a reputation of high quality, even though they are still being criticized for conducting planned obsolescence due to other quality dimensions like a streamlined user experience.

Especially well-controlled planned obsolescence attacks can significantly increase profits, as Zhao et al. (2021) demonstrate. The authors have shown, that manipulating the aging of a pivotal chip can increase profits by more than 50%, compared to unmanipulated aging. The ability to not only accelerate but also decelerate aging can avoid the unintended breakdown of a product within the warranty period and therefore minimize customer claims for free repairs and replacements. This strategy could be applied to many devices with electronic components, for example, smartphones. It could therefore increase profits in many cases. However, as this attack needs to be programmed somehow, it is also one of the most traceable ways of planned obsolescence. As France has already criminalized planned obsolescence and EU legislation is likely to follow, a traceable form

of obsolescence attack can entail negative implications. Besides legal repercussions, eroded trust from customers can potentially harm performance as well.

Moreover, for electronic products that do not face technological leaps regularly, physical longevity might increase competitiveness (Cooper, 1994a). According to Prakash et al. (2016), a laptop lasting six instead of three years is more than 10% cheaper for consumers, assuming no repairs are necessary. Low maintenance costs and higher resale value can be promoted as sales arguments and justify higher prices (Mackenzie et al., 2010). In this case, high durability can increase a brand's reputation, resulting in a higher willingness to pay and thus, a higher possible output price, which compensates, if not overcompensates, reduced output quantity (Hartl et al., 2023; Plambeck & Wang, 2009).

Next, nudging consumers to replace their devices prematurely is also a common practice in the electronics industry. Early evidence from the TV industry shows that various marketing mix measures can impact the replacement timing significantly, not only increasing demand but also enabling product managers to forecast demand more accurately (Bayus, 1988). Especially price had a big effect on premature TV replacements and shifted purchases by over a year while styling and new features shifted the timing by about nine months. These effects are likely applicable to other consumer electronics. Evidently, smartphone owners treat their devices significantly more careless when an upgrade is available and about 70% of smartphones are replaced without any malfunctions (Bellezza et al., 2017; Wieser & Tröger, 2016). While the strengths are not quantified, this shows that the variables found to affect the replacement cycle of TVs, like new features or style changes, are likely to influence the replacement cycle of smartphones as well.

On the other hand, frequent revisions can negatively affect sales for multiple reasons. Introducing a new product potentially harms customer loyalty if intergenerational changes are not meaningful (Stock & Zacharias, 2013). According to Stock and Zacharias (2013), the negative effects can be reduced when a brand is tightly associated with innovativeness, which is especially relevant for the electronics industry, where more brands are considered innovative than in other industries (Manly et al., 2023). However, because not all firms in the electronics industry are highly innovative and customers' perceptions can change over time, it is important to take the possible downside of product introductions into account. In line with that, longer replacement cycles increase the perceived value of smartphones significantly (Kuppelwieser et al., 2019). If consumers know that their current smartphone will be the latest for a longer period, their value perception rises.

Conversely, their willingness to pay for current products declines when a new product has been announced. Optimizing the timing of product launches can therefore greatly impact performance and should be connected to the rate of change (Boone et al., 2001).

Firms face a dilemma when planning product announcements because they need to balance opposing interests. On one hand, firms want their current product to be perceived as high value by consumers while it is the latest. On the other hand, as soon as a new product is released, the old product should become obsolete. If consumers can anticipate the forthcoming release of the next revision, the value of the current product is reduced, and consumers will halt buying it. But, if they cannot anticipate the next revision, their value perception is decreased because the current version could become outdated soon. It is, therefore, a preferable strategy not to announce the specifics of the next version if it is not available to consumers soon to avoid diminishing the value perception of the current product, while also giving consumers a reference point when the next revision will be released to reduce uncertainty. The frequency of revisions should be connected to the rate of technological change in the product category to preserve customer loyalty. Psychological obsolescence in the form of new product releases bears far more potential to boost performance in the electronics industry than physical obsolescence.

