Obsolescence of Electronics - the Example of Smartphones

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Abstract

Planned obsolescence has recently been a common allegation to manufacturers, but proof apart from isolated cases is missing. This paper analyses the situation for smartphones, looks at use- and lifetime of smartphones and the underlying reasons for their obsolescence.
Surveys show that a majority of consumers believes in "planned obsolescence" as a fact on the market and would like to have more durable products. Regarding smartphones, broken screens and bad battery performance are often reported problems. At the same time, most phones are still functioning when being replaced after the average use time of two years. How do these two aspects combine? Short product cycles, new functionalities and features trigger replacement purchases (functional and psychological obsolescence) more strongly than broken devices. Necessary repair of products is expensive due to miniaturized product design, glued in batteries, and the limited availability of replacement parts (economical obsolescence). Besides, buying new products is often subsidized by provider contracts.

1 Introduction

Obsolescence has been a trending topic, especially regarding electronics. Smartphones are one of the product groups with an expected (and partly even accepted) short product life. At the same time, the main environmental impact from smartphones is caused by the production phase, followed by the electricity consumption in the use phase. Transport and end-of-life have only a minor impact in the entire lifecycle [9]. So prolonging the use time of smartphones would significantly reduce the overall environmental effect.

But what are the reasons for the short product use time and how can that aspect be influenced? In the following paper, the different types of obsolescence will be introduced in general and possible examples regarding smartphones will be discussed.

The current use time of smartphones will be analyzed based on user survey and repair statistics (section 3) resulting in proposals for improvement for all relevant players (section 4).

2 What is obsolescence?

Obsolescence as such means the ageing of product which thereby loses its functionality or usability. The loss of usability can therefore be objective (e.g. product is not function any more, broken) or subjective (e.g. too slow, out of style). The following section presents types and reasons for obsolescence.

2.1 Types and motivation

Obsolescence is often only referred to under the term "planned obsolescence" (see below), but there are different types and motivations for obsolescence.

According to [3] and [12], there are four main types of obsolescence:

- Material/qualitative obsolescence: caused by deficient capability of materials and components leading to fast aging of the product.
- Functional obsolescence: fast changing technical and functional requirements on products (e.g. interoperability of soft- and hardware of electronic devices) causing functional obsolescence.
- Psychological obsolescence: subjective ageing of product because of fashion, technical trends and consumption patterns.
- Economic obsolescence: loss of functionality due to high prices for consumables, maintenance and repair as well as comparable low costs for new products.

Besides the general types of obsolescence, [3] names three different rationales:

- Planned/intended obsolescence: active and deliberate shortening of the product lifetime by the manufacturer.
- Accepted obsolescence: due to cost and time pressure and marketing strategies, cheap-quality materials and components will be used which

statistically achieve a "sufficient" lifetime from manufacturer's perspective.

- Obligatory obsolescence: caused by regulations (e.g. safety standards) which require replacement of security-relevant components in fixed time frames, although they are still functioning (this type is not analyzed further within this paper).

Differentiation between the different types and especially to identify whether obsolescence is planned or accepted is difficult. Besides, the different types of obsolescence overlap and interact to each other (Figure 1).

For instance, in case a device is broken or worn-out, this can be caused by material obsolescence. The fact that the product is not be repaired, can be caused by high prices for repair (economic obsolescence), but also that the user takes the chance to replace with a newer, device with more features (psychological and functional obsolescence).

