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Consumer decisions to repair mobile phones and manufacturer pricing policies: The concept of value leakage

Mostafa Sabbaghi[a], Sara Behdad[a,b,*]

[a] Industrial and Systems Engineering Department, University at Buffalo, The State University of New York, NY, 14260, USA
[b] Mechanical and Aerospace Engineering Department, University at Buffalo, The State University of New York, NY, 14260, USA

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A B S T R A C T

Mobile phones have become 'essential-to-have' devices for information-gathering and social communication. They are being technologically advanced, while they are readily available at affordable prices. This motivates consumers to upgrade their mobile phones more frequently. Given these considerations and the lack of accessible repair services, mobile phones have a relatively short life span. The underuse of mobile phones, despite the fact that they are made durable, may result in losses or value leakage. In this study, a probabilistic approach is proposed to quantify the value leakage that may occur due to consumer's decision to not repair broken mobile phones and simply replace them with new ones. A group of 208 mobile phone users has been surveyed to capture consumer's time-dependent willingness-to-pay for repair services. Then, consumer's repair behavior is combined with manufacturer's repair service pricing strategies to calculate the probability of repair or replacement decisions over the life span of mobile phones. Finally, the total expected leakage risk is derived for both consumers and manufacturers. For illustrative purposes, it is shown that a manufacturer may lose up to 331 million dollars over a period of five years due to consumers' decisions to not repair their cracked-screen mobile phones and switch to another brand.

1. Introduction

Nowadays, mobile phones have broadband applications rather than a simple communication device (Butler, 2011). The average selling price of smartphones has gradually dropped over the past few years (Jouihri et al., 2017). It is not surprising that the market of mobile phones is likely to be the largest in size among consumer electronics (Scruggs et al., 2016). Given the quantity of mobile phones, it is essential from a circular economy aspect to evaluate the life cycle of mobile phones and find out whether these resources are effectively utilized.

Over the past few decades, profit-driven strategies such as offering successive generations of products (Miao, 2011), shortening products' life span, and increasing the cost of repairs (Laurenti et al., 2016) have encouraged consumers to purchase new devices rather than fixing and reusing their currently-owned devices. A direct outcome of such strategies is a large number of End-of-Use/Life (EoU/L) mobile phones. According to a recently published report by the United Nations University (Baldé et al., 2015), 41.8 Mt of electronic waste (e-waste) – including discarded mobile phones – generated globally in 2014, and slightly collected by official take-back programs. A large proportion of ready-to-collect used mobile phones in developed countries is being dumped in landfills or exported to developing regions and informally recovered. On the other hand, when making a decision about the recovery of collected mobile phones, recyclers merely perform cost-benefit analyses that are not always economically, socially, and environmentally viable for the society. The recycling of mobile phones has the largest amount of economic losses among all considered consumer electronics (Ford et al., 2016) due to the fact that individual components of mobile phones are not fully disassembled before shredding and material extraction.

In addition to the role of manufacturers and recyclers, the impact of consumer behavior should be highlighted too. With respect to the role of consumers, it is essential to distinguish between consumers' actual behavior and their attitude. Consumers might be willing to repair their broken devices, but a number of existing barriers such as costly repair services and insufficient access to repair infrastructures may dissuade them from repair decision. As a consequence, mobile phones are underutilized (Guiltinan, 2009), and both consumers and manufacturers incur monetary losses. Consumers lose the potential remaining useful life of their devices and have to purchase new phones. On the other hand, manufacturers may lose repair profits. In addition, designing

* Corresponding author at: Industrial and Systems Engineering Department, Mechanical and Aerospace Engineering Department, University at Buffalo, The State University of New York, NY, 14260, USA.
E-mail address: sarabehd@buffalo.edu (S. Behdad).

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unrepairable products and offering low-quality repair services affect consumer loyalty and future sales since some consumers look for clues about the degree of repairability and extended warranty time when making a purchase decision (Lemke and Luzio, 2014).

To analytically formulate the concept of value leakage of used mobile phones, this study is focused on the effect of repair costs on consumers' decisions to keep using currently-owned mobile phones versus buying new devices. It should be acknowledged that in addition to repair cost, there are other factors such as service availability, spare parts accessibility, and personal information concern that influence consumers' repair and replacement decisions. A survey study is conducted to capture consumers' willingness-to-pay for repair services and the role of manufacturers' repair services pricing policies. Combining the consumer-manufacturer interactions, it is possible to quantify the value leakage for both entities. In fact, we will show how repair policies can prevent losses caused by not repairing broken mobile phones.

The rest of this paper is organized as follows: the concept of value leakage is introduced in Section 2 and the related literature is discussed in Section 3. The research questions and methodology are explained in Section 4. An overview of the current flow of used mobile phones in the US is provided in Section 5 to better clarify the value leakage concept. In Section 6, the analytical modeling of value leakage is discussed in three steps; exploring consumers' post-purchase behaviors by surveying a group of mobile phone users, investigating manufacturers' post-sale services, and integrating consumers' willingness-to-pay for repair services and manufacturers' strategic behavior. Finally, Section 7 concludes the paper.