This does not hold true for other industries. While more than 80% of smartphones do not last more than four years, the average lifespan for many large household appliances is over ten years (Bakker et al., 2014; Wieser & Tröger, 2016). This leads to a difference in repurchasing behavior, affecting the potential of planned obsolescence. For household appliances, the main reasons for a replacement intention are the unit's age and condition (Bayus & Gupta, 1992). For instance, most refrigerators are replaced due to malfunction and after more than ten years of use (Gutiérrez et al., 2011). In addition, household appliances like electric cookers and refrigerators are expected to last the longest, with over a third of consumers expecting them to be used for at least 15 years (Cooper, 2004).

Long use times, majorly determined by physical durability, are a pivotal purchase criterion for household appliances (Jaeger-Erben & Hipp, 2018). According to a case study by Prakash et al. (2016), a short-living washing machine costs consumers 14% more than a long-lasting one, even if the acquisition costs are assumed to be three times as high. Customers who usually buy premium washing machines are also significantly more likely to be satisfied with their product's lifetime while generally, washing machines have the highest share of households unsatisfied with their lifetime of all appliances (Cooper,

2004). Hence, customer loyalty is likely to suffer most if an appliance lasts less than comparable products or the customer's expectation. Conversely, building a brand image of high-quality products can nurture customer loyalty. Brands like Miele are known for their long-lasting household appliances and obtain high popularity rankings (FAZ, 2023). Since most household appliance brands' image is based on the longevity of their products, the potential damages of premature obsolescence would not be beneficial to performance.

On the other hand, consumers also see the cons to buy for longevity. Consumers often fear appliances becoming outdated more than they fear higher purchase prices (Cooper, 2004). 22% of washing machines, dishwashers, and tumble dryers and 37% of refrigerators and freezers are discarded while still functioning, which is less than mobile phones and computer parts at the time (59%), but still, a substantial amount that cannot be attributed to physical obsolescence (Cooper, 2004). Some home devices' functionality goes beyond their utility. For instance, TVs are not only electronic devices but are a central piece of furniture in many homes. Shifting consumer perception from viewing a product as a luxury or a status symbol could potentially heighten the importance of features other than longevity (Grewal et al., 2004). Using this strategy, manufacturers of household appliances could increase their customers' willingness to pay and hence, performance. Furthermore, psychological obsolescence could become more effective because consumers would see their appliances less as a utility and more as something with emotional value. Currently, manufacturers of household appliances should focus on building or remaining a brand image of longevity and avoid physical obsolescence to maximize performance.

Looking at car manufacturers' performance, perceived quality has a significant impact (Akdeniz & Calantone, 2017). High perceived quality can be achieved in many ways, for example, through warranties, price signaling, or advertising (Akdeniz et al., 2014). Also, factors like country of origin can affect perceived quality. While a German origin is favorable, a Korean origin is not. However, third-party quality ratings can potentially decrease perceived quality. Therefore, it is important to keep a level of actual quality to remain high perceived quality. Furthermore, durability can be a competitive edge. Low maintenance costs as well as higher resell value can be selling points for more expensive cars (Cooper, 1994a). Especially when customers select a car brand for hedonic reasons and seek exclusivity, a strategy of higher prices and lower output volume can be profitable (Agrawal et al., 2016). This could not only positively affect sales but also leasing. Besides, the positive competition effect of durability is significantly larger than the cannibalization effects of used products as suggested in theoretical models (Jayarajan et al.,

2018). Older models, therefore, do not interfere with sales of newer models of the same brand as much as they take market share from competitors, while also increasing sales due to improved perceived quality of their cars.

In fashion, consumers often prioritize other factors, like style or cost, over longevity (Sun et al., 2021). Therefore, selling cheaper apparel is likely better for output quantity. On the other hand, findings from Şener et al. (2019) highlight that customers of slow-fashion items are willing to spend more on them. Additionally, if durability is conspicuous, consumers are more willing to buy expensive goods (Sun et al., 2021). Also, customers of high-priced products plan to keep their products for longer. This implies that the attachment to a product increases with a higher paid price. Furthermore, selling more durable products is especially beneficial when consumers are exclusivity-seeking because higher output prices combined with lower output volume appeal to these customers (Agrawal et al., 2016). Overall, price seems to be key to sales in the mass market. However, for more expensive clothing, durability is a key feature to increase attachment to the product and the willingness to buy and should be accentuated as a sales argument.