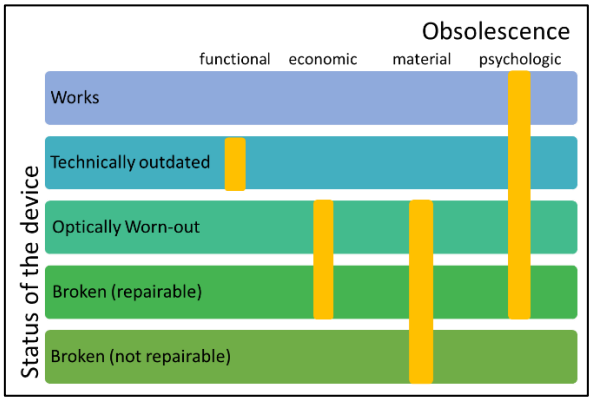

Figure 1: Types of obsolescence according to the device status

2.2 Obsolescence – examples for electronics

Today's electronics are built under high competitive constraints in fast product cycles and generations. Thereby, examples of weaknesses leading to failures of the device can be found every time. So there is qualitative obsolescence. If this relates to planned obsolescence, i.e. intended shortening of the lifetime, or accepted obsolescence, which could also be called „cheap design" due to time and cost pressure, can hardly be differentiated. Especially as the different types of obsolescence overlap. Furthermore, statistical failures of components or systems due to aging, production mistakes or high environmental stress (temperature, force) will always occur and can even with (costly and timely) quality management and reliability tests not be fully avoided.

In the following, examples of obsolescence of electronics are described to show the mechanisms, effects, and players interacting.

2.2.1 Non-removable batteries

Batteries of many smartphones are not easily removable (as it has been standard for conventional phones). This leads to qualitative obsolescence when the battery degrades and economical obsolescence when the replacement of the battery becomes very costly as it cannot be done by the average user. This early obsolescence of the device due to the lifetime of the battery might be an intention of the manufacturer. On the other hand, industry associations argue that non-removable batteries can allow a different product design (e.g. 25% thinner as additional housing of the battery can be avoided) which is considered as one of the main buying decision of the consumer [2]. However, existing products contradict this argument: e.g. Samsung Galaxy S4 (easily removable battery) and S7 (not readily removable battery) are both 8 mm thick. The LG G5 smartphone has a very sophisticated replacement option for the user and is also about 8 mm thick.

2.2.2 Fast product cycles

Products, especially smartphones, are developed in fast product cycles and generations. Technical improvements and features of new generations lead to functional and psychological obsolescence of the older devices. However, sometimes the technological innovations are only minor, but the new generation increase the pressure on the consumer to be up-to-date with the newest devices. On the other hand, strong competition on the market puts pressure on the manufacturers for fast and regular market introductions. The short "time to market" is often achieved on the expense of the testing period. Thereby, product weaknesses in hard- and software might be only identified after market introduction.

Companies are sometimes faced with the allegation to keep some technical innovations back to allow a fast introduction of a follow-up product[1]. This would be an example of planned, psychological and functional obsolescence.

[1] http://appadvice.com/appnn/2013/02/apple-getting-sued-for-planned-obsolescence-of-ipad-3

2.2.3 Updates and Support

Software support and regular updates are important for the functionality of a product. Manufacturers of the device are normally responsible for the operating system (OS) support, but do also depend on the OS developers.

For Android smartphones, the OS is normally adapted by the manufacturer with company- and model-specific changes. With increasing deviations from the baseline version rises the time and effort for updates. It can be seen that the support depends strongly on the price of the device [6].

The decision to stop the software support for a model or an OS version is normally based on costs. The user is thereby forced to change to a newer version.

An option for the user to avoid functional obsolescence of their devices in that context would be the so-called rooting of the device to install an alternative OS.

A problem known already from Windows PCs can also relate to smartphones: OS updates often require more hardware resources (e.g. more RAM) and are therefore sometimes not applicable on the device. These requirements are mostly outside the decisions from the product manufacturer, but depend on the software developers. According to [6], an update from Windows 7 to 8 (for Windows phones) is not possible as the OS was changed in too many basics. An update to Windows 10 is limited by the increased requirement or RAM and memory.

A limiting factor in the use time of smartphones can be the internal storage. This problem can be reduced by the technical option to integrate an additional memory card. However, sometimes it's not possible to shift apps from the internal memory to the memory card. This possibility depends on the specific apps and cannot be influenced by the device manufacturers.

