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I. The New EU Directive and Its History

A common charger for smartphones has been on the agenda of the European Commission (in the following, EC) since the early 2000s. In 2009, Günther Verheugen, then Vice President of the EC, was pleased with the memorandum of understanding of the adoption of Micro-USB for smartphones:

> *"I am very pleased that industry has found an agreement, which will make life much simpler for consumers. They will be able to charge mobile phones anywhere from the new common charger. This also means considerably less electronic waste, because people will no longer have to throw away chargers when buying new phones. I am also very pleased that this solution was found on the basis of self-regulation. As a result, the Commission does not consider it necessary to introduce legislation."*[2]

In the aftermath of this agreement the number of incompatible chargers in the market has come down from 30 to 3. In other words, an important part of the industry honored the agreement to converge to a common standard. However, the convergence to a common charger is still incomplete: Apple uses its proprietary charging technology (the so-called Lightning), whereas everybody else in the smartphone industry converged to Micro-USB and later USB-C. The remaining incompatibility could suggest the existence of fundamental differences in firms' incentives. Based on the impact assessment study on unbundling of access chargers, the EC acknowledges:[3]

> *"[...] those manufacturers that have invested heavily in proprietary charging technology appear less keen, since the high charging performance of their bundled phones and EPS is an important part of their marketing strategy."*

Frustrated by the incomplete transition of the industry to a common standard, the EC decided to intervene. On 23 September 2021, it advanced a legislative proposal to effectively mandate USB-C as the standard technology for charging smartphones and other types of electronic devices.[4] According to the EC, the new directive will help to reduce electronic waste and will also benefit consumers and firms. If implemented, this proposal would force Apple, which is one of the major producers of electronic devices, to adjust its technology to make its devices sold in the EU compatible with USB-C. The USB-C technology instead is already used by Apple's competitors. Currently, iPhone users must use a battery charger supplied or licensed by Apple to charge their smartphone, whereas a smartphone produced by any competitor can be charged using any USB-C battery charger (subject to some specifications). In other words, the market features a regime of "partial compatibility" according to which some but not all companies use the same charging technology. Instead, the new directive proposed by the EC, once implemented, will make any battery charger compatible with any smartphone (as well as other electronic devices such as tablets, handheld videogame consoles, and, at a later point in time, laptops). Thus, it will induce a regime of "full compatibility" according to which all companies use the same charging technology. On 7 June 2022, Council and Parliament reached a provisional agreement;

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[2] European Commission, "Commission welcomes industry's commitment to provide a common charger for mobile phones," press release IP/09/1049, 29 June 2009.

[3] This is part of the "explanatory memorandum" attached to the EC's proposal.

[4] European Commission, Proposal for a Directive of the European Parliament and of the Council amending Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment, COM(2021) 547 final, 23 September 2021.

the formal approval is expected shortly after the summer break.[5]

II. The Beauty of a Common Charger

In response to the global climate change crisis, the EC has recently presented the European Green Deal as "a roadmap for making the EU's economy sustainable by turning climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all."[6]

The introduction of a common charger fits into the broader strategy by the EC to make the European economy more sustainable. In particular, the implementation of the new directive will allow to reduce electronic waste in the EU, which is estimated to be approximately 11,000 tons annually, according to the EC.

Additionally, the EC argues that its proposal will have a positive impact on consumers. In particular, it will facilitate consumers' everyday life. For instance, consumers will no longer need to carry a different charger for any device, as a USB-C charger will be enough for all. Similarly, they may borrow a charger from a friend in case they do not carry their own charger. Moreover, when replacing a device, they could keep using the same charger. This increased flexibility applies both to different devices supplied by the same manufacturer and across manufacturers. What is more, consumers will face lower prices, according to the EC.

At a first glance, the idea of mandating a common charger seems an unambiguous improvement for consumers and society. Important benefits are a higher convenience in charging mobile electronic devices and a reduction in environmental impact. All the burden seems to be left to the tech firms that are selling devices not compatible with the standard technology. In the following, we argue that this proposal may have more complex and unforeseen implications.