Regardless of industry, if lower durability corresponds with a lower price, demand can be increased. However, a product breakdown always bears a risk of consumers switching brands and must be accounted for (Strausz, 2009). In addition, higher durability can be a successful strategy, especially when consumers value exclusivity (Agrawal et al., 2016). To mitigate the potential downsides of longer product lifetimes firms can provide a trade-in model for old units to alleviate the competition with older units (Vedantam et al., 2021).

In industries where new product introductions have a high obsolescence effect, like the textbook industry, regular product introductions effectively kill off used units and therefore increase sales (Iizuka, 2007). However, short replacement cycles lower consumers' willingness to pay. Optimizing the revision timing bears great potential to increase demand and should therefore be paid close attention to in any industry (Boone et al., 2001).

When firms implement other business models than selling, the incentives for low durability decrease. For instance, when a firm rents or servitizes its products, regular breakdowns or repairs adversely affect profits (Waldman, 1996). Kanatlı and Karaer (2021) find that a servitizing firm produces 18% more robust products than a selling firm.

The importance of durability and the potential of planned obsolescence cannot be generalized and must be assessed for every industry individually. However, in most industries

longer lifespans can nurture brand image (Hartl et al., 2023). Especially in today's market, risking an image of environmentally harmful business practices can lead to detrimental consequences for a company's performance. Evidence from selected industries clearly states the benefits of refraining from environmentally harmful business practices. In addition to a higher willingness to pay in the fashion industry, a better corporate image can increase purchase intention in retail (Ko et al., 2013; Şener et al., 2019; Sun et al., 2021). A recent study shows that consumers have a lower willingness to pay for products that are more harmful to the environment than the industry average (Petersen et al., 2021). This finding is particularly relevant for product categories where short replacement cycles have a big influence on the environmental footprint. Furthermore, younger generations, like Generation Z, are proven to have more environmental concerns and a significantly higher willingness to pay for green products (Gomes et al., 2023). Building an image of greener products will become even more important as these consumers grow older and gain purchasing power. Due to these findings, the next part will discuss the environmental consequences of planned obsolescence and product lifespans.

6.2 Environmental Consequences of Short Product Lifespans

Allegations about planned obsolescence often include criticism about the environmental harm created through shortened replacement cycles. The EU's Waste Hierarchy prioritizes waste prevention and preparation for reuse before recycling and disposal (Directive 2008/98/EC). This suggests that obsolete items are the worst because they will not be in either of the first two categories. For utmost scenarios, this claim is backed by research. When considering the lifetime impact of a product, the manufacturing and distribution, as well as the impact during its use and disposal must be included (van Nes & Cramer, 2006). Therefore, the lowest impact does not need to correspond with the longest lifetime. Especially for dynamic goods, energy consumption can outweigh the impact of new production if a more efficient alternative is available (Rivera & Lallmahomed, 2016).

For instance, freezers consume a substantial amount of energy during their use phase. While in 1980, the use phase made up over half of the environmental impact, it was less than a third in 2010 (Bakker et al., 2014). Due to exponentially declining energy consumption, the optimal replacement for a freezer produced in 1980 was eight years, less than the median lifetime of 20 years at the time. This changed due to the reduced potential in absolute saving, making the optimal lifetime of a freezer bought in 2011 closer to 20 years, six years longer than the actual average lifetime. Hence, declining lifetimes harm the environment, contrasting the belief that a premature replacement could be preferred.

Similar conclusions can be drawn from case studies regarding washing machines (Prakash et al., 2016). A washing machine lasting twenty years has about 43% less GWP than a machine lasting five years. The difference between a lifetime of ten and twenty years is still 12% in favor of the more durable machine. As the average assumed lifetime of a washing machine is about 12.5 years, a longer product lifetime would be the environmentally preferred option for washing machines as well (Boyano et al., 2017).

Laptops are less dynamic goods because manufacturing is responsible for about 70% of total primary energy consumption (Apple, 2021; Deng et al., 2011). A gain in power efficiency for the laptop's use phase can therefore barely affect the overall energy use. Even with a 10% efficiency gain, a replacement would only be environmentally preferred after 33-89 years of use (Prakash et al., 2012). Less significant, but still in support of longer lifetimes, Bakker et al. (2014) find that a desirable lifespan for laptops would be seven years, instead of the current four years. Furthermore, a laptop lasting six instead of three years decreases the GWP by about 25% (Prakash et al., 2016). All findings suggest a longer lifespan of laptops as the environmentally preferred option.

