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Investigating Obsolescence Issues in Mobile Phones: An Exploratory Study

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Abstract: *Obsolescence is a widespread issue, with impacts on economic, social, and environmental levels. This paper aims to examine obsolescence issues in mobile phones through literature review. The different types and nature of obsolescence in mobile phones were investigated, and based on that, the influence of consumers, producers, and the practice of obsolescence itself on each other were interpreted. It has been identified that obsolescence in mobile phones occurs through disposal or hibernation, and can be attributed to absolute, functional, economic, and most importantly, psychological factors. Based on this understanding, exemplary cases were analyzed in general, with some references to the authors' experiences in Bangladesh, and in terms of a case study into Apple's iPhones. Based on existing problems in mobile phone obsolescence, this article attempts to discover ways to combat this issue by identifying potential weak points, challenges, and resolutions, delving into discussions about topics including repair, recycling, consumerist behavior and a circular economy model. The nature of this article is largely an analytical discussion developed through the aggregation of dispersed knowledge relevant to obsolescence and its ultimate goal is to become a base upon which further research broaching into this field could be conducted.*

Keywords: Obsolescence, Mobile phone, Consumerist behavior, Circular economy.

Introduction

The mobile phone market shows one of the largest and most noticeable examples of large-scale obsolescence. While the statistics of mobile phone ownership, disposal, hibernation, recycling, and other relevant factors vary between sources, the general pattern is undeniable that consumerism is rampant in the mobile phone industry, but the disposal or repair of older phones is not well-organized. For example, as per results compiled by the WEEE Forum and consolidated by the UNITAR SCYCLE program, in 2022, approximately 16 billion phones were in the possession of people

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worldwide, and of that, 5.3 billion phones will become waste (UNITAR, 2022). In other words, it was estimated that about 33% of phones in the hands of customers in 2022 were removed from active duty. Yet, mobile phones in current circulation outnumber people on the planet, and more mobile phones are being added to the market by mass production every day.

The core reason that wastage is occurring in such relatively large proportions in the first place is obsolescence in mobile phones on various levels. Consumer perception, technological innovation, and producer tinkering, alongside other elements, play a role in driving obsolescence in mobile phones. Furthermore, the state of the modern market allows obsolescence to thrive, driving a continuous flow of mobile phones from the producers, but the lack of a proper structure and incentive prevents these phones from closing the chain into a loop.

Obsolescence is primarily a concern due to its wasteful nature. Due to the practice's negligence of resource scarcity and waste management, it has wide ramifications in the environmental and economic sectors. However, despite the controversy that surrounds obsolescence, the mobile phone market today maintains its stability through this practice. Thus, eradicating obsolescence would require nothing short of an overhauling of the economy, in both statistical and psychological terms. As a result, it is necessary to develop a deeper understanding of obsolescence to establish a viable and sustainable solution.

Objective of the Study

The primary objective of this article is to interpret, and potentially add to, the current understanding of obsolescence within academic circles by analyzing literature regarding obsolescence in mobile phones. There is, in general, a lack of a resource that cumulatively discusses multiple aspects of the obsolescence issue. Through the perusal of existing literature, it will be possible to gauge the academic perspective on obsolescence and highlight potential solutions and challenges pertaining to the problem. By the establishment of this article, an attempted extensive overview of obsolescence, considering mobile phones as an example, has been presented. This will allow for a diversified documentation of a relatively well-known, but poorly discussed problem, which can stand as a reference point to build upon for future studies of a more rigorous nature.

Data and Methodology

This paper was written primarily through the evaluation of published materials and analysis of said information to conclude the points of obsolescence in mobile phones. While not within the scope of this article's objective, the authors recognize the value of obtaining the first-person perspectives from all parties involved in the process, with potentially valuable insight coming from the narratives of both mobile phone producers and consumers. However, as this paper is intended to be primarily a literature analysis, no other data collection techniques, such as experimentation, interviews or surveys, were implemented. It has been noted that such techniques could be the primary tool in subsequent investigations.

To underlay the theoretical discussions of this paper, source materials were mainly gathered by searching the keywords 'phone' and 'obsolescence' through the Science Direct database of Elsevier, using a ten-year range of 2013-2022 to find research articles. Out of the obtained search results, further filtration was performed to exclude case studies from specific countries, due to an incomplete understanding of the economy and consumer culture in those countries. Instead, a focus was put on the more theoretical and global concepts that may apply to a generalized society. However, some relevant topics discussed in this paper are absent in journal literature, and hence, have been sourced from search engines. It has often been necessary to depart from an exclusive discussion about the case of mobile phones and take into account generalizations and assumptions, due to the need for studies centralizing on mobile phones. Observations of this article's authors related to the topic of this paper, with the focus largely on Bangladesh, have been included in the paper to establish exemplary cases for discussion.

In this paper, there is also a discussion of the case study of Apple's iPhones, due to their international renown, and some allegations of planned obsolescence. Because of the lack of enough data from official Apple sources, any issues related to obsolescence were identified through search engines and were qualitatively filtered based on relative frequency and import. It is important to note that, due to the nature of this particular information collection methodology, any conclusions drawn regarding their practices in the mobile phone industry are drawn from the investigation or opinions of parties other than Apple, and thus should not be considered a holistically complete viewpoint.

