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Common charger in the European Union:

how unbundling and standardization can affect price comparison?

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Abstract

This master thesis studies how decoupling and USB-C's harmonization may discourage the price-comparison in the context of the common charger in the European Union. By the end of 2024, companies are expected to comply with (i) chargers' harmonization, which is supposed to solve interoperability problems leading to improvements in consumer convenience; (ii) the unbundling of chargers from electronic devices to reduce carbon emissions. However, there are concerns that buying consumers would do less price-comparison under unbundling. In addition, there have been alarming reports on an increasing number of hazardous chargers that could arise with the USB-C's harmonization. It could lead the consumer to examine more the charger's safe use than price-comparing. This thesis assess effects of limited attention on the shopping behavior with a model under unbundling, while another one assess the presence of hazardous products.

Keywords: Limited attention, unbundling, standardization, minimum quality requirements.

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Part I

Introduction

By the end of 2024, companies in the European Union (EU) will have to comply with new regulations arising from the policy on the common charger.[1] The European Commission (EC) seeks to harmonize chargers with the USB-C as a solely norm.[2] The policy also implies that chargers will be sold separately, leading consumers to buy it on the standalone market (European Parliament, 2022b).[3]

The EC aims to improve consumer convenience in such a way that it encourages re-use of chargers. Environmental stakes are also on the agenda with the goal of reducing e-waste in the EU by decreasing chargers' production. Studies commissioned by the EC suggested the revised 2014 Radio Equipment Directive (which covers the EU common charger) could significantly increase consumer convenience and be in line with environmental concerns (EPRS, 2023). However, there might be consequences on the consumer's shopping behavior following regulations. Some arguments from the literature show how consumers' limited attention may affect them in their purchasing decision (Heidhues et al., 2021; Johnen and Leung, 2022).

This leads to my research question: "*Common charger in the EU: how unbundling and standardization can affect price comparison*"? While previous assessments commissioned by the EU have been made to measure the policy's impacts, this work nuances effects this policy based on issues of unbundling and standardizing related to limited attention. My master thesis tackles effects on the consumer surplus from a tradeoff that they face between *browsing* and *studying* based on Heidhues et al. (2021). The thesis also discusses the pros and cons of this policy.

[1] (European Parliament, 2022b)

[2] The term *harmonization* (also called *standardization)* refers to the adoption of a single charger norm. It must be distinguished of *minimum quality standards* discussed later on.

[3] The directive covering the harmonization of chargers can be found at the following https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=CELEX:32022L2380

Issues on innovation and environment are mentioned as they constitute fundamental aspects. Policy's effects on innovation are ambiguous, as there is a fear of a lock-in situation, in which technologies become interdependent and slow down technological progress (Innocenti and Peitz, 2022).

The structure starts with Part II. The first section makes a broad screening of firms, consumers, and other main concerns in the market. The second section sheds more lights on policy objectives and raises some concerns on potentially harming effects through a literature review. Part III, the third section details the basic model with its main assumptions based on Heidhues et al. (2021), while the fourth section and the fifth section draw the main models for unbundling and safety issues respectively. Following with the sixth section that discusses models' predictions. This thesis concludes in Part IV. References can be found in the Bibliography. Models' proofs, figures and tables can be found in the Appendix.

Part II

Overview

1 Before the common charger

It is important to shed light on the context in which the policy takes place. Here the focus is given to the structure on the market for chargers prior to the regulations' implementations. It is dedicated to the discussion in the analysis part.

The purpose of this section is to understand the players that the market is made of and their bundling incentives before the common charger's regulations. But also to understand the impacts on consumers, environment and technology. It should contribute to the policy discussion of this thesis. The following sub-sections describe the market before the common charger's regulations.

1.1 Firms in the EU

1.1.1 Multi-product firms

The charger market is partly made of multi-product firms, that also sell different head electronic devices on other markets (e.g. phones, e-readers, tablets).[4] For example, names such as: Apple, Samsung, Huawei, Xiaomi, Nokia, are some of the phone companies with the highest market shares in Europe that sell their main products with a charger in the same box. Some of those phone companies differ in their charging norm (i.e., some phones are equipped of the USB-C, others of the micro-USB). The table 1 below lists the most important companies and their respective market share and shows how fragmented the market is.[5]

[4] Through this thesis, the term *head electronic device* is commonly used. It defines a main electronic product that needs to be recharged and is concerned by the regulation of 2024, such as: headphones, tablets, smartphones, ... These devices require a charger to be functional.

[5] Data from table 1 are from Ipsos and Trinomics (2019), figure 40.

Companies	**Market shares**
Samsung	36%
Apple	19%
Huawei	16%
Xiaomi	5%
Nokia	3%
LG	3%
Sony Ericsson	3%
Others	15%

Table 1: Market shares of phone sellers in the EU.

Source: Ipsos and Trinomics (2019).

A variety of charger norms coexisted in the market in 2000s until a memorandum of understanding (MoU) was agreed in 2009 between main producers of phones and the EC to reduce from 30 to 3 the number of end-device norms (European Commission, 2009; Ipsos and Trinomics, 2019). Most of the dominant companies have converged to the micro-USB prior to the USB-C. Apple was the only firm to remain on its own norm of charger, making the market partially compatible.[6] It is interesting to note how significant Apple is, from table 1. Approximately 20% of phones on the market need a Lightning charger. As a secondary resource, Ipsos and Trinomics (2019) observe significant decline in Micro-USB shares, while the USB-C progressively gains them.[7]

The MoU was a first step to improve consumer convenience by allowing some compatibility between chargers and devices of different brands (DIGITALEUROPE, 2018). Chargers may differ in terms of charging speed from one brand to another.[8]

[6] In other words, only devices equipped of Lightning norm (Apple) were compatible with Apple chargers. The latter are unable to recharge any head electronic device equipped of the USB-C norm.

[7] Refer to the figure 2 from Ipsos and Trinomics (2019)

[8] It is worth noting that chargers are made of 2 components: 1) an external power supply (EPS), which is the intermediary that is plugged on the sector; 2) a cable with an entry and an end plug (commonly USB-C nowadays). Through this thesis, a charger is considered to be made of these two components.

1.1.2 Bundling practices

Before companies were to comply with the common charger, multi-product firms were selling their head-electronic devices and chargers both in the same box (for example, Apple was selling its iPhone with its Lightning-norm charger). Most of the phones are sold with chargers in the same package, with the appropriate charging norm (Ipsos and Trinomics, 2019). Chargers can also be bought apart on the single market. There exists a standalone market for chargers, and according to Ipsos and Trinomics (2019), approximately 16.8% of chargers used by consumers are bought separately. From the same authors, consumers may buy on the standalone market to find a replacement, or to have multiple chargers dispatched in different location.

There is an existent literature on bundling practices. From Evans and Salinger (2005), bundling can help create efficiencies by making a package of products at lower cost.[9] Authors argue how bundling can also be convenient for consumers: while the demand for each single good is not high enough when sold separately, firms bundle to attract more demand from consumers that seek all goods from the same package. In other words, it is more convenient for consumers as they have lower transaction costs when buying a bundle. Firms may bundle in presence of a competitor to leverage market power by having a package made of products A and B rather than selling separately (Belleflamme and Peitz, 2015).[10] For example, Edelman (2015) reviews tying and bundling practices by Google: Google may bundle search engine with some services such as Google Finance, Google Maps, Google Flights to leverage market power from other websites proposing similar services.

[9] Authors led a cost-analysis on bundling and tying practices in an oligopolistic setting, and applied bundling and tying theories for a series of products such as electrical adapters, medicines, sedans cars.

[10] See p.436 from Belleflamme and Peitz (2015) where authors designed a 2-stage model in which a monopolistic firm uses bundling to lead rivals in exiting a market.