2.2.4 Service contracts

In the context of the use time of smartphones, mobile service contracts play an important role. Many providers offer a subsidized device with a new service contract which often leads to an early replacement of an existing device. So the psychological obsolescence is caused in that case not only by the advertisement of the manufacturers but also by the offers of the providers. Besides, these subsidized product purchases are often the only financial possibility for these early product replacements.

2.2.5 The role and interactions of the main players

The examples show that in many cases obsolescence is caused by the interactions of different stakeholders: manufacturers, software developers, service providers, and consumers.

The manufacturer is primarily responsible for the product design, i.e. the quality of the product. However, fast product cycles and cost-efficient design are also an interaction between manufacturers, consumer expectation and market pressure.

Besides the design and quality of the used materials and components, also the post-production tests influence the quality of the product. These are often shortened under time pressure and lead to higher failure rates later on. Also time and cost pressure during production can reduce the quality especially in manual production steps (e.g. badly assembled connectors and ribbon cables).

In the case of repair, market players are besides the manufacturers and their own services also independent repair services and spare part producer. Initiatives like repair cafés and iFixit which allow consumers do-it-yourself repairs can lead to more independence for the consumer in that aspect.

Functional obsolescence is also partly caused by the market pressure – which manufacturer will publish a new feature which becomes (subjectively) important for the consumer – and by the manufacturers if they allow upgrades (e.g. through memory extension).

For IT devices, the software plays an important role regarding functionality. Therefore, the software developers are also key players in that context, mainly the OS developers. For Android devices, the manufacturers normally adapt the OS for their devices, whereas Windows will be used as is. This can lead to limitations outside the influence of the device manufacturer.

Besides the OS, application software (for smartphones apps) can have an influence on the long-term functionality of the devices. If apps are only running on the latest OS version, this can support a faster product replacement to products with newer OS. But also internal memory is a limiting factor for smartphones (according to [17]). Pageable apps (to external memory (memory cards) can help to extend the functionality of the device.

Economic obsolescence is caused by high costs (efforts) for repair services and spare parts, especially battery replacement. In case the (opportunity) costs (e.g. lost time) are too high, the consumer prefers to invest in a new product. Thereby it has to differentiated between

- Objective price
- Subjective price

Responsible for the objective price are the manufacturers (incl. their own repair services), independent repair services and spare part producers. With hard to repair designs, the time and therefore price for repair increases which effects the independent repair services most strongly. This effect can be increased by the manufacturer by withholding repair manuals, necessary proprietary tools and spare parts.

Independent repair services can have a positive effect on the lifetime as they have a damping effect on the price and are as local services often easier to reach.

An exception are counterfeit spare parts and especially batteries which can be of poor quality and might be used in independent repair services when no original spare parts are available. This can lead to a negative attitude towards repair.

Besides the objective price, the subjective price plays an important role during buying or repair considerations. Consumer compare the price for repair not only with the real market price of a new device, but also with subsidized prices (with mobile services contracts) or with an assumed remaining lifetime of the device (see also [17]). Thereby the consumer might not take into account that subsidized devices through service contracts are often instalments, so that over the duration of the contract there are no savings compared to direct purchase of a new device. Furthermore, the consumer may flinch from (letting the phone) repair because the opportunity costs are too high (e.g. loss of free-time, loss of services of the phone when being without it, or effort to find a replacement for the repair time).

Key player regarding *psychological obsolescence* is the consumer. The importance of smartphones, tablets and other IT products as lifestyle products and status symbol within a peer group leads to fast product replacements. Manufacturers intentionally intensify that effect by advertisement, sales approach and also fast product cycles.

Telecom providers, which offer clients new products for contracts or even on regular basis increase that effect and in many cases enable the financial option for the short first use times and fast replacement (overlap of psychological and economical obsolescence).

3 Use of Smartphones

Besides from the general mechanisms of possible obsolescence described before, the actual situation regarding the use of smartphones will be analyzed. In the following the user perception regarding obsolescence and the effect on the use time will be described and the use time ad reasons for replacement summarized based on existing user surveys.

