Identification of Factors Relevant for the Estimation of Smartphone Life Cycle

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***Abstract* — The smartphone industry is a fast-evolving industry with a bright future as smartphones became everyone's daily habit. This paper gathers existing research knowledge and provides the identification of factors that affect the stakeholders and the length of smartphone life cycle. Socio-demographic, economic, technological and psychological factors are found relevant by using comparative and compilation methods. Further aim of this research is to use the identified factors in a following research on life cycle estimation.**

***Keywords* — estimation, life cycle length, relevant factors, smartphone obsolescence**

I. Introduction

THE smartphone industry has grown into a major global industry with more than 2 billion users around the world, compared with a total world population of 7.5 billion people [1]. Every piece of consumers electronic - CE has a life cycle of its own and advances through five stages: introduction, growth, maturity, decline and abandonment [2]–[3]. Smartphones life cycle is an important ecological and economic issue and there is a lot of research on this topic assuming the average duration. Based on selected literature explained in Chapter 2, this research aims to identify factors that could be further used as guidelines in the estimation of the life cycle length. Identified factors are explained within Chapter 3 of the paper [4]. Chapter 4 identifies the stakeholders that are found relevant in the smartphone life cycle process. The conclusions on identified factors and further research plans, including proposed measures for life cycle elongation and control, are discussed in Chapter 5.

The main contribution of this research is the identification of relevant factors affecting the life cycle duration which is the first phase of the research on life cycle estimation and control.

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Due to growing numbers of new device models and meanwhile the numbers of waste being inappropriately disposed of, it is necessary to address the factors influencing the life cycle and to raise stakeholders' awareness.

The research [5] identifies eight factors; demographic, socioeconomic, behavioral, psychological, geographical, environmental, organizational, and technological, affecting the transition of technical features from one state of the life cycle to another. The research [6] identifies four types of factors affecting the smartphone life cycle and those are material/qualitative, functional, psychological and economic. Several stakeholders are identified in the process of smartphone life cycle and those are manufacturers, regulation, service providers, trade and consumers. The survey proves that most customers believe in planned obsolescence, i.e., predestined short smartphone life cycle. The research [7] offers a cradle-to-grave study of smartphones based on the life cycle assessment methodology. The user presents an important stakeholder in the life cycle process, especially regarding the usage behavior. The research identifies three types of users; heavy, representative and light user. The research finds that the type of user affects the life cycle duration as well as that representative user has one smartphone for approx. three years due to personal habits. The research [3] provides a life cycle forecasting model defining product market and product manufacturer as the most relevant factors in the life cycle. The same opinion has the author of [8] who delivers a case study based on Apple models, dates of release and discontinuance and belonging specifications and functionalities. All the mentioned research findings are compiled into four fundamental factors discussed in the following section.

In order to identify factors having the most relevant effect on the life cycle of smartphones, this research gathers various research findings and uses methods of compilation and analysis to present several factors as a final result. Identified factors are described for better understanding of their influence on life cycle duration. Research also identifies the stakeholders present in the life cycle process, as they are influenced by mentioned factors and generate the ending and beginning of every smartphone life cycle. This research is an important part (first phase) of the research on life cycle estimation and control. In the next step, the influence of identified factors shall be evaluated on the respondents through the online survey.

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II. THE IDENTIFIED FACTORS

A. Socio-demographic factor

Although most studies find 2.7 years as an average smartphone life cycle length, questionnaires show different results for different socio-demographic user groups. Millennials (18 to 35-year-old users) are found to use their smartphones for half as the average; namely 1.4 years. Results from the survey [4] find that people aged 18-29 spend roughly 4.3 hours per day on their smartphone, which is three hours longer than people between 60-65. Differences from their use patterns influenced the use-time of the phone. Firstly, extensive usage wears out the device more quickly, and secondary, such users are prone to sophisticated apps which require the latest software solutions and use large amounts of memory capacity which gets overloaded over time. Business people have similar user needs and often own more than one smartphone, and the elderly tend to use things longer than the younger users do [9]. The research [9] finds a difference between respondents' answers based on their age. Millennials seem to be especially affected by social influences. 4% of respondents purchase new devices because of changes in life circumstances, 5% because of social environment, 15% because the new device looks more attractive and 28% of the purchase is to follow the social trend.

TABLE 1: DESCRIPTION OF SOCIO-DEMOGRAPHIC FACTOR.

Socio-demographic factor
Gender
Age group
Education
Marital status
Profession
Occupation
Income level
Social environment and trends
Life changes
Household info

Samsung's report about smartphone industry from 2014 finds that among adults owning a smartphone 57% are women and 61% are men, 83% is in the age of 18-29, 71% have college education or higher, 81% have at least $75,000 of annual household income, and 64% of smartphone owners live in an urban environment [1].

The latest research by [2] in 2017 states that 89% of women and 87% of men own a smartphone. The key socio-demographic characteristics of the population are listed in Table 1.