Other important works in the bundling literature are worth to be mentioned on the incentives for monopolists to apply bundling, mix-bundling, or unbundling (Adams and Yellen, 1976; McAfee et al., 1989).[11] Other studies argue how bundling is depriving the consumer surplus and is seen as a pricing strategy to reduce competition through limitation of entry (Nalebuff, 2004; Peitz, 2008).[12]

Firms have incentives in using bundling or mix-bundling strategies over unbundling (e.g. Adams and Yellen, 1976; McAfee et al., 1989; Peitz, 2008) and can reduce the consumer surplus. Interesting findings from Rennhoff and Serfes (2008) show how regulating by unbundling horizontally differentiated goods may lead to a decrease in prices and can benefit consumer welfare.[13]

1.2 Consumer concerns

Prior to the MoU in 2009, one of the main issues in the charger industry was the high number of charger norms, rising up to 30. The memorandum allowed some interoperability across devices by decreasing the number of norms to 3 (European Commission, 2021). The MoU was one of the first steps to assess consumers' concerns, with the goal to improve their convenience. However, some consumers are unsatisfied with the current situation regarding chargers' interoperability.

[11] Adams and Yellen (1976) examine strategies for a monopolist to extract full consumer surplus: the firm decides either to do pure-bundling (exclusive sales through bundles), or mix-bundling (practice of pure-bundling and unbundling at the same time), or unbundling. Mix-bundling dominates weakly pure-bundling. While McAfee et al. (1989) have similar results and goes further by assessing monopolist's strategies in settings where he monitors the consumer's purchase and another situation where he does not.

[12] The study from Nalebuff (2004) is focusing on bundles of perfect substitutes, and how it can be used as a strategy for incumbent to remain dominant. Similarly, Peitz (2008) highlights how bundling can be used as a pricing strategy by firms to blockade an entrant that offers differentiated products. He concludes that a monopoly delivering bundles significantly reduces the consumer welfare.

[13] Rennhoff and Serfes (2008) emphasis the bundling of channels in the television market in the US. Authors modelized a two-stage game based on Salop model, made of upstream firms (content providers) and downstream firms (operators), where the latter offer bundles of TV-channels to consumers that seek to subscribe. They study the firms' incentives to bundle.

It has been found that 41% of EU citizens consider themselves dissatisfied with the current charger offer situation, and 22% very dissatisfied.[14] Such high proportion of consumers being unsatisfied may give enough reasons to policy makers to look closer into the issue. Picturing consumers' preferences and impacts of bundling help to understand main consumer concerns and whether regulations improve consumer convenience. This work relies mainly on surveys from Ipsos and Trinomics (2019) and Risk & Policy Analyst (RPA, 2019) that have been conducted to draw main consumers' concerns.

Statistics from the RPA (2019) report how consumers want to receive their charging solution: around 76% prefer to get provided a charger with their phone. Interestingly, a small proportion of 2% does not want to receive any charging solution at all.[15] Findings from Ipsos and Trinomics (2019) find that 45% of respondents were willing to buy a phone without a charger while 40% would not. If companies were not providing any charger in the same box, respondents would buy the phone with a discount.

Regarding reasons to buy an additional charger, 48% of respondents from the RPA (2019) survey have bought an additional charger after the purchase of a bundle. Those that were purchasing additional charging solutions were likely to seek having multiple chargers in different location, or because their old one was not working anymore.[16] In other words, consumers were unlikely to buy a new charger due to interoperability problems. Survey from Ipsos and Trinomics (2019) finds that additional mobile chargers bought were likely to be unbranded or unknown brands. Only a tiny fraction of respondents picked the charger from the same brand of their phone. When consumers have a defective charger, some of them have a low propensity to spend a significant amount of time in finding a replacement.[17]

[14] These numbers are reported in the figure 33 from Ipsos and Trinomics (2019).
[15] Figure 6-1 from RPA (2019).
[16] Figure 6-3 from RPA (2019). See also Ipsos and Trinomics (2019).
[17] See figure 14 from Ipsos and Trinomics (2019)

From RPA (2019) and Ipsos and Trinomics (2019) when looking for a new charging solution, consumers mostly focus on criteria such as: price, charging performance and safe use. Other traits like design, weights, presence of the brand logo are less significant when purchasing a charger.

Overall, results from surveys give insights on how consumers value bundles. There is some heterogeneity in preferences, with some consumers giving higher value for a separate purchase, and some to buy their phone with a charger included in the same package. These surveys also give a perspective on their willingness to search for a new charger and what they would pay attention to if they had to buy one.

1.3 Environmental Impacts

On the environmental side, producing chargers and transporting them emits carbon emissions.[18] According to Ipsos and Trinomics (2019), once chargers are not used anymore, they are considered as e-waste. The same report finds that charging blocks (also called EPS) are the most important source of carbon emissions, while cables are relatively less endangering the environment.

With the MoU, the need for consumers to regularly switch from one charger to another decreased, as the number of sales on the standalone market fell between 6 to 21 million (RPA, 2014). These findings may suggest that the relative increase in interoperability allowed consumers to make re-use of the charger provided with their phones and did not have to make a new purchase of an additional charger. Approximately, the MoU saved up between 390 and 1330 tons of raw material.[19]

[18] From Ipsos and Trinomics (2019), see section 3.6.
[19] See Table 3-29 for full estimates from RPA (2014).

As mentioned, some consumers have bought an additional charging solution on the standalone market after a phone purchase.[20] Several reasons can be invoked, including: consumers habits to have multiple chargers at different locations, replacement of a non-working charger. Buying cheap chargers that are affordable for some people with a low life cycle is also a reason of additional purchase on the standalone market, as consumers buy low life-expectancy chargers, they may be more likely to buy more regularly (RPA, 2019). Consumers in the European Union have important environmental concerns.[21] Should chargers be decoupled from phones, consumers looking for a charging solution could have the issue of finding a sustainable charger in their research. It is in the interest of the EC to encourage re-use of chargers to limit environmental impacts.

1.4 Innovation side

Before the USB-C's harmonization, the market is partially compatible with two major norms coexisting: the USB-C (applied to most of phones with Android, and other operating systems, while it replaces the micro-USB), and the Lightning norm (Apple's proprietary norm applied on its devices).[22] It is suspected that some firms may have their own norms to differentiate from other brands on charging performance. Even though some chargers are of the same norms, they may have different charging speed from one brand to another (Ipsos and Trinomics, 2019). It allows for some innovation on charger norms. Over time, several norms have seen the light, and some others were replaced. According to the same report, the USB-C norm has prevailed on the micro-USB (the proportion of USB-C users increased from 2% in 2016 to nearly 30% in 2018 while USB micro-B users were decreasing).

[20] See figure 3-2 from RPA (2019).
[21] From Ipsos and Trinomics (2019), around 72% of EU citizens have environmental concerns.
[22] (e.g. Ipsos and Trinomics, 2019; RPA, 2019; RPA, 2014; Innocenti and Peitz, 2022)

2 Policy of the European Commission

2.1 Main goals

The EC submitted a proposal in 2021 on the common charger that consists in solving consumers' inconvenience regarding the lack of interoperability and reducing e-waste in the EU.[23] Approved by the European parliament (European Parliament, 2022b), this policy enforces companies to comply with standardization of chargers, which consists in the generalization of the USB-C norm for cables that are compatible with several small portable electronic devices, such as: phones, radio, headphones, tablets, (...) (European Parliament, 2022b).[24] It is also worth mentioning that the EC is preparing a new proposal for 2026 to expand their compliance list to other devices such as laptops and should bring better clarity on charging information labels.

It is expected that harmonization would help consumers to be independent from a single manufacturer. For example, consumers might not be able to use their Apple charger for Samsung products, unless they have the same norm. It suggests that future consumers from Apple would benefit from this policy, since they would be able to purchase new devices and make multiple use of their standardized charger for it. The EC expects this measure to decrease consumers' dependency on the norm of a single manufacturer (European Parliament, 2022b).