Types of Obsolescence in Mobile Phones

Studies on obsolescence have classified it based on different parameters. Fels et al. (2016) present an overarching dichotomy in obsolescence, divided into absolute obsolescence and relative obsolescence. Absolute obsolescence is the point at which the product (in this case, mobile phones) technically becomes worn out and is rendered non-functional or sub-optimal. On the other hand, relative obsolescence is the point at which the consumer deems the product to be out-of-date and un-preferable in comparison to contemporaries available in the market. Due to the subjectivity associated with relative obsolescence, the exact point at which a product may be considered obsolete varies between consumers, but the point of relative obsolescence always happens to fall before the point of absolute obsolescence. This difference is representative of a portion of products that are still operational in utility but shuffled out of operation. Further leaning into this classification, Fels et al. (2016) reference the sub-categorization of relative obsolescence into technological, psychological, and economic factors by the model developed by Cooper T. in 'Inadequate Life? Evidence of Consumer Attitudes to Product Obsolescence,' which is considered a well-rounded and accepted model for portraying obsolescence. Technological obsolescence represents the functional deprecation of a product in comparison to newer models; psychological obsolescence comes from the customer's perceived decrease in product attraction or satisfaction; and economic obsolescence refers to a financial disadvantage in keeping an existing product in place of discarding or replacing it. In all of these cases, they do not reflect an objective breakdown of form or function and instead represent different forms of comparative arguments from the consumer's side to justify new purchases.

Cordella et al. (2021), Proske (2022), and Sátyro et al. (2018) discuss exemplary ways in which mobile phones eventually become obsolete. Breakthroughs in technology can prompt the advent of new hardware and software to run new enhancements or functionalities, which renders dated mobile phones obsolete in terms of operations. These devices are further excluded from active use through the eventual discontinuation of their respective software and hardware support. Mobile phones, like any other electronic devices, are also susceptible to failures and breakages, including hardware disturbances like display damage, cover damage and battery issues, and software malfunctions, such as a buggy operating system. Mobile phones are also prone to environmental damage, such as from water and dust, as it is

only natural for such a versatile device to be exposed frequently, and eventually succumb, to the elements.

There exists some rhetoric surrounding obsolescence that presents the idea of planned obsolescence, which is the idea that producers intentionally introduce faults into products or restrict the opportunity for upgrades or maintenance to promote sales of new models. Sátyro et al. (2018) describe potential design mechanisms by which producers can inflict different types of planned obsolescence among older models to discretely remove them from the market. To summarize, mechanisms for enabling obsolescence can be divided into physical and technological methods. Physical methods may constitute practices such as introducing designs for limited repair, limited functional life, degrading aesthetics, or fast consumption. Conversely, technological methods include practices such as introducing designs for fashion or style obsolescence, reduced technological update of hardware and software, or potential for functional enhancement in newer models. All of these represent the producer's side by which absolute or relative obsolescence can be introduced in products and stimulate consumer decisions.

Nature of Obsolescence in Mobile Phones and Associated Issues

Obsolescence in mobile phones can be divided into 2 primary modes: disposal and hibernation. Disposal refers to the throwing away of mobile phones once they are obsolete to the consumer, while hibernation refers to the storing away of mobile phones from active service once the consumer deems them obsolete. Both of these modes represent different barriers to a circular economy, not allowing for economic growth coupled with resource circulation. Mobile phones are more subject to hibernation than disposal, as they are more susceptible to relative instead of absolute obsolescence (Fels et al., 2016). These hibernated phones lock away a mass of potentially recoverable resources, while improper disposal through landfill dumping and incineration impede proper recycling procedures (UNITAR, 2022), creating an impediment to a circular economy on multiple avenues. However, it is important to note that, mobile phones that have been sold or given away are not yet considered obsolete, as they still have some functional value to some other consumer in the market; only when they have been taken away from active duty are they considered fully obsolete.

As an example, referencing European statistics, mobile phones are the 4th most hoarded small electronics products, for reasons including potential future use, sentimental value, presence of sensitive data, and lack of knowledge or incentive to recycle (UNITAR, 2022). The small size of mobile phones makes it easier to stow away somewhere in the house and forget about it. This hibernation also results in mobile phone depreciation and efficiency loss, as the phone is not being utilized but operational parts degrade over time nonetheless, albeit at a slower rate. For example, the article's authors have often witnessed on repeated instances, in Bangladesh, that a phone deemed obsolete had been kept in hibernation for a long time, as a contingency for the future. Upon accumulation of too many hibernated phones, the oldest ones are sold to scrap collectors or given to their domestic helpers, poor relatives, drivers, maid servants or security guards as gifts. However, gifting these phones to people from the lower social class is a risk, especially in developing countries, as due to the comparatively lower education level, they may improperly dispose of these phones once they become non-functional; the fact that hibernated phones are already at a higher risk of functionality breakdown than fresh ones only increases this risk.

Proper waste management practices can ensure that disposed mobile phones are stripped of valuable parts and rare minerals to be shipped back to manufacturers for reintegration into produced models. In this way, disposal presents a junction to a circular economy. Proske (2022) outlines that the manufacturing process is the most impactful part of a smartphone's life cycle, in terms of both climate change and resource depletion, with the motherboard and its electronic components bearing the brunt of the problem. As per Walton et al. (2021), and Makov and Fitzpatrick (2021), mobile phones can contain about two-thirds of the elements from the Periodic Table, many of which come from precious, critical, or conflict materials. A breakdown of the elements that may be used in the design of a typical mobile phone is outlined in Table 1.