The carbon footprint of smartphones is similar in distribution as manufacturing makes up 85-95% of the total impact (Belkhir & Elmeligi, 2018). However, a smartphone has a GWP of less than 100 kg CO_2e (Apple, 2022; Proske, 2022; Samsung, 2023). This is a fraction compared to other devices like laptops whose GWP is about four times higher (Apple, 2021; Prakash et al., 2016). Still, smartphones are often in the spotlight of environmental debates. Due to their large quantity and short lifecycle, smartphones are the single largest contributor to the total GWP of consumer communication devices (Belkhir & Elmeligi, 2018). In addition, smartphones include a variety of metals and toxic materials that can harm the environment and human health (Proske, 2022). Even though the individual footprint of smartphones is relatively small, longer lifetimes are clearly environmentally beneficial and could make a significant difference due to the large quantity.

Valid for all examined product categories, extended lifespans are advantageous for the environment. As many products consume most of their energy in manufacturing, energy savings through a replacement by an eco-friendlier alternative are rare. Cherry et al. (2018) estimate the emission savings potential from extending product lifetimes in all categories at up to 13 Megatons of CO_2e, about 2% of total emissions in the UK. Short product lifespans result in unnecessary use of resources that are not compatible with our growing world population and planetary boundaries (Satyro et al., 2018).

Consumers got used to short product lifetimes over the last decades, creating a culture of fast consumption (Satyro et al., 2018). The demand for affordable products gives manufacturers a justification to produce less durable goods. This raises the question of who is responsible for the current state, which will be discussed in the following section.

6.3 Who is to Blame for Planned Obsolescence?

Replacement behavior does not form in a vacuum but is created by an interplay between consumers and firms (Wieser, 2016). Even though empirical evidence suggests that manufacturers decrease durability for their profit, they might just produce what consumers ask for (Rangnekar, 2002). Lifespans have evidently decreased in many categories over the last decades, matching the subjective feeling of consumers (Cooper, 2004; Huisman et al., 2012). However, the accusation that shorter lifespans can only be attributed to malicious intent from manufacturers disregards the circumstances. Rising technological complexity and shorter development times increase stress on engineers and create more possibilities for product failure (Longmuss & Poppe, 2017). Moreover, cost pressure becomes noticeable in cheaper materials as well as less rigorous testing and quality control.

Consumers could incentivize more durable products by buying more of them or by paying higher prices for them. At least partly, consumers act and penalize environmentally harmful products by reducing their willingness to pay (Petersen et al., 2021). But, when products are eco-friendlier, consumers do not reward that, leaving out incentives for significant improvement. Another weakness in consumer choice to promote greener products is that they only compare a product's impact to the industry average, which does not create incentives for change in an industry as a whole. Thus, consumers do partially disincentivize harmful practices but do not exploit their full potential to drive change.

In some cases, consumers might not even be aware of the environmental impact of their choices. Longevity is unobservable and not as salient as style or price and therefore, consumers tend to neglect it (Strausz, 2009; Sun et al., 2021). A lab experiment from Sun et al. (2021) has shown that almost 80% of people choose to buy multiple mid-range pairs of shoes instead of one high-quality pair. Generally, the primary reason for consumers not buying products that last a long time, especially significant for men, is the fear that they might become outdated (Cooper, 2004; Cooper & Mayers, 2000). Buying short-lived products to hedge against style changes, again, incentivizes products with low durability but also proves that psychological obsolescence is a meaningful aspect of consumer decision-making.

Even though consumers could choose to buy for longevity, firms heavily promote short replacement cycles. Periodic product revisions and style changes trigger psychological obsolescence and increase the perception of consumers to be outdated (Bayus, 1991; Kuppelwieser et al., 2019). Seasonally changing fashion assortments and yearly smartphone releases combined with marketing campaigns like T-Mobile's *JUHU!* promote short replacement cycles and decrease consumers' mental resistance to replace functional products (Wieser, 2016). Also, targeting promotional offers to consumers who do not require a replacement is a way to provoke premature replacements. Especially consumers, who replace their products prematurely quote a promotional deal or desire for a style change as primary reasons for their behavior (Bayus, 1991). Of course, this weighs differently in various industries as malfunction is by far the most common reason for a replaced freezer while most smartphones are replaced while still functional (Wieser & Tröger, 2016; Guiterrez et al., 2010). Perceived speed is one of the most prevalent reasons for a discarded smartphone (Wieser & Tröger, 2016). However, according to a study by Makov and Fitzpatrick (2021), measurable smartphone performance stays constant, regardless of the device's age. This does not mean that consumers' perception is wrong because newer software versions can be more demanding than older ones, but still, the device's objective performance cannot be responsible for short replacement cycles. Despite this, consumers still want upgrades at some point. And because the mental value of a device has not fully depreciated yet if it is still functioning, the replacement process is more painful for the consumers (Bellezza et al., 2017). That is likely why consumers exaggerate smaller shortcomings in performance as an excuse to replace the whole device. Jacoby et al. (1977) have shown that consumers use minor flaws in their watches to justify a replacement purchase, which is most likely also applicable to smartphones.