Furthermore, firms producing headline products such as phones, would have to unbundle their devices from chargers. This is expected to encourage the consumer in long-term re-use of their charger, and avoid accumulation of unused charging solutions (European Commission, 2021).

[23] (European Parliament, 2022b)

[24] See also the fact sheet from European Commission (2022) available at the following address: https://ec.europa.eu/docsroom/documents/50321

Ipsos and Trinomics (2019) discuss a large list of economic impacts on consumers, businesses, technology, investments.[25] Overall, this set of regulations would influence chargers' prices and reduce the variety in products for companies that would decide to stop selling in the EU afterwards (even though most of the manufacturers of phones already have the USB-C as a charging solution, while Apple decided to comply with this norm).[26] The press release from European Parliament (2022b), states that consumers would save up to 250 million euros from avoided additional purchases per year thanks to this policy.

Aside from the consumer's side, this policy aims to achieve environmental goals. As mentioned before, production of unused chargers generates around 11,000 to 13,000 tons of wastes per year (Ipsos and Trinomics, 2019). It is suggested that the set of regulations would reduce by 1,000 tons the amount of e-waste on a yearly basis.[27]

The predictions from Ipsos and Trinomics (2019) give credits to the policy makers considering all the gains in consumer convenience and environmental aspects. Nevertheless, there may be side effects of these regulations related to consumer convenience. It is further discussed through this work with a literature review in the next subsection, giving justification to the analysis in Part III of this thesis.

[25] See Ipsos and Trinomics (2019) in their section 5.4.

[26] Apple agreed to comply with the harmonization of chargers in the EU, see Kelly (2022) at the following address: https://www.forbes.com/sites/gordonkelly/2022/10/26/apple-iphone-usb-c-lighting-port-new-usb-c-iphone-15-pro-max-ultra/

[27] See the pdf document from footnote 24.

2.2 Could this policy be harmful? Literature review

It is the role of the EC to guarantee the competitiveness in the EU and to promote innovation while it improves consumer convenience in price, quality, and choices (Monti, 2000). This policy is effective if consumers are better off after the implementation of these regulations. Effects of a rise in firms' prices decrease the consumer surplus of a purchaser (Perloff, 2017). Should regulations achieve environmental goals by reducing e-waste quantity, it remains to be seen whether this policy would have positive effects on prices.

Firms may use bundling and mix-bundling to avoid competition and to raise prices (e.g. Adams and Yellen, 1976; McAfee et al., 1989; Nalebuff, 2004; Peitz, 2008) while unbundling could have pro-competitive effects benefiting consumers (Rennhoff and Serfes, 2008). However, should multi-producers of head electronic devices and chargers comply with regulations from the EC, it is ambiguous whether the consumer convenience is improved. Literature proved that consumers have limited attention (DellaVigna and Pollet, 2007; Malmendier and Lee, 2011), and could be affected in their decision making. Under unbundling, consumers would have to make more efforts in their search for a head electronic device (e.g. a phone, tablet, etc) and a charger in the single market — the latter are supposed to be complement goods since the head electronic device needs full battery to be functional (one cannot work without the other). There exist some consumers that have a small propensity to devote a considerable amount of time in the search of a charging solution (Ipsos and Trinomics, 2019). This could mean consumers exhibit search costs as they seek a charger and would only search for a limited number of items. Under unbundling, it is suspected that price-comparison would be harmed since consumers have to examine relatively more price tags while the bundle's price reflects the total price for two goods within the same package.

Some complex goods can exhibit add-on prices (Ellison, 2005).[28] Most common example of an add-on price would be the disposal of foods in the hotel room's fridge (which constitutes an extra-fee that is not clearly advertised). Contract insurance might exhibit hidden prices that can be more difficult to read. In the context of the regulation, a charger from the standalone market can be seen as a hidden price, as consumers seek to buy a phone. A consumer would have to search for a phone and a charger with search costs. Hidden prices can be more difficult to observe compared to headline prices. Other authors assume presence of add-on price such as Armstrong (2015). According to the latter, firms may have incentives to "confuse" consumers on the presentation of an offer with the additional price , so it becomes more difficult to price-compare.[29]

Heidhues et al. (2021) presents a novelty in the search literature with a tradeoff on how consumers strategically decide to devote their attention on products by either: (i) studying — consumers pay more attention to the specifics of a product but compare fewer price tags of headline products (i.e., look at the additional price); or (ii) browsing — they make more price comparison between a range of headline goods and look superficially at their specifics. This may suggest that anti-competitive effects arise when consumers study to discover the value of the additional price of a product. Similarly, Johnen and Leung (2022) study how sellers use consumers' limited attention to distract them by using product design, ads, information while reducing competition.

[28] The author assess the consequences of add-on prices on market outcomes. He considers vertical and horizontal differentiation for products while add-on prices can be a tool for price discrimination. Learning the add-on price is costly when it is hidden.

[29] The study from Armstrong (2015) relates to the effects of add-on prices in presence of savvy and non-savvy consumers in a market and how market outcomes are impacted by those consumers' types. As the share of savvy consumers increases, firms' profits fall which induce them to make the price information more difficult to read for consumers. They would expect to decrease the share of savvy consumers. Regarding add-on prices, few firms may decide to select quality as an additional price so only a little fraction of consumers is able to read it.

Some authors made contribution to this search literature, by assuming existence of search costs among consumers (e.g. Anderson and Renault, 1999; Varian, 1980).[30] While other works suggest that consumers may have convex search costs (Ellison and Wolitzky, 2012; Stiglitz, 1987).[31] Models from Heidhues et al. (2021) and Johnen and Leung (2022) capture consumers' limited attention through a tradeoff that consumers face between browsing versus studying, while assuming convex search costs.

Intuitively, unbundling could lead consumers to study and look at phones and chargers' prices instead of price-comparing different bundles with a single price for both products. This master thesis is based on the model of Heidhues et al. (2021), modeling how price comparison changes with the unbundling of chargers and head electronic devices — analyzing consumers' capacity to search with limited attention.[32] This work steers away from classical bundling literature, with a focus on consumers' limited attention to price-compare while focusing on the issue of unbundling chargers from head electronic devices. Furthermore, this framework deviates from the bundling literature by assuming that consumers do not have full information on products' prices that are sufficiently complex. It requires to devote some attention to understand the full price. As in Heidhues et al. (2021), this work assumes increasing marginal search costs and existence of the tradeoff between studying and browsing.

[30] Anderson and Renault (1999) study effects of product differentiation, the number of firms and search costs on prices. While, Varian (1980) assess price discrimination towards informed and uniformed consumers, where some consumers may exhibit search costs.

[31] Ellison and Wolitzky (2012) link concepts of convex search costs and obfuscation on how consumers are affected to learn about products prices. Stiglitz (1987) focuses on concave, linear and convex search costs and whether the increasing number of firms brings more competition.

[32] See the fourth section for the unbundling model of phones (as head electronic devices) and chargers.

This thesis also relates to issues of safety use on products, and analyses whether the consumer surplus is improved now that consumers have to seek for a charger by themselves while there may be counterfeit chargers on the market. The safety analysis is justified on the basis that chargers' standardization may raise the number of counterfeit products on the standalone market (CEN and CENELEC, 2022; Ipsos and Trinomics, 2019) since consumers may seek cheap chargers.[33] Among the problems that counterfeit chargers have, they can cause damages to consumers. There have been proven results that counterfeit chargers can have physical damaging effects from a report of Electrical Safety First (2018).[34] In some cases, a minimum quality standard (MQS) policy tends to improve products' quality on the market. Products become relatively more homogeneous which leave the consumer surplus better off with price competition in oligopoly from Ronnen (1991). According to the latter, low-quality firms have to raise their quality to reach minimum standards, while high-quality firms try to differentiate and raise their quality above the lower ones. It is showed later that MQS policy can greatly benefit consumers by allowing them to browse since it clears any fear of buying a damaged charger.[35] There are arguments in disfavor of standardizing since consumers may be worse off with choices taken away (Shapiro, 1983).[36] It is debated in the discussion section.