Table 1: Breakdown of technology-critical metals in a mobile phone

Component of mobile phone	Technology-critical metals required
Touch screen	Indium, Tin, Silicon, Molybdenum
Microphone, speakers and vibration unit	Nickel, Gadolinium, Praseodymium, Terbium, Neodymium, Dysprosium, Iron
Battery	Lithium, Cobalt, Nickel, Manganese
Display	Lanthanum, Gadolinium, Praseodymium, Terbium, Europium, Dysprosium

Component of mobile phone	Technology-critical metals required
Electronics	Nickel, Gallium, Tantalum, Gold, Silicon, Copper, Zinc
Casing	Nickel, Magnesium, Aluminium

Source: Walton et al. (2021); Resource Capital Funds CIO Team (2023)

These technology-critical metals are prone to supply shortages due to reasons such as rapid market expansion, varied geographical resource distribution, political disruptions (e.g. trade disputes, quotas, and taxes), low recycling rates, and a lack of alternative substitute materials. As there is a lack of resource deposits, secondary sources can be obtained from discarded mobile phones. Gómez et al. (2023) discusses this in depth: dissecting end-of-life mobile phones as a fast-growing and resource-rich, but largely untapped, secondary source for high-value critical and strategic metals can help establish a circular economy. Their studies mark technology-critical elements as possessing much economic potential due to their higher concentrations in waste mobile phones than natural ores, while also realizing the potential of polymer recovery from mobile phones. On the basis of UNITAR's estimation of 5 billion mobile phones becoming waste by the end of 2022, Gómez et al. calculate a grand loss of a potential US$ 9.25 billion that could be fed back into the economy.

Okafor (2023) presents an overview of current waste trading trends. In general, waste management and recycling facilities are concentrated in industrially advanced developing countries as an economic opportunity, where developed countries could offload the waste materials they produce on a gigantic scale for processing. However, large-scale waste accumulation ended up being a drain: improperly separated waste could not be efficiently recycled, pollution was rampant due to waste overflow in landfills, extra waste that could not be processed properly was incinerated and illegal waste processing operations improperly disposed of waste to rack up profits. All of these issues finally led to China's ban on waste imports, which, due to its prominence as a waste importer and processor, resulted in a crash throughout the world's waste trade.

It is undeniable that present waste management techniques are inefficient and assist in the promotion of obsolescence in mobile phones, through the unaccountability of hibernated devices and the lack of organized feedback of disposed devices back into

the economy to close the loop. Hence, methods of tackling obsolescence must take into account the post-usage states of mobile phones, among other factors, to be effective.

As previously mentioned, there were approximately 16 billion phones in the possession of people worldwide in 2022, which, even assuming universality of mobile phone ownership, implies that 2 mobile phones are owned per person. However, mobile ownership is limited by numerous factors like age, income, and developmental outreach, suggesting the presence of a large imbalance in the quantitative distribution of mobile phones. Many households with sufficient disposable income consider purchasing more mobile phones than required to diversify their purposes. For example, in Bangladesh, the authors have witnessed that numerous middle-income and high-income families keep more mobile phones than there are household members, for diverse reasons including: working outside the home, working inside the home, children's education, flaunting purposes, internet use, entertainment purposes, and a central set for the family. This is not limited to the upper classes only: nowadays, low-income households also attempt to maintain a cheap, rough-handling handset for outdoor work and invest in a slightly more lavish smartphone to use within their homes. Despite the stated reasons, multiple phone usage introduces redundancy, especially since modern phones are capable of diversifying and compartmentalizing varied purposes in a single set. Instead, maintaining multiple mobile phones runs an added factor for obsolescence, as each set is subject to comparison to newer models on the market that could fit their niche roles.

Obsolescence of Mobile Phones on the Consumer End

Consumers are the primary source of demand in the market and hence play a crucial role in deciding when products like mobile phones become obsolete. Although producers also play a sizable role in the obsolescence of mobile phones, some tactics they employ are ultimately geared to influence the consumer mindset, making it crucial to understand the factors of consumer interests.

As mentioned earlier, consumers are susceptible to declaring relative obsolescence, leading to these obsolete phones being stored away in hibernation or disposed of upon dysfunctionality. As per the investigations of Fels et al. (2016), reviews of 2 mobile phone brands on *Amazon.de* that mentioned the reason for obsolescence were mostly

psychological, namely ergonomics, sensory quality, and changing needs. If a mobile phone satisfies the customer for at least a period that the customer assumes is a reasonable product lifetime, then the customer values the durability of the product rather than its eventual obsolescence, regardless of the reason. Whenever customers shifted brands due to their old product becoming obsolete, physical wear-out appeared to be under-proportionally related to brand change, potentially due to customers associating mobile phones with haphazard usage, while changing needs were not significantly important, as most brands currently maintain a standard uniform range of technologically similar products. This serves to further highlight the relatively superficial reasons for mobile phone obsolescence.