Another facet of lifetime extension is repairability. In Germany, computers are the only electronic device with a repair rate of more than 50%, while smartphones, washing machines, and fridges have lower repair rates (Jaeger-Erben & Hipp, 2018). This is in line with findings from other regions. Cooper and Mayers (2000), find that about 40% of households rarely or never have any products repaired and Cooper (2004) finds that only 26% of households usually repair items. In Brazil, 24% of people have attempted to repair a malfunctioning device (Echegaray, 2016). Few consumers are attempting repair due to rising complexity and the lack of repairability in many products.

The Fairphone is one of the products counteracting this trend (Proske & Jaeger-Erben, 2019). The goal of the Fairphone is to prolong its lifespan to five years by having easily

replaceable and upgradable modules. This would lead to a 28% decrease in GWP compared to a smartphone lasting three years. However, because physical impairment is not the primary reason for smartphone replacements the challenge of psychological obsolescence is not solved. Especially in environments of fast obsolescence, fewer consumers try to get their products repaired or buy used products (Wieser & Tröger, 2016). For popular smartphones, interest in repairs shrinks as the devices become older, regardless of repairability (Makov & Fitzpatrick, 2021). Also, as pointed out before, volume is key to making a difference in the environmental footprint of smartphones. About 100,000 Fairphones were sold in 2022, compared to over 200 million iPhones (Fairphone, 2022; IDC, 2023). The concept has the potential to be more environmentally friendly than other smartphones, but it does not solve the dominant, psychological reasons for smartphone replacements and currently lacks the volume to make an impact. Still, offering consumers an eco-friendlier alternative is likely an important first step to changing consumer culture.

Currently, not repairing things is entrenched in consumer culture and low repair rates give manufacturers justification for low repairability (Cooper, 2005). Even though young consumers in particular have partly shifted their consumption, consumers still demand cheap products. They want to own modern devices and fashion items and therefore incentivize firms to produce short-living products. The narrative of planned obsolescence gives consumers an excuse to replace items quickly while on the other hand, firms promote frequent upgrades and nudge consumers to premature replacements (Wieser & Tröger, 2015). Accusing consumers of a throwaway mentality justifies products with a short life expectancy. Both sides blaming each other creates a downward spiral of shorter lifespans. Change needs to happen on both sides for a sustainable future. Governments have the power to force or accelerate this change by implementing legislation. Which measures can be taken and what effects they have will be discussed in the next section.

6.4 How Can Legislation Effectively Support Change for the Better?

Malinauskaite and Erdem (2021) criticize current EU laws and motions for focusing too much on current economic factors instead of focusing on intergenerational arguments. They argue that ecological ambitions about a circular economy could be undermined by short replacement cycles and demand a ban on planned obsolescence on the EU level. However, the ramifications of France's criminalization of built-in obsolescence are not yet fully clear. Wieser (2016) argues, that a ban is ignoring socio-economic factors. Low durability is not the only reason for short replacement cycles and therefore, the problem needs to be approached from multiple directions.

One example of legislation already intact in the EU is a minimum warranty. According to Hartl et al. (2023), a warranty period has an inverted U-shaped effect on product lifetimes. A short warranty period lacks incentives to produce high durability for the producer. On the other hand, if the warranty period is too long, an investment in higher quality would be less profitable than fulfilling warranty claims. Hence, a longer warranty period than currently installed in the EU might not be beneficial for product lifetimes. A clearly effective measure is to make consumers aware of the existing warranty period because it will increase pressure on the manufacturer to adhere to the set warranty.