[33] See section 3.8 on illicit market from Ipsos and Trinomics (2019). CEN and CENELEC (2022) also argue that firms may produce more low-quality chargers at low prices.

[34] The report from Electrical Safety First (2018) is available at: https://www.electricalsafetyfirst.org.uk/media/1119/counterfeit-and-imitation-apple-chargers.pdf

[35] See section 5 for the model on safety issues of chargers.

[36] Shapiro (1983) showed that MQS can be ineffective in a setting with many entrants without any fixed costs. His basic model relies on heterogeneous consumers with different willingness to pay and different tastes. Consumers expect a certain quality level based on firms' reputation prior to the purchase and only discover the true quality of a product once they have bought the good. Products' quality is endogenous in his analysis.

There is a lot at stake regarding environmental and technological issues and the latter should not be undervalued. Authors on innovation raise important concerns that are worth to be investigated (i.e., keep incentives for innovation in fields such as wireless charging solution from Innocenti and Peitz (2022)). The reader should understand that the focus is given on consumers' shopping behavior with limited attention. Unbundling, standardization and safety concerns may have direct consequences on decision-making which give more sense to analyze through search angle. The literature provides a background for this framework to analyze how the common charger and its accompanying regulations affect price-comparison.

Part III

Analysis

3 Methodology

3.1 Main assumptions

Models of this thesis rely on assumptions from Heidhues et al. (2021), and from the search literature (e.g. Armstrong, 2015; Ellison and Wolitzky, 2012). The following defines the models' framework:

- *i. Consumer's search strategy is assumed to be endogenous.*
- *ii. Search costs are convex.*
- *iii. When consumers are indifferent between browsing and studying, they browse with positive probability.*
- *iv. Headline prices are more visible than additional prices.*

The first assumption (*i*) is in line with works from Heidhues et al. (2021) and Johnen and Leung (2022), where the consumer decides how to devote his attention by either studying or browsing. Second (*ii*) consumers are assumed to have increasing marginal search costs. It captures the disutility for consumers to search. Third (*iii*) rules-out the Diamond-Paradox (Diamond, 1971) to get rid of the equilibrium in which firms set the monopoly price and where consumers study. It implies that firms have the same pricing strategy. Finally, (*iv*) the additional price requires some attention to be read.

3.2 The basic setup

Models from sections 4 and 5 follow the basic setup described as follows with slight variations. Firms set their headline and additional prices. Then the consumer first, is allocated randomly to a headline product of firm i and sees its headline price. Second, he decides how to spend his attention by either studying the product to observe the additional price or browsing by looking at another headline price. Finally, he decides whether to purchase. For simplicity, the consumer is assumed to have one unit of attention. There is a tradeoff between browsing and studying, so that the consumer cannot at the same time observe the headline price, the additional price and the rival's headline price. Firms are trying to maximize their expected profits while consumers maximize their expected utility.

This tradeoff is applied to products' unbundling, and potential counterfeit chargers' raise.[37] The following sections 4 and 5 assess whether pro or anti-competitive effects arise. For each model I define the main parameters (i.e., headline prices, additional prices, consumers value for the headline product and additional price). Then, I draw the main assumptions by explaining the consumers' concerns. Finally, I state a proposition on Nash equilibriums' prices and how consumers who buy devote their attention for both in the unregulated and in the regulated market.[38] All these equilibriums exist. The models' expected outcomes are discussed in more detail in section 6.

[37] See section 4 and 5 for models on unbundling and safety issues respectively.
[38] Proofs of the propositions are available in the Appendix section A.

4 Unbundling model

4.1 Bundle of phones and chargers

In this setting, we are in a Bertrand competition in which there are $I = 2$ firms selling homogeneous products. Phones and chargers are sold in a single bundle priced T_i by firm i where bundles are perfect substitutes.[39] There is a mass of consumers equals to one that has a value V^P for phones and V^C for chargers, that is looking to buy one bundle at most. Each consumer is randomly assigned and either sees the total price of firm i or firm j. On one hand, consumers are said to be browsing when they spend their attention on the headline price of firm i and rival j. On the other hand, consumers are studying when they strictly pay attention to the headline price and additional price of firm i. Consumers decide whether to purchase or not.

Proposition 1. *In the pure strategy and symmetric Nash equilibrium, both firms charge a total price that is equal to the marginal cost $T_i^* = c$. Buying consumers end up purchasing at the marginal cost. This is the only symmetric equilibrium solution.*

In this equilibrium, firms are profit-maximizing, and both set the total price at the marginal cost. Consumers can check the total price of the rival firm, making any raise above T_i^* unprofitable. Any harm is limited by having a single market in which buying consumers can obtain a phone with a charger while they dedicate their unique attention on the total price of the rival. As consumers browse, firm i can charge a slightly lower price and attract consumers, thus the total price equals the marginal cost. This setting encourages consumers to make price comparison only between the price of the two bundles. Buying consumers purchase at the lowest price. In other words, bundling leads to more competition between firms.

[39] The phone is chosen as a head electronic device for simplicity to represent the tradeoff as it is one of the most common electronic devices.

4.2 Regulation by decoupling

With unbundling, such a setting could be imagined: phones and chargers are now sold separately, with a standalone market for each good. There are $I = 2$ firms, with i selling phones for the head price f_i, and chargers for the additional price a_i, chargers are perfect substitutes. There is a mass of consumers equals to one that has a value V^P for phones and V^C for chargers.

Each consumer is randomly assigned and either sees the price of the phone from firm i or firm j. Those who see the phone's price of firm i can choose to spend their one unit of attention either to check the price of the phone of rival j, or to study the product by looking at the charger's price a_i. Consumers eventually decide whether to purchase.

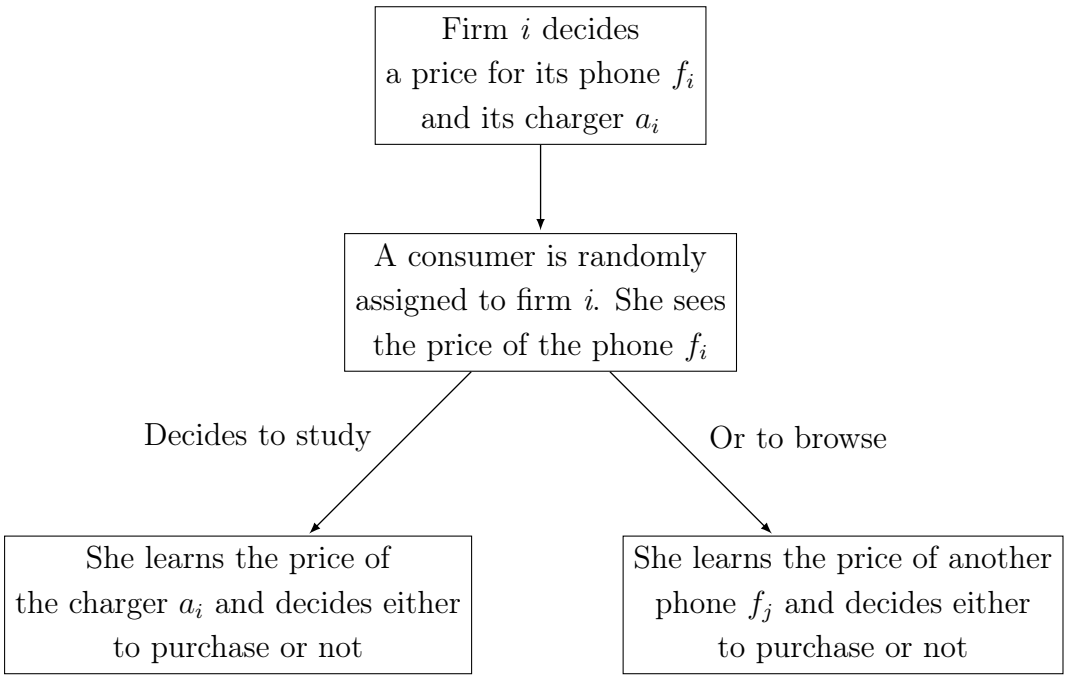

Figure 1: Timeline of the game under decoupling.