The technological and economic factors of obsolescence are, comparatively, straightforward, as they have definable parameters to describe their nature (hardware and software across mobile phones, and market forces involving different brands, respectively). However, psychological obsolescence is the one that is least susceptible to analysis techniques, due to its relative variability, vagueness, and immeasurability. Examples of such factors include a desire for novel features, better appearance, sleek usability, and social status association with branding. Makov and Fitzpatrick (2021) discuss, to some degree, the psychological implications behind consumers engaging in obsolescence, especially concerning repair initiatives. Consumers idealize a long-lasting and easily repairable mobile phone that they do not have to replace every time there is a defect. Indeed, although these phones do not usually become completely dysfunctional in a short time, the lack of appropriate repair opportunities gives ample time for consumers to grow a cumulative distaste for the flaws and defects a phone develops through use, prompting them to shift to a new model. Moreover, consumers establish an alibi to justify purchases of new mobile phones based on minor issues, which psychologically serves to neglect any guilt associated with wasteful behavior. The presence of new mobile phones on the market that the consumer may covet also influences them to adopt a relatively carefree attitude regarding their current phone. As a result, it comes to the point that, despite the environmental advantages of and consumers' initial wishful thinking towards repair, the realistic interest in repair declines exponentially over time.

Makov and Fitzpatrick (2021) claim that repair initiatives do not promote mobile phone longevity and that the focus should be on suppressing the ‘planned

obsolescence' rhetoric and realizing the objective stability and functionality of older mobile phones. However, the authors of this article stand on the viewpoint that negligence towards repair opportunities is not a step in the right direction. Especially in developing countries, such as Bangladesh, mobile phone repairs are not only widely practiced but also crucial for extending mobile phone longevity. People with minimal means need to cope with both exceptionally rough phone usage and cut down on purchases, and thus, repair opportunities are abundant for their mobile phones, where numerous cheaper unofficial repair shops exist everywhere in the country to deal with the scarcity of official brand-mandated repair stations. It is undeniable that rhetoric surrounding 'planned obsolescence' perhaps has created an easy avenue for consumers to easily shelve their mobile phones, by blaming any flaws in their products to alleged producer malpractice. However, the matter of speech suppression regarding this practice, as suggested by Makov and Fitzpatrick (2021), creates an entirely different problem, one where producers could hypothetically claim a defamation case in court against sustainability advocates. In contrast, establishing cheap and effective repair facilities initiates the first step towards a positive mentality towards older devices, which can be further cultivated to raise awareness regarding sustainable mobile phone usage.

Hence, it can be surmised that, amid a multitude of other reasons, consumers primarily act on psychological whims when considering the purchase of a new mobile phone. This portends to the consumerist mindset that is present in modern society while illustrating a key vulnerability that producers utilize to further their interests, as shall be discussed in the next section.

Obsolescence of Mobile Phones on the Producer End

Producers cover a different angle from consumers in the establishment and maintenance of obsolescence in mobile phones. As addressed previously, the consumer side largely derives from the nature of personal benefit and comfort, and as such, it is largely self-centered. However, the producer side is powered by the corporate drive for profit, and hence, obsolescence in mobile phones, whether natural or intentionally introduced, exists either as a boon for profit generation or an obstacle to overcome to achieve a more profitable approach.

Obsolescence is vital in the maintenance of sales turnover in the modern economy, as obsolete products guarantee new sales. Durable products would mean that demand

would stagnate over time, causing the economy to falter. A well-documented instance of obsolescence was the infamous Phoebus cartel: several notable corporations met to limit lightbulb lifetimes to a standard of 1000 hours, set a production limit per company, and a standardized price for their lightbulbs to manipulate the industry towards their benefit. Since then, however, corporations have become more careful about such practices, and hence, any further instances of obsolescence, whether intended or not, are speculative and suspected, but without any further concrete evidence or cases. Any claims of obsolescence are often waved away with an excuse that stands under evidence-less scrutiny or paid away with fines, leaving little room for investigation with respect to company privacy. Furthermore, few people now question the prevalence and power of obsolescence, due to the relatively high penetration rate of major companies across the globe (Makov & Fitzpatrick, 2021). However, it is imperative and lucrative for companies to maintain a high sales turnover, especially on the 'sunny days,' to store away capital for the 'rainy days' that may potentially come with the volatility of world economics.

Kuppelwieser et al. (2019) present numerous arguments from various sources that support the planned obsolescence scenario. There exist claims that obsolescence guarantees that new product designs, features, and variety are brought to the public in increasing frequency, thus maintaining welfare. It also ensures that the wheels of innovation continue turning, as durable products would discourage product research and development. Newer models of a product can be more energy-efficient and technologically up-to-date, allowing products to have a more eco-friendly lifetime. However, producers must ensure that their mobile phones remain moderately functional for at least the minimum expected life expectancy of about 2 to 3 years. If mobile phones do not last for that long, customer satisfaction is reduced and brand loyalty is challenged. By ensuring that obsolescence occurs within an acceptable range, it can be claimed that the mobile phone industry will maintain a profitable model, while simultaneously catering to the requirements and welfare of customers. Kuppelwieser et al. also presents the idea that consumers can be subject to planned obsolescence regardless of their immediate demand for the product at hand, and thus, producers can utilize varied marketing strategies to maximize their share of potential customers in the market.

Mobile phones can be subjected to functional obsolescence when producers introduce hardware and software updates, present new features and capabilities for added functionality, and remove support for older devices for safety reasons. In all of these examples, despite claims of customer welfare, security, and usability, it must be acknowledged that most of these 'features' are introduced by mobile phone companies largely through their initiative, not through wider customer consensus, and thus, can potentially be seen as fulfilling a self-serving agenda beyond that of customer satisfaction.