2. The concept of value leakage

There is no established definition for the value leakage in the literature. In this section, we introduce the overall concept of the value leakage as follow with the aim of providing a simple tool for evaluating the circularity level of materials contained in mobile phones:

> 'Any intentional or unintentional deviation from the best-known existing recovery method for an EoU/L product may result in a value leakage. The leakage might be found, either implicit or explicit, significant or inconsiderable, avoidable or unavoidable, in forms of economic loss, environmental degradation or social harm that would affect a wide variety of entities, ranging from consumers to national governments.'

The above-mentioned general definition can be tailored based on the scope of the current study as follow:

> 'The consumer decision not to repair a failed mobile phone may result in a value leakage. This leakage can be found in a form of economic loss that would affect both consumers and manufacturers as the primary stakeholders. The magnitude of value leakage is mainly linked to the time elapsed since the technology release date.'

According to this definition, we aim at showing the economic loss as a result of insufficient utilization of values still embedded in mobile phones (e.g., energy and materials). To produce a product, a remarkable amount of energy and resources are consumed during manufacturing operations. However, the values can easily be lost due to improper decisions of consumers and manufacturers on the early disposal of mobile phones. Recycling a reusable phone is a good example of energy and resource loss.

In this paper, a case study of cell-phone that requires screen repair is chosen to explain the concept of value leakage. The stakeholders considered in this paper are consumers and manufacturers, but the value leakage can be conceptualized for other stakeholders such as government, and society depending on their motivations and objectives.

Fig. 1 illustrates the impact of repair on extending the life span of a mobile phone and preventing the value leakage.

From a high-level perspective, the value may transfer from one economy system to another. For example, e-waste is exported from developed regions to developing regions. As a result, the economic values are lost in developed regions and gained by developing regions, while it leads to environmental issues for developing regions due to informal recycling.

The focus of this study is to evaluate the economic loss for consumers and manufacturers. However, in the context of environmental economics, there has been a wide range of studies that have been concerned with showing the economic impacts of environmental issues. To better conceptualize costs and benefits of a policy, strategy, or project, useful schema have been provided in the environmental economic field to evaluate the total impact on human well-being and ecosystems (Atkinson and Mourato, 2008; Pearce et al., 2006). This idea to conflate the economic and environmental values has also been a controversial topic between environmental economists and engineers.

The concept of value leakage can be of interest to manufacturers, not only due to its effect on building consumer loyalty, but also for improving corporate social and environmental responsibility (Cetindamar, 2007). Another motive for Original Equipment Manufacturers (OEMs) is to prevent the scarcity of materials in the future. Outside recovery or out-of-network 'leakage' is becoming a critical problem for developed regions and many OEMs who rely on certain types of rare earth materials for their production. The faster rise of natural resources prices compared to global economic output combined with less predictable commodity prices, and the fact that by 2030, some 3 billion consumers from the developing world will enter the middle class is driving corporate concerns about resource costs (Nguyen et al., 2014). However, due to the ex-ante nature of analyses, Söderholm and Tilton (2012) argued that the material scarcity cannot be a robust basis for designing material efficiency policies, and instead, environmental impact concerns have been suggested as a motive for making such intervention polices. In addition, societal norms and behavior should be addressed when forming environmental policies (Lane, 2014).

The value leakage in mobile phone recovery process may happen in various cases and in different life cycle stages. First, a significant number of EoU/L mobile phones are discarded in trash cans or stored in households for an uncertain amount of time (Silveira and Chang, 2010) due to the lack of consumers awareness about available reverse logistics channels(Yin et al., 2014). As a result, the disposal misbehavior and delay in returning EoU/L mobile phones for recovery operations may impose an additional cost on reverse logistics systems and, furthermore limit phones remanufacturability and the future marketability due to the technological obsolescence. Second, the product may leak from one economy to another. For example, consumers may receive repair services from a third party. This creates a cost or profit loss for the original manufacturer. In addition, the manufacturer may lose consumer loyalty and future purchase opportunities. Third, the net cost of purchasing new phones to have access to the same phone service and functionalities may be higher than the case of repairing them. In this case, individual consumers are bearing an additional cost. The value leakage may happen at the material recovery stage as well. For example, due to the complexity and mix of materials, the full recovery of all materials in the recycling processes is not possible. Finally, the value leakage of all life cycle stages is not just limited to the economic loss and can be extended to environmental damages and human health issues (Sullivan, 2006).

Capturing the total value leakage over the entire life span of a product is very difficult since a significant comparison between the current system and an ideal system is needed. In addition, it is challenging to define the ideal system or 'most-perfect action'. For example, the total amount of gold recovered from one metric ton of used mobile phones is about twenty times greater than that obtained from mining one metric ton of the ore. However, rigorous logistical efforts are needed to collect used mobile phones, while ore deposits are more accessible. Also, it is not certain that extracting metals from used mobile phones would be more eco-friendly than the other approach.