Proposition 2. *When products are unbundled, firms charge the monopoly price for chargers and phones in equilibrium with* $f_i^* = V^P$ *and* $a_i^* = V^C$*. Buying consumers end up purchasing the phone and the charger for the monopoly price. This is a unique-symmetric equilibrium solution.*

In equilibrium, buying consumers study by looking at the additional price. Regarding consumers assigned to firm i, looking at the headline price f_j does not bring any utility (i.e., it gives a value 0 since an extra phone without a charger is useless). Buying consumers end up paying the monopolistic price for both products. Regulating by unbundling could relax the competition between firms as this setting discourages price-comparison. By decoupling, this setting turns from two perfect competitors into two dominant firms acting as monopolists, resulting in a raise in phones and chargers' prices. There is a fear that unbundling may discourage consumers with limited attention to do less price comparison which may raise prices. The propositions 1 and 2 are further debated in the discussion.

5 Minimum quality standards

5.1 Presence of counterfeit products

There are concerns regarding a raise in sales of hazardous chargers in the market following the harmonization to the USB-C (Ipsos and Trinomics, 2019; Ipsos and Trinomics, 2021; CEN and CENELEC, 2022). Earlier, it has been discussed that some consumers may have concerns regarding the safety use of their charger (RPA, 2019). This model assess how this raise may impact the consumer's shopping behavior.

There are $I = 4$ firms. Among those there are 2 firms selling *brand quality* and the 2 others sell *counterfeit quality* chargers.[40] Both types of chargers use the same norm but differ in quality and are sold at price P_i . There is a mass of consumers equals to one, and each consumer is looking to buy one charger at most. Consumers are concerned about the safety use of their electronic devices. Consumers have a value $V^C > 0$ for *brand quality* charger's type, and they suffer a damage $d < 0$ for the *counterfeit quality* (d captures the disutility of electrical shocks caused by a counterfeit charger).

First, consumers are randomly assigned with equal probability either to a *brand quality* or a *counterfeit quality* firm (each one with a probability $\frac{2}{4}$) and see the price of their initially assigned firm. Second, consumers have one unit of attention, and can either decide to study the value of their charger (and observe whether they get V^C or d) or browse to check the headline price of another firm. Eventually, consumers decide to purchase the charger or not.

[40] Ipsos and Trinomics (2019) define counterfeit chargers as copies of certified chargers' producers in the EU that are likely to be of low quality and may exhibit safety issues.

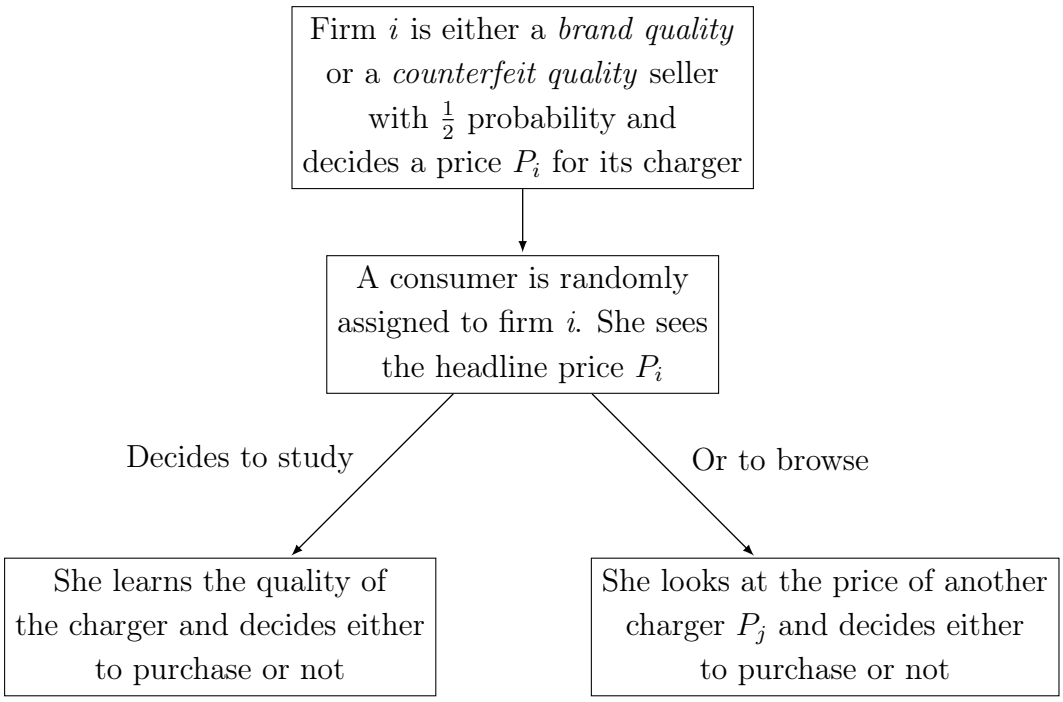

Figure 2: Timeline of the game under safety concerns.

Proposition 3. *In presence of counterfeit products in a market, buying consumers study and learn the quality to avoid the damage from a counterfeit quality charger. Firms charge in equilibrium* $P_i^* = V^C$. *Buying consumers are studying and pay the monopoly price for the brand quality charger. This is a unique-symmetric equilibrium solution.*

In such equilibrium, buying consumers spend their attention to study the product they were originally assigned to. Any harm can be described as such as electronic shocks, and consumers would be left worse off if they were buying it. Even though chargers look like perfect substitutes in appearance, some hide safety issues. Consumers study to discover the identity of their initially assigned charger. Firms take advantage that consumers can no longer compare prices, and do not have to undercut their price relative to their rival. Thus, firms act as monopolists and end up setting the monopoly price.

This proposition 3 captures the on-guard behavior of consumers due to the presence of hazardous chargers. This unregulated setting benefits firms selling *brand quality*, while *counterfeit quality* firms are unable to extract any rent from studying consumers. *Counterfeit quality* firms still sell at price V^C as buying consumers do not price compare. Those firms are unable to change their means of productions to provide higher quality products that do not give a damage $d < 0$ to consumers. *Counterfeit quality* firms can only decide on prices and put the monopolistic price to extract as much surplus as possible.

5.2 Setting a minimum standard

It is supposed now that a policy maker sets MQS for chargers. Due to the regulation, companies are required to meet the technological requirements to produce a charger, which excludes all firms that give a damage $d < 0$ to consumers.[41] Only the 2 firms selling *brand quality* chargers remain on the market. It is assumed that consumers are aware of this regulation that prevents them from any damage.

Proposition 4. *With MQS, only brand quality firms remain on the market, and encourages consumers to make price comparisons. Prices are equal to the marginal cost, such that* $P_i^* = c$. *This is a unique-symmetric equilibrium solution.*

In equilibrium from the proposition 4, there is a pro-competitive effect following the MQS policy, and all buying consumers are browsing and do not have to worry about safety issues. The regulation makes studying useless, and consumers spend their attention to look at the rival's price. This MQS policy enhances competition between firms, and erases concerns on safety use when making a purchase decision.

[41] It is assumed that companies producing *counterfeit quality* charger are not able to raise their technology and would leave the market. If they were able to do so, they would otherwise sell a higher quality product that does not give a damage d to consumers.