B. Technological factor

Technology is the accelerator of smartphone life cycle, as industry constantly produces new smartphone models of better performances. Within this research, the technological factor considers not only technological innovations but the technical functionality of the device as well. Since technology is the first reason of purchase, the users wish to keep up with innovations, therefore a technology factor has a strong influence on the life cycle [17]. Software support and regular updates are smartphone software maintenance necessary to maintain the functionality [6]. Survey [4] made by the Dutch Consumer Association finds that nearly one of ten respondents found their phone was reacting slowly. Due to the introduction of new models, a operating system - OS of some of the existing products is no longer supported by regular updates. Smartphones with no longer available OS updates are no longer compatible with new applications and are also less protected against viruses and the like. For example, a regular OS update for iPhone 3GS was terminated after 56 months, and 84% of Android smartphones could not be updated after only 2 years of life. Technical functionality problems are considered a natural result of usage, such as inadequate amount of memory capacity. The survey [9] finds restricted functionality as the reason of re-purchase in 30%, and not enough memory in 10% of the total reasons for the abandonment. The internal storage is the limiting factor as for some models it is not possible to integrate an additional memory or to choose the memory to use and store to (i.e., shift from internal to external) [6]. Research [6] finds technical failure as the reason for smartphone replacement in 50% of cases. Weak or broken battery is the most common technical failure, i.e., makes 40% in technical failures. Based on repair statistics, most common technical damage is a broken display and that is by 52% [6].

TABLE 2: DESCRIPTION OF TECHNOLOGICAL FACTOR.

Technological factor
Model
Ownership history
Length of possession
Software characteristics and functionality
Hardware characteristics and functionality
Quality of smartphone gear
Technological innovations
Introduction of new models
Efficiency of preventive maintenance
Maintainability

The maintainability of high-end smartphone devices is often poor because of the integrated battery and high-end touchscreens, compact housing, and thus non-removable battery can be the reason of smartphone disposal as well [9]–[10]. The characteristics of the technological factor are given in Table 2.

C. Psychological factor

Every identified factor has an influence on the user's decision, but psychological factor perhaps has most powerful influence, as every person is a unique individual and makes its own priorities [5].

The survey [10] identifies reasons for smartphone abandonment in a percentage of respondents. 23% of respondents have abandoned their old phone because they have found the new phone better, 22% claim that their old phone could not keep up with their needs, 15% decided to replace their current phone because new smartphone appeared more attractive, 10% made the new purchase based on a recommendation. As already stated,

psychological factor plays an important role in making purchase and abandonment decisions, but the users' behavior characteristics, such as the intensity of usage, also influence the life cycle of smartphone devices. The users' attitude towards their smartphone devices makes their usage careful or careless. Also, smartphone users can be prone to certain manufacturers or models. Nowadays, smartphones are IT lifestyle products and status symbols and manufacturers and operators intentionally impose that fact to their customers through advertisement, short-term offers and fast product life cycles [5]–[10].

TABLE 3: DESCRIPTION OF PSYCHOLOGICAL FACTOR.

Psychological factor
Start of ownership
User's satisfaction with device
Previous experience
Purchase / repurchase decisions
Behavior characteristics
The influence of social surrounding and trends
Emotional attachment to brand or device
The type of user

Details of the psychological factor are given in Table 3.

D. Economic factor

The economy is a key to every industry within which every stakeholder wants a great deal for himself. For the manufacturer, a mass production can decrease product quality but surely increases the profit. On the other hand, the user wants to buy the latest model of high-quality product at a reasonable price. The economy factor is perhaps of most influence when deciding about repair or repurchase. Smartphone repairs are nowadays expensive due to the integrated battery and high-end touchscreens, compact housing, etc. If the repair costs too much, the user will probably decide to buy a new device. A German study finds 135€ as the average repair cost of corrective maintenance, which exceeds the price of about 26% of devices. According to that calculation, a repair would pay-off for about 75% of the devices. Also, when failure rate is high, no matter of the nature of necessary repairs, the user will more likely abandon the device due to bad user experience [4]–[10]–[11]. The list of economic factor characteristics is given in Table 4.

TABLE 4: DESCRIPTION OF ECONOMIC FACTOR.

Economic factor
Currently available purchase offers
User's annual income
Device warrantee
Price of repair/s
Failure rate
Current device value
Current smartphone market situation

When buying a new or previously owned device, the user considers the price, functionality, current state and previous damages, as well as warrantee status of the device. Even though everyone strives to own a brand new device, buying a well-conditioned previously owned smartphone is proven better for the user's long-term budgeting [5].

III. IMPORTANT STAKEHOLDERS

A. Manufacturers

The smartphone industry has been steadily developing and growing in models and suppliers since the introduction of Apple's iPhone in 2007, followed by first Android models in 2008 [12]. Due to costs and unsustainability, manufacturers make decisions to stop the software support for a model or an OS version. The user is thereby forced to change to a newer version. Also, some manufacturers decide to limit smartphone's internal memory, i.e., they do not provide the ability to use a memory card to expand the storage. Strong and competitive smartphone market puts a pressure on the manufacturers to make fast market introductions. For example, in the year 2014 Samsung introduced 62, LG 42, and HTC 28 different smartphone models on the market [5]–[12]. Survey [11], conducted among manufacturers, discovered that the manufacturers estimate the average smartphone life cycle to be around five years which is clearly longer than the average life cycle length estimated in the observed studies. The manufacturer is primarily responsible for the product design and quality. By offering a high-quality, durable, maintainable device the brand assures long-term users and expands estimated smartphone life cycle [9].