Producers can also implement faster obsolescence through the lack of repair opportunities and facilities. Makov and Fitzpatrick (2021) indicate that the reparability of phones has become more difficult. The implementation of embedded batteries and the use of adhesives support the production of integrated, thin, and light smartphones, but they provide little opportunity for taking apart the phone to access the interior for repair and replacement. Moreover, official brand-approved repair stations are usually not widely accessible, and repairing mobile phones can be an expensive venture with a lot of terms and conditions attached. As a result, mobile phones can accumulate damage over time, eventually rendering them either dysfunctional or undesirable in comparison to newer models.

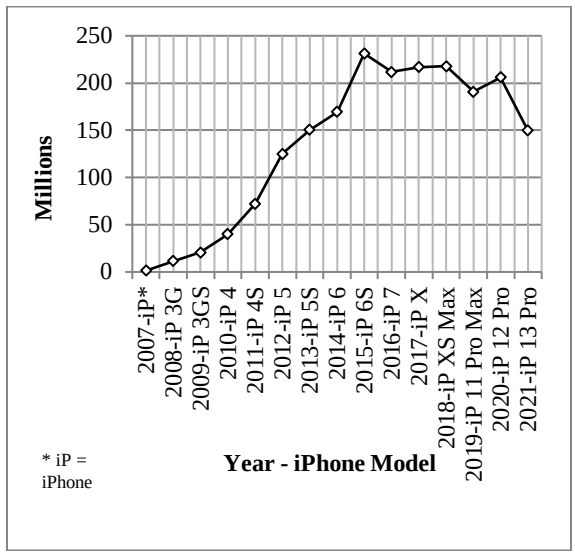
While all of the above mechanics describe primarily technical and functional aspects of obsolescence, producers play an active role in catering to the psychological impulses of a consumerist society. Apart from the base role of advertisements in informing consumers about upcoming products, the more elaborate role is to entice potential customers into buying their new product. The nature, features, and commentary of adverts have changed based on defining social characteristics of the time and place, but they all served to prove that their product was superior to anything currently in consumer hands or available in the market. Product presentation varies across adverts and often caters to various segments of the consumer population: broadcasts and billboards for public attention, comparisons to an industrial standard for option seekers, promotional offers for bargain hunters, celebrity endorsements to appeal to fanbases, or minimalistic descriptions of premium products that let their brand reputation speak for themselves. However, advertisement is a natural and important part of a business that is necessary for consumers to gauge the current market situation and for producers to reach out to consumers. It is not the cause of obsolescence, but its unique role in the market makes it a conduit for such practices to

proliferate nonetheless. Based on the above, it can be understood that the actions of producers, whether intentionally directed or otherwise, play a major influence on consumerist behavior, and thus is a major focal point in the fight against obsolescence.

Apple's iPhone: An Exemplary Understanding of Obsolescence in Mobile Phones

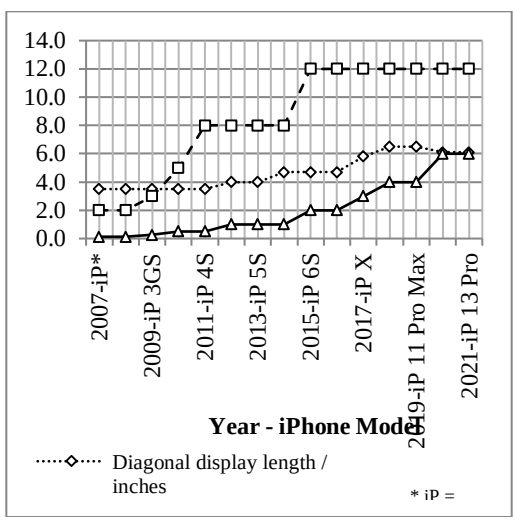
To understand the extent of obsolescence in mobile phones, it is important to look at the overall scenario to judge how prevalent this practice is within this sector of the market. Thus, Apple's iPhone can be used as a prime example due to its global renown, high market volume, and well-documented history of scandals in obsolescence.

Apple started releasing new models of the iPhone on an annual basis, starting in 2007. They were a revolutionary step in this industry and played a role in introducing new technology that is considered standard in modern phones. Apple has remained among the top mobile phone brands since its inception, and as a result, developed a mass following within the target consumer group. Figures 1 and 2 display the worldwide sales volume and a few graphable functional trends, respectively, in some selected iPhone models that have been released annually from 2007 to 2021.



Source: Turner, c. 2023

Figure 1: Worldwide Sales Volume of iPhone Models (2007-2021)



Source: Turner, c. 2023

Figure 2: Annual Trend in Functional Characteristics of iPhone Models (2007-2021)

The displayed infographics attempt to indicate that, in general, iPhone models have become more technologically sophisticated, while also attracting more customers with each model. The performance of the existing phones speaks for itself, keeping loyal consumers poised for what features they will witness in the models to come.