The market becomes a Bertrand competition and firms sell their chargers at marginal cost. There is more competition as companies try to attract more demand. Firms play strategically by undercutting the price of each other until they reach the marginal cost in equilibrium. In comparison to the setting in section 5.1, purchasing consumers are better off with the price decrease. Removing *counterfeit quality* does not restrict the choice for studying consumers, since they were not paying for a counterfeit charger anyway. Under the limited attention, this model encourages policy makers to create minimum requirements policy. Some arguments from the search and the MQS literature are given in the discussion.

6 In favor or against regulations? Discussion

The goal of this section is to interpret the models' results and relate to the literature. It discusses pros and cons of the policy both from the channel studied in this work and the classical literature with full information.

In summary, from section 4, buying consumers study when phones are unbundled from chargers. Regulation by unbundling could leave the consumer worse off as it discourages price-comparison. However, bundling encourages consumers to browse with homogeneous products. While from section 5, with damaging chargers in a market, buying consumers study as they are aware of safety issues and avoid hazardous products by learning the quality of the charger. By setting an MQS policy that removes firms producing counterfeit chargers — while consumers know about an MQS policy protecting them — buying consumers freely browse.

6.1 Interpretations, and related literature

6.1.1 To unbundle or not? : propositions 1 and 2

The duopoly model from section 4 predicts that equilibrium prices may raise with unbundling. In line with Peitz (2008) from the classical bundling literature, prices are determined endogenously. Unlike few works from the classical bundling literature (Rennhoff and Serfes, 2008; Belleflamme and Peitz, 2015), the bundling decision is given exogenously in section 4. In other words, firms have no other choice than bundling their products in proposition 1, and reversely to unbundle in proposition 2.

Other works from the bundling literature consider asymmetric firms such as sellers having monopolistic power in market A competing with an incumbent in market B and bundle products from A and B (Belleflamme and Peitz, 2015). Those firms have incentives to leverage market power, leading to firms' exit. Intuitively,

companies may bundle their chargers from phones to remain competitive with other rivals. It could be suggested that most multi-producers companies of phones keep selling chargers with phones to remain competitive with their rivals. Despite the MoU from 2009, bundle sales of chargers and phones remained persistent (Ipsos and Trinomics, 2019). Regulation through unbundling could reduce the number chargers sold and fulfill environmental goals from the EC.

As seen, unbundling homogeneous products may lead to increase in prices as buying consumers look at charger's price of firm i. In practice, chargers are differentiated before the common charger's policy takes place. If there are varieties of chargers in the market, consumers would not only have to learn about prices but may also learn their preferences for one charger over the other. Heidhues et al. (2019) obtain predictions for a model with a basic and a premium product.[42] The premium product can be understood as a combination of the basic product with an add-on that is costlier to produce. For example, the USB-C charger could be thought of as the basic good while the Lightning as a premium product.[43] Consumers may prefer the basic or the premium. In their setting, a consumer is assigned randomly to firm i and sees firm i's basic and premium's prices. Purchasing consumers study to learn whether they prefer the basic or the premium product and end up deciding whether to buy or not. By studying, those consumers do not have enough capacity to price-compare with the firm rival's basic and premium products. Purchasing consumers study and end up paying the monopoly price as firms behave as local monopolists. In other words, the latter may show that differentiated chargers damage consumers with raise in prices, as it makes price-comparison more difficult. Harmonizing the USB-C erases this differentiation by making chargers relatively more homogeneous.

[42] Refer to the proposition 10, Appendix C from Heidhues et al. (2019).

[43] This choice is justified on the fact that the Lightning charger has its exclusive Apple's design, is relatively lighter and has its own cable norm according to Ipsos and Trinomics (2021). From the same report, the Apple's charger is costlier to produce on average than the USB-C charger.

Although there are anti-competitive effects arising with homogeneous chargers' unbundling, USB-C's standardization may affect consumers' preferences since only one charger's type remains on the market. Intuitively, standardization may prevent a consumer to learn whether the charger matches his preferences and focus on price comparison. With the USB-C as the only norm remaining, consumers may not have to worry whether this would fit their phone for instance. It would encourage consumers to price-compare different chargers' prices on the standalone market. Standardization improves the consumer convenience by reducing the amount of information (Johnen and Leung, 2022). There are pro-competitive effects with standardization, making products look relatively more substitutable in the consumer's eyes. Intuitively, they cannot be distracted by the differentiated norms, as standards make interoperability possible with any other devices.

However, removing varieties takes choices away. There might exist some consumers having higher value for a Lightning norm rather than the USB-C. For instance, a consumer might prefer Apple's charger to recharge an iPhone equipped of the Lightning norm produced before harmonization. There are reasons to think that some consumers may be worse off after standardization, as there have been proven differences in weight, and materials between the USB-C and the Lightning's charger (Ipsos and Trinomics, 2019). From the classical MQS literature, Shapiro (1983) suggests losses for consumer when a fraction of consumers cannot purchase anymore their favored product or because remaining product's price has increased.

Moreover, the unbundling model considers phones as homogeneous products. In practice phones are likely to be differentiated. As discussed previously with the working paper from Heidhues et al. (2019), variety may lead consumers to study to learn about their matching value.

Some consumers prefer bundles combining chargers and phones together than single purchase for each good (RPA, 2019; Ipsos and Trinomics, 2019). The proposition 1 predicts that prices equal the marginal cost and improves consumer surplus. From classical theory with full information, bundling could be convenient for consumers seeking both products. As argued in the sub-section 1.1.2, bundles can create efficiencies for consumers (Evans and Salinger, 2005). Evans and Salinger (2008) account for convenience gains when consumers like two complementary goods sold together. Intuitively, there may be cost savings for firms by bundling phones and chargers under a unique packaging compared to single purchases.

In relation with chargers' harmonization, it is worth noting that innovation issues play an important role. Innocenti and Peitz (2022) call for caution that standardization could slow down the innovation curve, and that technologies could become strongly dependent of the USB-C. Among these issues, switching from partial compatibility to full compatibility setting could have reverse effects such as a raise in prices and is understood to leave consumers worse off (Innocenti and Menicucci, 2021).[44] Technological progress could be at risk with a common norm agreed, since it would be difficult to incentivize companies to innovate in more effective electrical norms (Innocenti and Peitz, 2022). Innocenti and Peitz (2022) state otherwise that the EU must count on non-EU countries that are not concerned by the regulation to make improvement in technologies. They argue on the uncertainty whether other industries outside of the EU would apply the same standardization. Authors end their note by suggesting that standardization could encourage firms by leading them into wireless technologies (which is not covered by the revised directive).

[44] Innocenti and Menicucci (2021) elaborate an oligopoly model and compare partial and full compatibility outcomes with multi-product firms. There is a concern that under full compatibility firms' prices would increase due to the incentives of sellers to raise their markups.

6.1.2 Safety threat: propositions 3 and 4

From proposition 3, expected outcomes result from buying consumers' awareness that seek to avoid hazardous chargers. Buying consumers are led to pay more attention to the charger's information and learn whether it is safe to use. It prevents them to freely check rivals' prices. Firms act as monopolists as buying consumers only see the headline price of their initially assigned firm. Those firms have no interest to cut their prices to attract more demand. Both sellers of *brand quality* and *counterfeit quality* set monopolistic prices in equilibrium in absence of any quality standard requirements. As for propositions 1 and 2, prices are endogenous as well in the model from section 5.