Right-to-repair is another globally discussed measure to empower users to be able to repair their own devices. However, because the current willingness to repair is low and psychological obsolescence is the primary reason for product replacement in some product categories, the actual benefits are unclear (Jaeger-Erben & Hipp, 2018; Makov & Fitzpatrick, 2021). According to the theoretical model from Jin et al. (2023), introducing right-to-repair can possibly harm the manufacturers' profit, consumer surplus, and the environment. They argue that manufacturers lose profits from repair due to decreased prices for independent repairs. This would lead to reduced output prices in the short term to remain competitive, but increased output prices in the long term to balance the lost profits. The growth in output prices could be higher than the savings from price decreases for repairs, reducing consumer surplus. The decreased prices in the short term would lead to higher demand and therefore more production volume, increasing environmental harm.

A further idea to promote repairability is to increase taxes on energy while also decreasing taxes on labor (Cooper, 1994a). Currently, repairs are often economically nonsensical because the repair costs are barely less or more than buying a new product. A minimum period to keep replacement parts in stock could be mainly beneficial for products with low psychological obsolescence, for example, washing machines (Prakash et al., 2016).

Moreover, making information about product lifetimes and environmental consequences of a product more transparent is a popular demand (Cooper, 1994a; Maitre-Ekern & Dalhammar, 2016; Petersen et al., 2021). The concept of a "product passport" in the latest proposal by the EU's Environment Committee has great potential to enable consumers to make educated choices. The change would be in line with 73% of consumers, who think that more information on lifespans is important (Cooper & Mayers, 2000). This would give consumers a notion about how long their products are going to last and the corresponding environmental impact, which is beneficial to companies selling higher-quality

goods where the environmental benefits of longevity are not salient (Sun et al., 2021). In addition, making the environmental harm of products more visible would lower the willingness to pay for products worse than average (Petersen et al., 2021).

Overall, a ban on planned obsolescence could potentially be effective but cannot prevent fast replacements on its own. It must be supported by an optimized warranty period, transparency for consumers, and a strategy to promote longer product lifetimes and repairs.

Increasing durability can even stimulate the economy. A one-year life extension for cars was found to result in gross domestic product growth in Japan, compensating for lost output quantity, while also decreasing waste production and energy use (Kagawa et al., 2006). Research examining the potential benefits for the European economy is also positive. Longer lifespans would result in job creation with the repair industry and firms focusing on renting or the development of long-lasting products being profiteers (Malinauskaite & Erdem, 2021; Montalvo et al., 2016). Manufacturing or raw-material-providing companies are likely the ones to suffer. Still, durability would be a competitive edge on the global market and therefore boost the European economic zone.

7. Implications

7.1 Implications for Management

While the economic incentives for planned obsolescence seem obvious in theory, the effects are more ambiguous in reality (Waldman, 1996). Wear-out is a primary driver for replacements and especially when the breakdown can be controlled, planned obsolescence raises profits (van Nes & Cramer, 2006; Zhao et al., 2021). However, planned obsolescence can also induce losses in the brand image and therefore harm sales.

For products, that will become technologically obsolete before they physically break anyway, planning for a limited lifetime can make more sense than building for the maximum physical lifetime. In those cases, repairability does not prolong a product's lifetime, and consumers' interest in repairs is mostly determined by the device's age (Makov & Fitzpatrick, 2021). Even though extending the product's lifetime is an environmentally favorable choice, the benefits of repairability and other lifetime-extending measures would be minor if psychological obsolescence is not addressed (Wieser & Tröger, 2016). In industries with slow technological progress and rare style changes, repairability has great environmental potential, and longevity can build a positive brand image and nurture customer satisfaction (Cooper, 2004; Prakash et al., 2016). High durability is therefore a

recommendable strategy in categories with slow progress, while it likely does not affect performance in industries with regular technological advancements.

In fashion, mid-range products are preferred to high-end ones by most consumers (Sun et al., 2021). However, buyers of slow fashion are willing to spend more, and with a higher paid price, the attachment to a product increases (Şener et al., 2019; Sun et al., 2021). When consumers are seeking exclusivity, higher quality and lower volume can increase profits (Agrawal et al., 2016). This likely holds true for cars too. Also, the perceived quality of automotive brands is crucial for their performance and could be undermined by premature failure (Akdeniz & Calantone, 2017). Moreover, the effects of longevity are positive overall, as the expected cannibalization effect of used cars is lower than the competitive effect combined with the increase in brand value (Jayarajan et al., 2018).