This allows the majority of consumers to overlook the features of their current model over time and instead they are more eager to shift to the newer model. The fact that Apple offers a one-year warranty on all of its iPhones and that new models are released annually also forms an interesting pair of points that give more weight to the idea of purchase over maintenance. Selling iPhones gives Apple a decent level of profit, as illustrated in Figure 3, though it is important to note that the bill of materials is reflective of only a portion entire cost behind an iPhone, as there are other associated costs, such as production, services, transport and advertising.

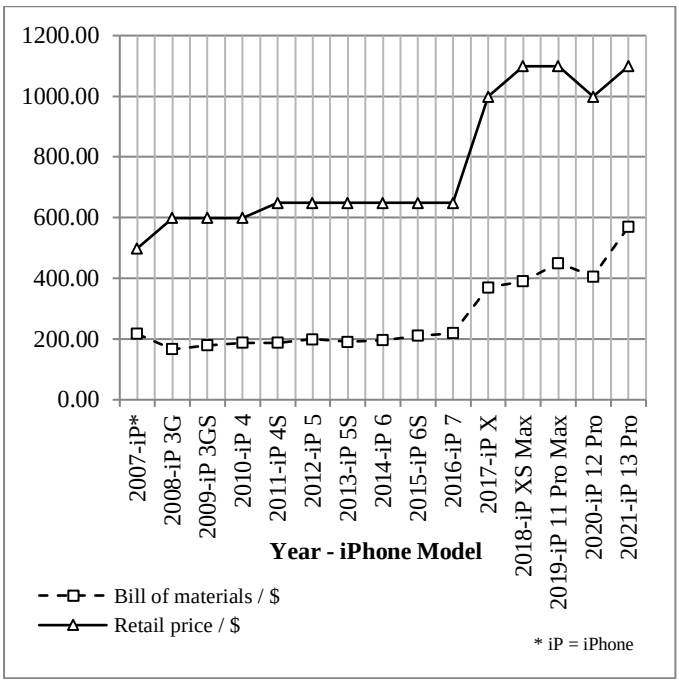


Figure 3: Comparison of Bill of Materials and Retail Prices of iPhone Models (2007-2021)

Source: Turner, c. 2023

Obsolescence in iPhones involves many different factors, some more questionable than others. For example, the leading reason for obsolescence in the earlier models is technological limitations. Although older iPhone models are still largely functional within their respective iOS versions, they cannot run iOS versions or mobile applications that are past the phones' operational constraints (Richter, 2023). This

often excludes earlier models of iPhones from modern usage except for mundane functions. Due to a lack of technological prowess, Apple itself declares any iPhone model vintage when it has been 5-7 years since its release, and obsolete when it has been more than 7 years since its release, for which Apple provides no hardware service (Apple, 2023a).

However, Apple does not have the most innocent of tactics for mobile phone repair and maintenance. Compiling data for Turner (c. 2023) and Apple (2023b), the ratio of average repair costs (considering the category of 'Other damage') to the retail price for some select models shows that Apple charges a sizable amount for repairs, often making it more worthwhile to buy an updated model for a reasonable price hike. Self-repair opportunities with iPhones are pretty shallow, as they are limited to a few models, only available in limited regions, and the prices are similar to sending the phone to designated Apple repair shops (Ganapini, 2022). These sources further mention that Apple keeps record of the parts installed in an iPhone through tracking of associated serial numbers and actively obstructs the smooth operation of iPhones that violate their designated part-pairing protocols. Due to this serialization, functional parts from other iPhones cannot be reused by customers to be repaired for cheaper elsewhere, discouraging self-repair and promoting consumerist behavior.

One of the most notable and controversial records of Apple's planned obsolescence is the battery gate scandal. As per Shi (2018), the history of this scandal started back in 2016 when many older iPhones started showing reliability and usability issues, including shutdowns. The issue was rooted in battery quality, but instead of addressing it on a large-scale and open level, Apple silently masked the problem through the iOS update 10.2.1 in January 2017, which limited performance to stop battery overexertion. This prevented the aforementioned critical issues from occurring in these phone sets but gave the impression to consumers that the update was the only solution to their problems and that their sets were becoming obsolete by current technological standards if they were unable to support the post-update performance. However, in December 2017, a Reddit post broke down the truth of the battery issue in the iPhones and revealed the performance throttling done by Apple, leading to public uproar and lawsuits against Apple. Throughout 2018, Apple performed compensatory actions against their hidden performance throttling, such as offering payouts and discounted, but limited, battery replacements. Poole (2017) helps break down the performance issues related to the battery gate issue in detail, based on the

original Reddit post, from which the summarized graphs of the kernel density of Geekbench 4 single-core scores for the iPhone 6s running different versions of iOS have been displayed in Figure 4 for reference. From the graphs, it is evident that, at least for the investigated models and iOS versions, the issue of performance hindrance got worse with each new version, as Apple set hidden benchmarks for throttling as the battery quality kept decreasing.