3.1 User Perception of Obsolescence

The majority of users believes in planned obsolescence as a widespread problem [17] and also a survey among volunteers in repair cafés showed that they see the problem of planned obsolescence regarding electronics [5]. In general, the expectations regarding quality and lifetime of products, especially electronics, is rather low. This leads to the interesting effect, that due to the low expectations, consumers have less inhibitions to replace their devices and willingness to repair decreases [17].

Consumer would appreciate an average lifetime of 5.2 years for smartphones and mobile phones, contradicting the actual use time of 2.7 years. However, most consumers expect the reality to be even worse and assume an average use time of one to two years [17].

The low expectations regarding the technical lifetime of products (due to assumed poor quality and planned obsolescence) leads to a downward spiral. Consumers are not willing to pay for high quality products as “they are going to break anyway”. If the expected lifetime is exceeded, the product is mentally depreciated which makes it easier for the consumer to replace the device even when it is still working and has at the same time a low interest to repair a broken device [17].

3.2 Use time

In Germany, the first use time of smartphone correlates strongly with the duration of the mobile service contracts and has an average duration of two years [10]. This is often followed by a second use time, so that according to [10] the total average use time is 2.5 years. Thereby it has to be taken into account that the ratio from fixed contracts to prepaid services has shifted from 2011 to 2014 to fixed service contracts, which accounted for about 65 % in 2014 [16].

It can be assumed that a major share of prepaid user cannot follow this rapid path due to financial reasons. In that context, the German testing institute presents a more differentiated picture. 42 % of the user replace their smartphone (or mobile phone) after 2 years or earlier, but there are also 30 % who use their device longer than 5 years (these figures stem from 2013 and cover smartphones and conventional mobile phones) [14].

According to an Austrian survey, the average use time of smartphones and mobile phones is 2.7 years. Only 10 % of the devices were bought second hand. The average use time of conventional mobile phones (3.8 years) and smartphones (1.8 years) differs widely [17].

According to [17], second hand devices are used as long as new devices. However, users who sell their

products use them comparably shorter in the first use time.

3.3 Reasons for Product Replacement

Reasons for product replacement seem to be a mixture of the wish for new features and trends (psychological and functional obsolescence) and the opportunity through subsidized devices through service contracts.

According to [17], 14 % of the users replaced their products because of a new contract. The use time of these "contract devices" is with 1.9 years (compared to 2.7 years) significantly shorter. According to [14] the main replacement reason is the desire for a new device with more functions. For user which use their device shorter than 3 years, this was followed by a new contract. Technical failures were only on third position. For users, which use their devices longer, technical failures (weak battery, technical failure or accident) were already on second position but still in less than 50 % the reason for replacement [14]. This distribution of replacement reasons is also shown by [17], where the main replacement reasons were limited functionality and "the new phone is better". A new service contract was the reason in 14 % followed by limited storage capacity (11 %).

In most cases of technical failures it was a weak or broken battery (40%). About two thirds of the technical failures were assumed to be symptom of age. About one fifth of the failure were allocated to shocks, fall or water damage [17].

According to [7], a repair service, which conducted according to their information a survey with more than 10.000 participants, a broken display is with 52 % the most common damage, a figure which is backed also by other repair statistics[2]. This seems to contradict the before presented figures, however [17] asked not only for damages but also for weaknesses and showed at the same time, that a single weakness will in most cases not lead to a direct repair or a fast product replacement, but the user will keep on using the device. According to [18], who conducted an online survey with more 720 participants, dropping the phone to the ground is the most common for damages (38 %). [18] also showed that most devices were used also with (minor) damages. Only 31 % of the devices were replaced. Interesting, repair by professions and self-repair happened equally often (8 %) [18].

[17] also compared functional (technically outdated, incompatible) and psychological (out of style) obsolescence and showed that the fact that friends have newer devices has a higher influence than incompatibilities.

To summarize, the main reasons for replacement is that new devices have more functions combined with the opportunity for new devices through service contracts, the second reason are technical failures or breakage. However, phones with minor technical defects are often continued to use.