Style changes and promotional offers can nudge consumers to replace their products more frequently and therefore increase revenue (Bayus, 1988, 1991). Furthermore, the frequency of product introductions can increase sales and should be paid close attention to. Making product upgrades available will induce psychological obsolescence (Bellezza et al., 2017; Kuppelwieser et al., 2019). However, if the replacement cycles are too short or upgrades are not meaningful enough, consumers reduce their willingness to pay or delay their purchases (Boone et al., 2001; Iizuka, 2007; Stock & Zacharias, 2013). Hence, the frequency of product releases can greatly influence performance and should be assessed for every product individually, depending primarily on the rate of change.

Besides, as planned obsolescence is a major contributor to e-waste production, energy consumption, and resource depletion, refraining from such business practices is likely beneficial going forward (Bakhiyi et al., 2018). Consumers becoming more conscious about the environmental impact of their consumption creates incentives to become eco-friendlier (Gomes et al., 2023; Petersen et al., 2021). Although extending product life carries certain risks in the form of lost sales, the benefit of a positive brand image as well as protection against potential regulatory changes is a favorable strategy for most companies. Following this assumption, sustainability must not need to be balanced with performance, but must rather be seen as a condition for long-term success.

7.2 Implications for Legislation

Due to the environmental consequences, consumer drawbacks, and economic potential, there is a need for government intervention. Even though legislation promoting longer lifetimes jeopardizes manufacturing firms, it supports other industries, making the overall

effect on the economy positive, while also benefiting consumers and the environment (Kagawa et al., 2006; Montalvo et al., 2016). Banning planned obsolescence is a possible approach but does not solve the problem on its own (Wieser, 2016). As longer lifetimes are favorable from an environmental and consumer standpoint, they need to be promoted. A minimum warranty period can be an effective measure but not if it exceeds a threshold where decreasing durability increases profits (Hartl et al., 2023). Calling attention to existing warranty rights incentivized more durability.

Right-to-repair can extend the product lifetime in some categories but will likely not significantly affect product lifetimes in all categories because psychological obsolescence cannot be delayed by repairability (Makov & Fitzpatrick, 2021; Wieser & Tröger, 2016). Furthermore, right-to-repair might have negative effects on profits, consumer surplus, and the environment (Jin et al., 2023). Tax rebates for repairs could also help to prolong some products' lifespans (Cooper, 1994a). Also, making expected product lifetimes more transparent and environmental harm more visible in the form of a "product passport" is a recommendable action (Maitre-Ekern & Dalhammar, 2016). Pointing out that a product is environmentally worse than a certain benchmark, for example, the industry average, can support consumers to choose products more consciously and reduce their willingness to pay (Petersen et al., 2021). Laws for heightened transparency also get approval among consumers (Cooper & Mayers, 2000). Furthermore, strict e-waste regulations must be enforced to avoid hazards to human health and the environment (Bakhiyi et al., 2018).

7.3 Implications for Research

The current research gives some insight into the consequences of product lifetimes on the environment, consumers, and firms. Still, many details on planned obsolescence remain the topic of future research. For instance, the findings from sustainability-related case studies and theoretical models referenced in this work should be tested empirically. Furthermore, as consumer preferences change, future research must examine the importance of various product attributes for consumers. For example, the effects of eco-friendliness or longevity on repurchases are not explored for many product categories. Regional differences in consumer behavior must also be paid attention to. Developing countries' growing prosperity could exacerbate e-waste and pollution problems which planned obsolescence contributes to and cannot be ignored for future solutions.

Future changes in legislation must be monitored precisely by research and evaluated for their effectiveness. Also, current laws should be analyzed more deeply to grasp a better

understanding of their ramifications. Product lifetimes need to be observed closely to evaluate whether the trend of shortening lifetimes reverses. If new laws are introduced, their consequences for the economy and the environment are also an interesting topic of future research. Lastly, the compatibility of planned obsolescence with the ambitions of a greener or circular economy must be addressed in future research.