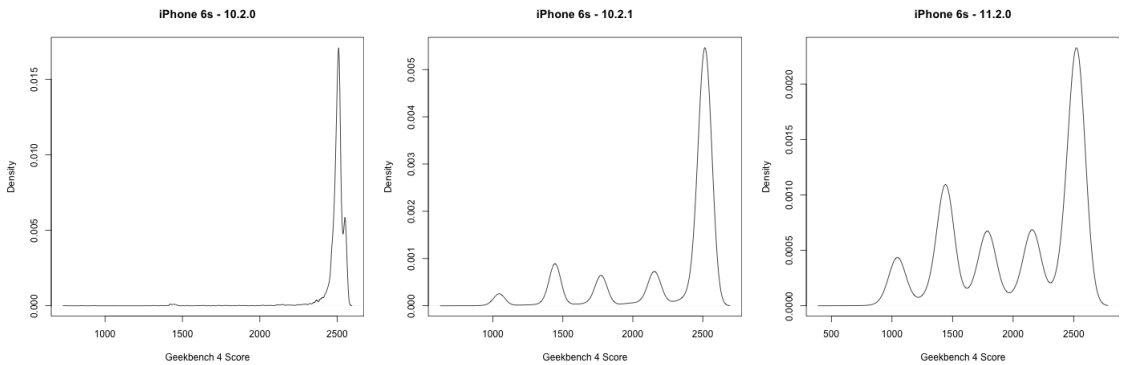


Figure 4: Kernel Density of Geekbench 4 Single-core Scores for the iPhone 6s Running Different Versions of iOS

Source: Poole, 2017

Challenges and Potential Solutions to Obsolescence in Mobile Phones

Per the modern capitalist economic model, it is indisputable that obsolescence is lucrative to any large-scale industry, with a guaranteed market and high sales turnover ensuring steady profit, continuous research and development for products, stable employment opportunities, and other benefits. Hypothetically speaking, banning consumerist behavior and shutting down planned obsolescence would potentially cause a global economic recession, not mentioning how much of an impossible venture it would be to enforce this rule worldwide. However, the failure of internalizing environmental costs to economic activities can be attributed as one of the core reasons why the concept of obsolescence was birthed in the first place (Nicolaisen and Hoeller, 1990). Because of both human ignorance and a lack of clear understanding of the complex machinations of the environment, it has always been difficult to devise and incorporate a mathematically sound model of environmental

costs into a preexisting economic framework. Hence, it was always simpler to ignore environmental repercussions as an aspect of the base economic model, instead attributing it as a byproduct to be dealt with separately. Complications of numerical environmental cost estimations can come from the lack of data about the quantity and location of non-renewable resources, consequences of resource extraction, the spatial and temporal spread of negative environmental impacts from their sources, and the interconnection of environmental processes. It can also be reasonably assumed that many other factors escape notice simply from a lack of knowledge, which marks environmental studies as an important frontier for further understanding of such consequences. As a result of this separation of the environment from economics, practices of obsolescence have been promoted within both consumer and producer circles as the most effective lifestyle and led to dealing with the repercussions of these actions as a disconnected issue. Despite growing eco-awareness and steps taken by eco-conscious parties toward sustainable development, any initiatives taken seem to be more related to environment-friendly manufacturing and disposal processes, and the majority of industrial practices have not shifted away from the marketing aspects like obsolescence.

Policies have been implemented in an attempt to recuperate environmental costs from economic activities, such as pollution charges and emission trading. While these initiatives undoubtedly help in the clean-up of environmental problems, isolating environmental factors from a business model leads to the promotion of the consumerist mindset and practices of obsolescence. This acts as a barrier to achieving a sustainable circular economy that reuses non-renewable resources with minimal environmental impact. To reduce obsolescence, it is necessary to incorporate a model of resource scarcity and pollution measures, such as by implementing a pollution-free, energy-efficient industrial process with a systematic recycling pathway from the trash back to the source. However, these policies cannot be implemented drastically; despite the urgency of these changes, it is important to allow breathing room for the present economy to adapt. By ensuring slower, transitional policy changes, it will be possible for the economy to shift in nature, as drastic transformations are destabilizing to the status quo, leading to inefficient turmoil.

Considering the case of mobile phones, the primary concern is related to resource usage. Like any other industry, power is required in the manufacture, distribution, and usage of mobile phones, and although most of this power is derived from fossil fuels,

the international community is alleviating the reliance on them through the implementation of alternative energy sources. This helps deal with the issue of energy scarcity, carbon emissions, and climate change, which appears to be a more immediate threat to mankind than resource scarcity in the far future.

Proske (2022) examines the more critical aspects of repairing mobile phones. The sustainable use of mobile phones depends on maintaining them and ensuring that they stay effective for as long a use-time as possible. However, the solution is not as simple as replacing faulty or outdated parts within the mobile phone. Alternative replacement parts also cost resources, and hence they should yield a net environmental profit over the initial resource cost by staying active for a minimum payback time. This payback time is shorter nearer the beginning of the device's lifecycle and lengthens as the device becomes older. However, replacing the motherboard of a mobile phone for the sake of upgrading software capabilities or for replacing a hardware fault is inefficient and wasteful. Furthermore, a faulty part may also have functional implications for other interconnected parts, influencing the lifetime of the mobile phone as a whole. Consumers cannot be aware of all of these minuscule details that can add up to the mobile phone's functionality, hence it is a matter of more extensive research and open disclosure of relevant information from the side of producers. Makov and Fitzpatrick (2021) also mention a very important point: although repair is crucial in tackling objective degradations in mobile phone quality and operation, it does not counteract any psychological stimulus that influences consumerist behavior. While it is true that repairs, replacements, and refurbishments can restore, or even upgrade, a mobile phone's functional and aesthetic capabilities, it is unlikely to out-trump newer models that come out on the market.