III. Fly in the Ointment

Economists and, in particular, industrial organization economists are often good at finding a fly in the ointment – this also applies to mandated full compatibility, which is the essence of the new directive.[7]

We first argue that the regulation will not necessarily imply lower prices for consumers. In the impact assessment of the proposed regulation, it is claimed that mandating USB-C as the standard charging technology will reduce prices.[8] The reasoning behind the EC's claim can be summarized as follows. Products using proprietary technologies have higher retail prices than those using USB-C technology. Therefore, by mandating the USB-C technology as the standard, prices for consumers should be lower.[9]

Recent advances in the economics literature (Innocenti and Menicucci, 2021; Shuai et al., 2022) have considered a market that can feature a regime of partial compatibility. These papers show that partial compatibility can be the unregulated market outcome when firms stand for different quality: the firm with higher quality may have the incentive to offer products incompatible with those of the rivals. In the market for mobile electronic devices, Apple may be seen as the higher-quality firm. Apple's quality advantage can have multiple origins: for instance, higher intrinsic value or a brand effect. Independently of the origin, if the higher-quality firm's advantage is sufficiently strong, the

[5] European Parliament, "Deal on common charger: reducing hassle for consumers and curbing e-waste," press release 20220603IPR32196, 7 June 2022.

[6] European Commission, "The European Green Deal sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind", press release IP/19/6691, 11 December 2019.

[7] For a textbook treatment of models around compatibility, see Belleflamme and Peitz (2015, chapter 21).

[8] Such an assumption contrasts with the survey evidence by the same study, inquiring firms about the expected market reaction to the policy. We refer to the "impact assessment report" accompanying the EC's proposal.

[9] The report by the EC mentions a reduction in marginal costs as a side explanation for lower prices. Whereas this could be a more credible reason to expect lower retail prices, the policy should induce a strong reduction in marginal costs to have a noticeable effect. It seems to us a bit far-fetched to believe that mandating USB-C as the common standard is sufficient to induce such a meaningful shift in the production function. However, competition effects may be more important since a common standard may encourage third-party entry in the market for chargers.

market features partial compatibility. Indeed, Apple is the firm using proprietary technology for charging its devices.

Following Innocenti and Menicucci (2021) and Shuai et al. (2022), in the status quo of partial compatibility, the proposed policy of mandating full compatibility could lead to higher prices and, thus, harm consumers. Contrary to the common intuition, consumers ultimately do not benefit from the ability to "mix and match" more products. The counter-intuitive result that full compatibility harms consumers follows from the finding that competition is less intense and leads to higher prices under full compared to partial compatibility. Put differently, in a regime of partial compatibility, the firm offering incompatible products (i.e., the firm with higher quality) has a more elastic demand than the rivals. This triggers lower prices (by all firms) than under full compatibility.[10] Based on the oligopoly model of Innocenti and Menicucci (2021), mandating full compatibility would induce the higher-quality firm to increase its mark-up and its competitors would increase their mark-ups as well. As a result, consumers would be worse off.[11]

The risk of higher prices arguably is of second-order importance in the context of chargers since these usually have relatively low prices and, with full compatibility, Apple will have to give up on its licensing revenues from its Lightning technology. However, mandating a standard technology could have more serious long-run effects on the incentive to develop new and potentially superior charging technologies.

The directive is not fully static: it allows for the possibility of revising the standard after a superior technology has been developed. However, it may become harder to move to a new standard than agreeing on the current standard. Indeed, the choice of USB-C as common charging technology happens after most manufacturers have adopted it in the aftermath of the agreement reached in 2019. In the future, it may be harder to assess which technology, among the ones available at a certain point in time, should be made the next standard. More importantly, the introduction of the standard may change the entire dynamics for the development of new technologies. Does it?

Since the regulation applies only to the EU and not to other countries, one possibility is that little would change globally and there would be a lot of experimentation of new technologies in countries outside the EU. Then, the EU could free-ride on those experimentation efforts and evaluate as new standard the technologies that have been developed elsewhere. For such experimentation to take place, other countries must not follow the EU's lead and companies must see benefits from experimentation outside the EU.

EU regulation may, however, spill over into other countries. Using Bradford (2020)'s terminology, if the Brussels effect is present, tech firms will design their products complying with EU regulation even when selling elsewhere. Bradford distinguishes the *de jure* from the *de facto* Brussels effect. According to the former, countries outside the EU mimic the legislation introduced by the European Union.[12] According to the latter, even in the absence of regulation in other countries that imitate EU regulation, firms decide to comply with the EU standard worldwide in particular because of scale economies. Either way, the Brussels effect could reduce and, in the extreme, eliminate experimentation.