8. Conclusion

Planned obsolescence is entrenched in current consumer culture and must be dealt with. From the firm's perspective, conducting planned obsolescence is multifaceted. Malfunction is generally one of the major reasons for replacement purchases of more utilitarian products and therefore faster wear-out can increase overall demand (Bayus & Gupta, 1992; Gutiérrez et al., 2011). However, longevity and reliability can nurture brand loyalty and can be a selling point for high-priced goods (Cooper, 1994a). For washing machines durability is the most important attribute and perceived quality heavily affects car manufacturers' performance (Akdeniz et al., 2014; Jaeger-Erben & Hipp, 2018). Especially if consumers are seeking exclusivity, high-quality products can increase profits, which might be applicable for hedonic car purchases but also for fashion (Agrawal et al., 2016). Despite consumers neglecting product quality and rather buying multiple cheaper items than premium products, marketing durability can heighten value perception and willingness to pay in the fashion industry (Şener et al., 2019; Sun et al., 2021).

Still, hedonic goods are often not affected by shortened physical lifespans because they are replaced primarily due to psychological factors before they break anyway (Bayus, 1988; Grewal et al., 2004). The availability of an upgrade decreases the perceived value of the old product and leads to reckless behavior toward old products (Bellezza et al., 2017; Kuppelwieser et al., 2019). Especially in industries where technological progress is fast and every product revision constitutes a meaningful upgrade, frequent product releases can be a meaningful contribution to sales (Boone et al., 2001; Stock & Zacharias, 2013). Conversely, if new products are introduced too frequently and without meaningful upgrades, consumers reduce their willingness to pay in anticipation of quick obsolescence and customer loyalty can be damaged (Iizuka, 2007; Stock & Zacharias, 2013).

Regardless of the reason for obsolescence, short lifecycles have detrimental consequences for the environment. E-waste production is growing and poses threats to human health and the environment (Bakhiyi et al., 2018; Forti et al., 2020). Additionally, shorter lifetimes increase energy consumption and resource use, as only a small fraction of disposed

products are recycled (Ertz et al., 2022; Forti et al., 2020). However, recycling would still be environmentally undesirable compared to longer lifespans (Cooper, 1994a). Although, in theory, premature replacements of products can be environmentally desirable if the efficiency gains of the replacement outweigh its production impact, case studies have shown that longer lifespans are better in utmost cases (Bakker et al., 2014). Freezers' desirable lifetimes are estimated to be 20 years, instead of the current average of 14 years, and small electronics like laptops and smartphones are also most sustainable if they last as long as possible (Bakker et al., 2014; Prakash et al., 2012; Yu et al., 2010).

Although extending product lifetimes is environmentally beneficial, especially for larger appliances, the right to repair might not even lead to longer lifespans as few consumers repair their items anyway (Cooper & Mayers, 2000; Echegaray, 2016; Jaeger-Erben & Hipp, 2018). Especially for product categories with fast technological progress or hedonic characteristics, long or extendable lifetimes do not prolong the length of ownership (Makov & Fitzpatrick, 2021; Wieser & Tröger, 2016). Hence, psychological obsolescence is equally meaningful as physical obsolescence and must therefore be addressed as well.

Environmental concerns alone, necessitate government intervention to promote longer product lifespans. Next to sustainability benefits, legislative changes for longer-lasting products bear potential for economic growth (Kagawa et al., 2006; Montalvo et al., 2016). Regardless, measures must be taken with caution as some can possibly backfire. Overly extended warranty periods can incentivize lower durability and is less effective than making consumers aware of their existing rights (Hartl et al., 2023). Similarly, right-to-repair can negatively affect firms and consumer surplus (Jin et al., 2023). Overall, legislation plays a pivotal role in future developments.

This work has shown that planned obsolescence, indeed, can benefit performance. However, the benefits of longer-lasting products compensate for reduced output quantity while also being environmentally preferable. Products should be designed for longevity, not obsolescence, and consumers must recognize the benefits of longer-lasting, more repairable products. The narrative of firms producing products that break easily combined with the narrative of consumers demanding cheap products who dispose of them quickly might be true but results in a downward spiral of shortening lifespans (Wieser & Tröger, 2015). To achieve a balance between economic success and sustainability, firms and consumers need to make cultural changes, which must be supported by legislation. The transition to longer product lifespans is effortful but beneficial for everyone and worth striving for.

IV. References

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V. Eidesstattliche Erklärung

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