3.4 Purchase Criteria

Purchase criteria regarding smartphones are asked for in different studies, however the listed criteria in the questionnaires mostly do not include durability and lifetime. According to [17], durability are important for 9 % of the users, robustness 7 %. Performance, durability and lifetime of the battery is more important for the users (25 %, possible answer were possible and add up to more than 100 %). According to [2] a long battery run-time is important for more than 80 % of the users. At the same time it is important for almost half of the users to always have the newest model and technology [2].

3.5 Attitude towards repair and second hand

If products will be repaired in case of a damage of technical failure depends on the (assumed) costs and the expected remaining lifetime. [17] showed that low expectations regarding the lifetime and the quality of products reduces the willingness to repair. Assuming that a repair would be too cost-intensive, many consumers do not even ask for the actual repair prices. In case that a device was replaced due to a technical failure, only in 34 % a repair was tried/asked for [17].

According to [7] the average repair price of smartphones is 135 €, which exceeds for about 26 % of the devices the price for a new product. According to that calculation, a repair would pay-off for about 75 % of the devices. But as mentioned before, the users compare not only with the price for a new device but also with their assumed remaining lifetime.

According to [13], the repair market has a volume of 150 € in 2015 which would mean about 1 Mio repaired devices per year (based on the figures by [7]).

According to [17] only about 10 % of the consumers use a second hand device. Main argument against second hand devices is the missing warranty which is closely connected with the anticipated low product quality and lifetime.

Also a survey on second hand market by [11] showed that mobile phones are traded rarely compared to other product groups.

[2] Handyreparaturvergleich.de, repairline.de

4 Longer Life – Improvement Options on All Sites

The analysis of use time, technical failures and user perception showed that most phones are replaced when still functioning. Nevertheless, technical failures and damages can be a problem. Therefore it should be analyzed which improvement options are there to prolong the use time of smartphones.

[4] presented general strategies for a durable design according to [15]:

- Design for reliability and robustness
- Design for repair and maintenance
- Design for upgradability
- Design for product attachment
- Design for variability

Whereas the first three strategies are classical strategies for long-living products and against qualitative obsolescence (and in case of upgradability against functional obsolescence), the last two strategies go beyond and do not directly address durability.

As shown before, psychological obsolescence has a big influence in the case of smartphones. A stronger product attachment could help to reduce early replacements. Thereby it is important that users are attached to the personal device and not to the brand as brand attachment could have the opposite effect to get the newest device as soon as possible.

A similar effect could have design for variability. Outer appearance could be changed by casings, but also additional gadgets such as external lenses, speaker boxes, etc. and the ongoing change of apps would have that effect.

Similar for the five approaches is that they depend mainly on the manufacturer and its development and sales strategies. But there are other players who can reduce obsolescence of smartphones.

4.1 Manufacturers

The manufacturer has the possibility to address different aspects of the phone. The obvious one is the product design, which should in context of durability the following aspects.

- Robust product design, especially more robust displays as they are a weak point of smartphones
- Long-lasting batteries, which are easy to replace
- Modular and upgradable design (e.g. storage)
- Universal connectors (already implemented by many manufacturers)

Besides the general product design, the manufacturer has further options to influence the lifetime of the product.

- Long-term availability of spare parts, availability also for independent repair services
- Long-term and (in case of vulnerability) prompt software support
- Coding: interoperability of apps for various software versions; “slim” software for low hardware resource use
- Low number of pre-installed (and not deletable) apps as storage can still be a limiting factor, but this aspect becomes less important with newer product generations
- Offer options for data erasure to facilitate second-hand use
- Open-source software (OS and apps) and hardware could help to reduce functional obsolescence. However, lacking support and non-existing hardware drivers could also lead to dysfunctions.

4.2 Regulation

Regulatory requirements could force some changes to industry which are currently only voluntary measures from manufacturers (and trade):

- Mandatory availability of spare parts for independent repair services for a minimum time.
- Longer warranty and reversal of evidence as the consumer often connects warranty and lifetime [17].
- Stricter requirements regarding replaceable batteries.
- Minimum lifetime or information regarding the planned lifetime could help consumers to make informed decisions, however methods to estimate, proof, and test the lifetimes in a comparative and legally binding way do not yet exist.