Even though the equilibrium in proposition 4 is a duopoly, it is more competition-enhancing compared to the setting in proposition 3. With the MQS, the market turns to a Bertrand competition. As long as the number of firms is strictly higher than one while some consumers devote attention to rival's price, then competition arises. Results of proposition 4 are surprising compared to other models with perfect information from classical Industrial Organization models. For example in the Salop model with homogenous products, equilibrium prices fall with the increasing number of firms (Salop, 1979). The last model is a spatial competition with locations of consumers on the circle. As the number of firms increases, firms' locations get closer to each other which lead the equilibrium price to fall down. More in line with the search thematic, in Stiglitz (1987), when consumers have convex search costs, a duopoly may be more competitive than competition with higher number of firms with higher prices.[45] Intuitively, it is easier to examine a change in price in a duopoly than in competition with a high number of firms. Expected outcomes of proposition 4 hold even for a number of firms $N>2$ under MQS.

[45] In Stiglitz (1987), if consumers exhibit convex search costs and the number of firms on the market tends to infinite, the market price may increase. He obtains a kinked demand curve for a competition model made of $N>2$. The equilibrium price is more difficult to determine as N increases.

With the right regulation, proposition 4 predicts how withdrawal of *counterfeit quality* sellers can lead to an increase in consumer surplus by allowing them to price-compare, and lead *brand quality* firms to mutually undercut their prices until they reach the marginal cost. If consumers are perfectly informed about the regulation, they freely browse. In fine, the consumer's belief on the additional price tends to 0 if he is aware of the regulation. Instituting an MQS policy that elevates the quality level in a market is assumed to improve safety use of a product.

In proposition 3, both *brand quality* and *counterfeit quality* sellers sell at the monopolistic price. In practice, hazardous products are likely to be priced lower compared to classical brands (Centre European Consumer, 2017). Those fake chargers try to attract consumers through low pricing (i.e., a low headline price and high add-on price). Heidhues et al. (2021) shows how regulations can prevent consumers to get hurt from the additional price. By regulating through a cap $\overline{a}$ on the additional price, while consumers assume that all firms may charge $\overline{a}$, may lead them to look at the lowest headline price f. As $\overline{a}$ decreases, it becomes more interesting to buy from firms where the additional price is unobserved, as consumers know they cannot endure an additional price above $\overline{a}$. Consumers are assured any harm is limited and freely browse by devoting their attention on f.

The setting from propositions 3 and 4 argue differently from the current literature on MQS. In fact, quality is exogenous in this model, and pro-competitive effects arise depending on how consumers devote their limited attention. Ronnen (1991) shows from a different angle how an MQS policy could increase the competition and lead to safety improvement. He shows that under MQS, firms choose strategically their qualities to differentiate from each other. Low-quality firms raise their quality to comply with the MQS, while high-quality firms try to raise their quality as well. It becomes harder for those firms to differentiate themselves from their rivals. Pro-competitive effects arise because products become relatively more perfect substitutes, benefiting consumers with lower prices.

Other authors from the classical MQS literature are skeptical in the way an MQS is consumer welfare improving. As discussed previously, consumers' welfare may be impacted with a reduction in variety as some consumers would not purchase a product from some firms anymore with an MQS. Furthermore, Shapiro (1983) suggests that no MQS policy is necessary when consumers have full information on products' quality. He follows that if qualities cannot be observed prior to purchase, then an MQS can indeed protect the consumers, as they are not "surprised" by the product's quality after the purchase.[46] In line with this interpretation, the appropriate regulation can play in favor of consumers to price-compare if they are aware of this regulation. Any charger bought in the market would not go under their expectations with the MQS policy.

Proposition 4 shows how strict regulations on chargers can encourage price-comparison. In practice, there exist safety certifications on non-food products in the EU with the "CE" marking (European Commission, n.d.).[47] While these kind of markings are simple and visible, firms are able to replicate them on their fake products (Electrical Safety First, 2018). It still requires consumers to study the authenticity of such markings, which does not lead to price-comparison. According to Heidhues et al. (2021), they argue that disclosed information on a product still needs to be read by dedicating some attention. While the setting from proposition 4 is extreme, it shows how consumers spare their attention to browse.

[46] Consumers are "surprised" in the sense they were expecting a higher product's quality after buying it. This quality could not be observed prior to the purchase, and they relied on firm's reputation to make their own expectations of the product (Shapiro, 1983).

[47] The « REGULATION (EC) No 765/2008 » covers safety marking "Conformité Européenne" (CE) in the EU.

6.2 Concluding remarks

The models from section 4 and 5 have limitations. However, equilibrium exist and are robust and bring insights on the effects of the shopping behavior. The models rely on several assumptions.

Relying on the literature, some authors assume existence of convex search costs for consumers (e.g. Ellison and Wolitzky, 2012; Armstrong, 2015; Heidhues et al., 2021; Johnen and Leung, 2022). The convex search cost assumption may be plausible. As discussed in section 2.2, some consumers have reluctance to look for a replacement charger when their initial charging solution is damaged (Ipsos and Trinomics, 2019). It can be criticized whether consumers have the same search disutility if they were not having an initial charger even damaged.[48]

From the propositions, consumers face a study vs. browsing tradeoff. Surveys investigated could not bring clear evidence of this mechanism in the context of chargers. But as supposed by Heidhues et al. (2021), this tradeoff is assumed to arise when consumers face convex search cost with complex products.

[48] Refer to the figure 14 from Ipsos and Trinomics (2019). A damaged charger in that context does not necessarily mean it is not working anymore, but rather less effectively over time. It is wondering whether consumers may be more willing to search for a new charger type if they did not have one initially (e.g., an Apple buyer used to the Lightning norm would need a USB-C charger to recharge future iPhones with harmonization, which he did not have beforehand).

Part IV

Conclusion

This master thesis digs into the problem of price-comparison under unbundling and safety issues as companies comply with the common charger's harmonization. It raises concerns on how unbundling, harmonization could affect the consumer at price-comparing. A broad literature review is led to understand the previous contributions on unbundling, limited attention, search, standardization. The thesis focuses on an innovative tradeoff from Heidhues et al. (2021) that consumers are supposed to face, as there are convex search costs.

The models rely on a tradeoff in which consumers choose between browsing multiple headline prices or studying a product's additional price. With homogeneous products, unbundling could leave consumers worse off compared to bundling, by discouraging them from price-comparison. Serious concerns about a raise of counterfeit chargers in the EU can damage consumers by leading them to study products. Overall, equilibrium prices tend to increase when consumers have the tendency to study than to browse. Even though the models' settings have limitations, these expected outcomes can be interesting for policy making, as they further explore the price-comparison problem with limited attention. Surveys from previous studies have been used to draw consumer preferences, habits and explore the models assumptions' validity (e.g. Ipsos and Trinomics, 2019; Ipsos and Trinomics, 2021; RPA, 2019; RPA, 2014).

Some fundamental aspects are briefly discussed such as environmental issues, that benefit from this policy (Ipsos and Trinomics, 2019). Regarding innovation, some authors discuss their concerns on whether this policy is slowing down the research curve by disincentivizing firms to explore new more effective norms (Innocenti and Menicucci, 2021; Innocenti and Peitz, 2022). It deserves further attention as there may be an increase in equilibrium prices due to standardization.

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Appendix A

Proofs

Proposition 1. *In the pure strategy and symmetric Nash Equilibrium, both firms charge a total price that is equal to the marginal cost $T_i^* = c$. Buying consumers end up purchasing at the marginal cost. This is the only symmetric equilibrium solution.*

Proof of proposition 1. *Suppose otherwise that firm i raises the price greater than the marginal cost. But since consumers are browsing with positive probability and can check the total price of other firms, firm j might attract the consumers if its price is slightly lower. Firm i loses its demand and makes zero profit. Thus, firm i has no incentive to deviate its price from the marginal cost. Reversely, if firm i were to sell below marginal cost it would not be profit-maximizing. Thus, $T_i^* = c$ is the only symmetric equilibrium solution.*

Proposition 2. *When products are unbundled, firms charge the monopoly price for chargers and phones in equilibrium with $f_i^* = V^P$ and $a_i^* = V^C$. Buying consumers end up purchasing the phone and the charger for the monopoly price. This is a unique-symmetric equilibrium solution.*

Proof of proposition 2. *Let's suppose otherwise that firm i decides to price its phone below the monopolistic price, with $f_i < f_i^* = f_j^*$ in order to attract a higher demand for its phones. But since consumers who browse do not buy (i.e., an additional phone without a charger gives 0 value for consumers), firm i does not increase its demand. Buying consumers would not browse for phones from other firms and stick to the price of the phone they were originally assigned to. Regarding chargers, if firm i decides to deviate by doing $a_i < a_i^*$, profit of firm i would decrease since buying consumers are studying to look at the price of the charger of i, and cannot price-compare with firm j 's charger. Reversely, if firm i decides to price*

its charger and phone such as: $a_i > a_i^*$ or $f_i > f_i^*$, it may exceed the consumer's willingness to pay and the latter would not buy. Thus, firm i does not deviate from $V^C = a_i^*$ or $V^P = f_i^*$.