A commonly discussed solution to the issue of obsolescence in mobile phones has been the modular phone model (Cordella et al., 2021; Proske, 2022; Sátyro et al., 2018). The primary concept behind the modular model is that a phone can be constructed as a conglomerate of several independent modules, differentiated by form and function, which could be disassembled and reassembled with ease. The modular model is a highly versatile solution, as it allows for both repair and updates: faulty modules could simply be exchanged for functioning ones, modules with updated hardware could be exchanged into the mobile phone to support better software, and

parts recycling would be easier and more efficient based on module partition. This also decreases the overall reference flow of consumables, spare parts, and upgrade modules, due to module replacements becoming specifically geared instead of replacing an entire mobile phone set due to catastrophic failure in one part. One such company that is trying to leverage the modular phone model is Fairphone. Although they are a rising mobile phone holding themselves to ethical and eco-friendly standards, they struggle to reach a comparative market size as other tech giants who do not share the same values.

All the discussions above considered the technological or economic aspects of obsolescence in a multitude of manners. Most methods of combating obsolescence seem to be geared towards sustainable manufacturing processes, reuse and recycling chains, and repairing opportunities, but none of them attack the core reasons for obsolescence. It is a difficult compromise between influencing the general population to excessively spend on products and maintaining the economic stability of industries, but as psychological factors play one of the greatest roles in obsolescence, it is an important issue to tackle. An obvious strategy is to raise public awareness regarding obsolescence, but it is a rather vague solution to a multifaceted problem and only tackles the consumer population. The nature of such awareness campaigns must be delicately balanced: to appeal to a larger audience, a solution allowing current consumerist behavior, albeit in an altered form, should be presented, while environmental sustainability must be maintained to address the actual problem of obsolescence. It is unreasonable and impractical to force a drastic change in mass public behavior over a short time. Actively calling out corporations for obsolescence is not encouraged, as it risks retaliatory action from producers against an awareness campaign. Possibly, the primary motion of a public awareness campaign should be to influence consumers to reduce, reuse, and recycle products, judge the environmental sustainability of processes and resources used by producers before purchasing products, and promote and support eco-friendly policies, especially those that support waste management and reduction. Concerning mobile phones, it is especially important to discourage mobile phone hibernation and introduce them back into the circular loop, either as functional devices or as useful sources of spare parts and resources.

On the other hand, to force producers to account for obsolescence, governments should establish eco-friendly policies and interventions in appropriate sectors of industry operation, such as manufacturing and waste disposal. It is also necessary to

subsidize, support, and innovate the recycling industry to increase resource cycling efficiency. Ideally, waste generated by both producers in manufacturing and distribution processes, and consumers after product use should be collected, partitioned by material type, and reclaimed into a form that can be sent to producers for reuse. Consumer waste would potentially have to be handled by a third-party recycling group, but studies should be conducted on whether waste from the production side is most efficiently handled on-site or by a third-party recycling group.

Conclusion

This review has demonstrated that mobile-phone obsolescence is a complex, multi-dimensional phenomenon (Proske & Jaeger-Erben, 2019) driven by an interplay of technical degradation, economic pressures, and, most critically, psychological incentives. It has been shown that absolute obsolescence (physical wear and functional failure) and relative obsolescence (perceived outdatedness) frequently precede one another, yet neither occurs in isolation. Consumers' decisions to discard or hibernate older devices often stem from subtle shifts in aesthetics, ergonomics, and status signaling rather than outright dysfunction. At the same time, manufacturers' design choices reinforce consumers' inclination to replace rather than repair. The result is a reservoir of hibernated phones and mounting e-waste (Singh et al., 2020), exacerbating resource depletion and environmental harm.

Combating this challenge requires an integrated, cross-sector strategy that addresses both the supply and demand sides of the mobile-phone lifecycle. On the design front, embracing modular architectures, standardized components, and open repair protocols can extend device lifespans, lower maintenance costs, and reduce barriers to third-party refurbishment. From a policy perspective, extended producer responsibility schemes, take-back mandates, and eco-labelling can internalize environmental costs and incentivize genuine circularity. For consumers, transparent information on the environmental footprint of their purchase choices, paired with targeted educational campaigns, can reshape attitudes toward repair, reuse, and responsible end-of-life management. In tandem, improvements in formal collection networks and high-efficiency recycling technologies can ensure valuable critical-metal flows are reclaimed rather than lost to incineration or landfill.

Looking ahead, there is a pressing need for empirical validation of these proposed solutions. Mixed-methods research by combining large-scale surveys of consumer disposal habits, interviews with repair-shop operators, and quantitative lifecycle assessments will illuminate the real-world efficacy of modular designs, legislative interventions, and awareness initiatives. Comparative cross-cultural studies could reveal how socioeconomic factors shape obsolescence behaviors in both developed and emerging markets. Moreover, standardized metrics for "useful service life" and "resource circularity" would enable consistent benchmarking across brands and regions, guiding both policymakers and industry toward best practices.

Ultimately, resolving mobile-phone obsolescence is not merely a technical or regulatory challenge, but a collective endeavor that bridges engineering, economics, environmental science, and human behavior. Only through sustained collaboration among manufacturers, regulators, academics, and consumers can there be a transition from a throwaway culture to a truly sustainable, circular model — one in which every device lives longer, every resource is thoughtfully stewarded, and every stakeholder shares in the rewards of reduced waste and resource security.

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