4.3 Service providers and trade

Service providers and trade can influence the use time of smartphones in two ways: promoting product replacement and influencing the choice regarding the specific model. Improvement options would be:

- Ranking products/promoting products according to reparability (e.g. by showing the iFixit reparability score [8])
- Promoting more robust/ruggedized devices
- Professional second hand market with warranty which would increase the trust and therefore the

positive attitude towards second-hand devices according to [17]

- Ensure that branding of the OS does not hamper software updates after the end of the contract
- No SIM- or net-lock of the devices
- Avoid promotions of fast product replacement ("each year a new phone"), although this might be difficult for service providers in the competitive environment
- Marketing of accessories which reduce vulnerability of the devices (reduce shocks, water protection) and offer additional functionalities (e.g. additional battery in casing)
- Leasing instead of sale

4.4 Consumers

Although having no direct influence on the design of the products, consumer have the strong potential to change the currently short use time:

- Use devices until they are broken
- Make lifetime, robustness, durability, reparability important purchase criteria
- Bring unused devices back in the market (second hand market)
- Independence from "loss leader"
- Protect devices (additional casings)
- Correct loading for a long battery life
- Use and support activities like iFixit and repair cafés to achieve more independence from manufacturers
- Reflection of which functions and services are really required

4.5 Conflicts of objective

As described before, there are many improvement options to reduce obsolescence and increase the use time. However, there are often conflicts of objectives which have to be taken into account when thinking about improvement options. These conflicts are not easy to solve and often not by one player alone.

4.5.1.1 Technical conflicts

Regarding the product design, technical trends are often in conflict with durability.

- Miniaturization versus reparability: small and densely built devices are hard to repair
- Miniaturizations versus modularity: additional housing of boards and connectors needs more space in the device
- Dust/water-proof design versus easy to open/reparability: water proof devices have to be sealed by gluing the casing which hampers opening the device in case of repair.

4.5.1.2 Economic conflicts

Economic conflicts seem to be the hardest problem regarding long-used products and thereby overall less produced products:

- Business volume of manufacturers and trade is based on the number of sold products: Trade and service providers are sometimes faced with fixed number of sales and special communication obligations by the manufacturers in exchange to be allowed to have the newest flagships in the portfolio
- New devices are used to win over and tie customers by service providers. This is currently also expected from consumer perspective which makes it difficult for an individual provider to change that strategy.

The economic conflicts for service providers could be reduced by acting together with other providers and develop guidelines against obsolescence which could ban strong marketing of short use times and fast product replacement.

5 Conclusions

Surveys show that a majority of consumers believes in "planned obsolescence" as a fact on the market and would like to have more durable products. Regarding smartphones, broken screens and bad battery performance are often reported problems. At the same time, most phones are still functioning when being replaced after the average use time of two years. So easily degraded or broken smartphones are less a problem than other forms of obsolescence: Short product cycles as well as new functionalities and features trigger replacement purchases (functional and psychological obsolescence). Necessary repair of products is expensive due to miniaturized product design, glued in batteries, and the limited availability of replacement parts (economical obsolescence). Besides, buying new products is often subsidized by provider contracts, which increases the relative price of repairs further.

On the one hand, user awareness regarding aspects such as reparability and durability is increasing, also through activities such as the iFixit reparability score. On the other hand, brand loyalty and appearance are still major aspects in the buying decision.

This shows that durable products are not relevant for all types of users. So besides addressing the technical life-time of the products by robust and repairable design, addressing the use directly is important as well.

Especially for a product such as the smartphone, where the main environmental impact is caused by the manufacturing phase, extending the use time is important to decrease the environmental effect. Modular product concepts which allow easy repairs and functional upgrades could be a way to prolong the use of the devices. Enabling secondhand use through secure data erasure is another option.

6 Literature

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