B. Sellers

Smartphones are now most popular CE as numbers of purchased smartphones continue to rise rapidly. Smartphone shipments worldwide are projected to add up to 1.71 billion in 2020. By 2018, over a third of the world's population is expected to own a smartphone, an estimated total of almost 2.53 billion smartphone users in the world with a quarter of the entire user population located in China [1]–[12]–[15]. In 2016 alone, Apple sold more than 210 million iPhones worldwide [14]. The seller is an important stakeholder of the smartphone market chain as well as of the life cycle of smartphone devices. Manufacturer's stores and CE stores are most common device vendors. But there are also private sellers who sell their new or used smartphones via online ad pages, such as Njuškalo and Plavi oglasnik in Croatia. Currently, there are about 15,700 new and used smartphones on sale in online ads on Njuškalo [18], from which 4,590 devices are Samsung smartphones and 2,134 are Apple iPhones. Newly introduced shops for smartphone maintenance, reselling and recycling have a potential to make positive changes. iFixit stores and repair cafes are getting more and more popular. Croatia currently owns one iFixit store in the center of Zagreb. There are no Repair Cafés but the nearest one is in our neighboring country Slovenia [5]. Repair shops are smart and efficient initiatives that reduce repair costs and prolong the life cycle of the device.

C. Operators

The operator, i.e., service provider, is a relevant factor to influence the life cycle. The research [4] finds that 14% consumers change their smartphones because service

providers offered them new flexible contracts including new devices at a lower price. The research also finds a positive correlation between the number of subscribers and the number of phones sold, and they have both been rising in the past 8 years. Most subscription offers are for 12 or 24 months' duration what it is very congruent with most estimations of the average smartphone life cycle. The research [10] among operators finds 1.9 years as the use time of the contract-purchased devices. Operators basically offer a new market value to the customer (i.e., user), who not only gets the latest trendy device of wanted functionality but the telecom services as well. In other words, the operator raises the perceived value of device with his telecom services included, i.e., offers subsided smartphone prices with a service commitment.

D. Users

The user is a stakeholder who gathers information, and affected by all the stated factors, decides to buy, use and dispose of a device [10]. Also, the user is the key player regarding psychological obsolescence. The research [11] shows that consumers would appreciate an average lifetime of 5.2 years for smartphones, but their actual use time is 2.7 years. Because new smartphone models are introduced on almost daily basis, users are prone to feel pressured. Namely, millennials are found greatly affected by social influences and technology changes, and they hold a majority of smartphone user population.

According to research papers [7]–[12], there are three types of smartphone users regarding the pattern of usage; heavy, representative and light users. The most important smartphones functionality nowadays is access to the internet, but there is also messaging, calls, multimedia and other. For instance, a heavy user is defined as the one using 30 GB of Wi-Fi data and 30 GB of mobile network data per year. Due to previously mentioned, a user charges his smartphone every day and a duration of the device in such possession is approximately 2 years in length. The representative user spends about 11 GB of mobile and Wi-Fi data per year, charges his battery every 2 days and holds on to current device a year longer. Finally, the light user can hold the battery for three days as he uses only about 5.5 GB of Wi-Fi and mobile data (a half of the representative type) and holds on to his phone for approximately 4 years. Results of the existing research show that the users are not aware of smartphone mass consumerism and ecological threats. Only 17.2% of users dispose their previous devices at the recycling points, and there are only 10% second-hand device users among respondents. Every second user keeps his smartphone after the end of usage and nearly every fifth user gives it away or sells. As every fourth smartphone user has more than two devices and over 10% have five or more devices stored at home, the numbers reflect the moral considerations of consumers who are hoarding their old and functional smartphones at home [10]–[16].

IV. Conclusion

Smartphones industry is a growing industry in trend and smartphone life cycle as a subject should be further explored due to its ecological and economic aspects. The socio-demography, psychological, technologic and economic factors are identified as relevant for the life cycle estimation and shall provide the ground for further research on this topic. In term of maintenance, further research should propose measurements for identified stakeholders with a positive effect on prolonging the life cycle and cutting down the trendy consumerism of smartphone industry.

Based on identified factors for the estimation of a life cycle, further research will include an online survey on the respondents of different age groups (with emphasis on millennials) in order to evaluate the identified factors in term of importance. Planned evaluation will include defining of criteria (and sub-criteria) for the estimation of smartphone life cycle, based on qualitative research and criteria evaluation by specific groups (manufacturers, sellers, operators, and users). For evaluating the criteria, the use of multi-criteria analysis is expected.

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