Proposition 3. *In presence of counterfeit products in a market, buying consumers study and learn the quality to avoid the damage from a counterfeit quality charger. Firms charge in equilibrium $P_i^* = V^C$. Buying consumers are studying and pay the monopoly price for the brand quality charger. This is a unique-symmetric equilibrium solution.*

Proof of proposition 3. *In the proposition 3, firms charge $P_i^* = V^C$ in equilibrium. Suppose otherwise that firms decide to charge $P_i > P_i^*$, consumers would not buy the charger since it is above their willingness to pay. Similarly, it would be unprofitable for firms to charge below the equilibrium price to undercut their rivals $P_i < P_i^* = P_j^*$, since buying consumers do not make price comparison and spend their attention to study in order to not suffer from the counterfeit quality. Firms do not increase their demand through undercutting. Thus, firms do not deviate from the equilibrium $P_i^* = V^C$.*

Proposition 4. *With MQS, only brand quality firms remain on the market, and allows consumers to make price comparison. The price is equal to the marginal cost, such as $P_i^* = c$. This is a unique-symmetric equilibrium solution.*

Proof of proposition 4. *In this proposition, firms charge $P_i^* = c$ and buying consumers are browsing. If we suppose otherwise that now firm i charges $P_i < P_i^*$, to attract more demand, the company would sell under the marginal cost and would not be profit-maximizing. If firm i sells $P_i > P_i*$ would find it unprofitable since consumers would see the rival's price as a better deal, and attract the whole demand, as consumers are able to observe the rival's price. Thus, buying consumers are browsing and pay the price $P_i^* = c$.*

Appendix B

Figures

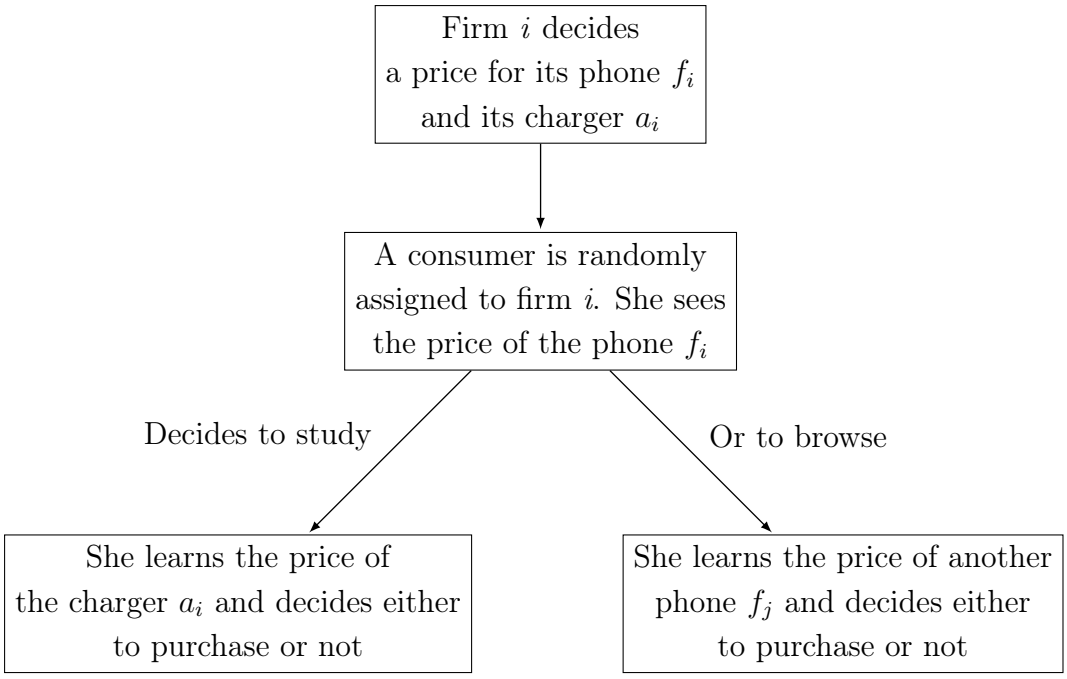

Figure 1: Timeline of the game under decoupling.

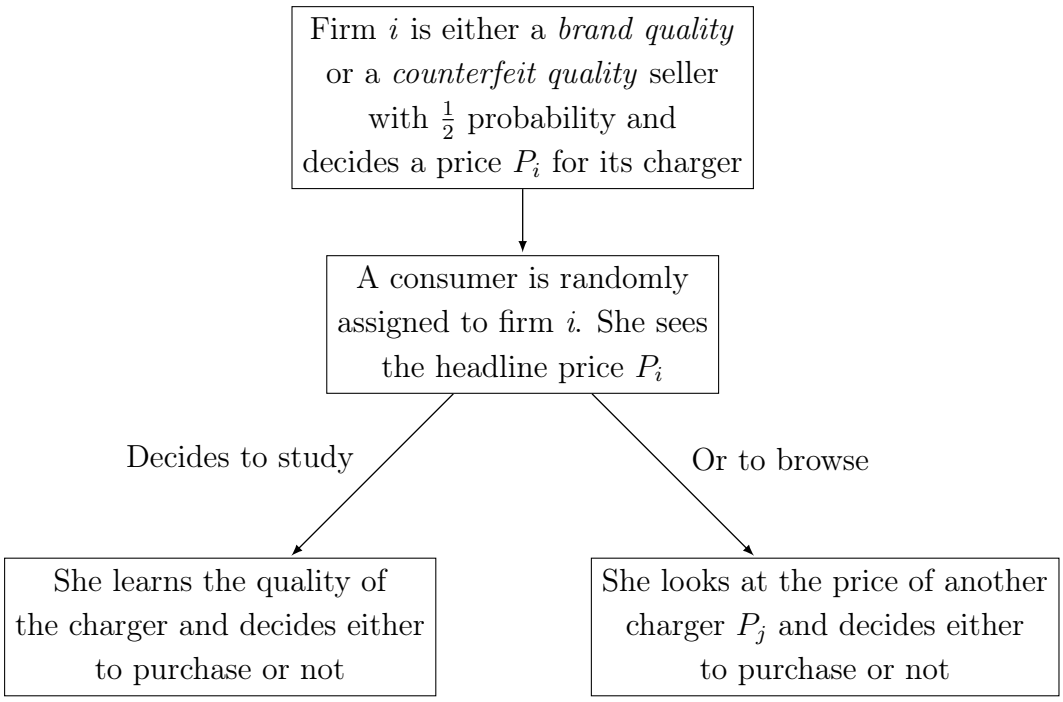

Figure 2: Timeline of the game under safety concerns.

Appendix C

Tables

Company	**Market share**
Samsung	36%
Apple	19%
Huawei	16%
Xiaomi	5%
Nokia	3%
LG	3%
Sony Ericsson	3%
Others	15%

Table 1: Market shares of phone sellers in the EU.

Source: Ipsos and Trinomics (2019).