If the Brussels effect is present, the directive is likely to harm innovation incentives because firms cannot gain a (possibly temporary) advantage over competitors not just in the EU but also elsewhere. In the case of the charging technology, a Brussels effect is not far-fetched. Already in 2009, Commissioner Verheugen got

[10] It is worth mentioning that the same mechanism does not work when moving from partial compatibility to a regime of "full incompatibility" (i.e., any firm uses a different proprietary technology): consumers suffer from the inability to "mix and match" without a beneficial price adjustment.

[11] Allowing for entry of third-party suppliers of battery chargers, the negative effect of endogenous pricing on consumers welfare becomes less pronounced, but it could still be present (Shuai, Yang, and Zhang, 2022).

[12] Currently it is unclear how this will play out internationally. It has been reported that the UK will not follow the EU's lead, which goes against the de jure Brussels effect. See e.g. Tom Gerken, "UK will not copy EU demand for common charging cable," BBC News, 8 June 2022.

coverage in Australia with his statement: "We are assuming that this new European standard will have a knock-on effect globally and that manufacturers won't be just doing this on the European market, but will be doing this in other markets."[13] Once the new directive is in place, incentives are stronger to implement the European standard elsewhere.

Even though the EC commits to the possibility of changing such a standard as new technologies are developed, the length of the regulatory process and the uncertainty associated with it would imply that it will take longer for a superior technology to be adopted. What is more, if the Brussels effect is present regulation in the EU could undermine firms' incentives to innovate elsewhere since the EU market is – at least for some time – closed to the new technology. A firm willing to develop a more efficient charging technology would not be able to bring it on the EU market unless its technology is compatible with the standard or recognized as an important improvement by the authority, thus becoming the new standard. This takes time (if at all successful) and ultimately may be too costly, in particular, for a financially constrained small firm. While established firms may have the financial resources and the political connections to push for the new standard, it is unclear whether they have the incentive to engage in such investment activities under full compatibility. In this context it would be interesting to know the answer to the following counterfactual: suppose that the EU had mandated Micro-USB in or shortly after 2009. Would we now have USB-C as the mandated standard, or would we be stuck with Micro-USB? A possible response to the EU regulation is a concerted industry effort developing a superior technology and pushing to adopt it as the new standard. However, it is questionable that such collective action would lead to the same innovation dynamic as private actions in a less regulation world. Thus, long-term negative effects on innovative activities are likely if there is still scope for meaningful improvements on USB-C and if innovation incentives outside the EU are muted.

IV. A Less Heavy-handed Regulation

Mandating USB-C as the standard technology for charging mobile electronic devices is thought to lead to lower prices, be beneficial to consumers, and have clear environmental benefits.[14] We have argued that the most serious concern is the risk of lock-in into a charging technology. How could this concern be addressed?

To reduce the risk of a negative effect on innovation, exemptions and experimentation clauses could be introduced in the regulation. This would allow firms with a (in at least some dimension) superior technology not to be forced to adopt USB-C and thus make the current regulation less heavy-handed. This would not be a free pass to Apple and others who would like to use a different (and, most likely, proprietary) technology, as they would have to demonstrate that their technology offers consumer benefits compared to the European standard.

The first test for the common charger legislation will be the wireless charging technology whose development is ongoing and acknowledged in the directive. Therefore, the new directive may have the side-effect that some firms will focus on proprietary wireless technology to bypass the new regulation. This may then lead to more innovation in this alternative technology. For several years, Apple and others have filed patents related to wireless charging and some firms may be tempted to introduce devices that only allow for wireless charging.

Wireless charging may then be the next target for regulation. As stated by the European Parliament:[15]

[13] The Sydney Morning Herald, "Europe to get standard mobile phone charger," 30 June 2009.

[14] The EC focuses on the reduction of electronic waste when claiming a positive environmental effect. However, this policy could have another long-run environmental effect which is connected to innovation. Future technologies may allow to charge devices with a lower marginal consumption of electricity. Therefore, more efficient technologies can reduce the environmental impact of charging. By creating a barrier to innovation, the common charger may have a negative long-run effect on the environment.

[15] European Parliament, "Deal on common charger: reducing hassle for consumers and curbing e-waste," press release 20220603IPR32196, 7 June 2022.

"As wireless charging technology becomes more prevalent, the European Commission will be empowered to develop so-called delegated acts, on the interoperability of charging solutions."

As readers can glean from the above quote, more regulation is likely looming, and it will be interesting to observe future developments in charging technologies. Our key message continues to apply to the regulation of wireless charging: While a common technology would benefit consumers in the short term, the search for the next, improved technology may require the need for exemptions and experimentation clauses. It also requires the willingness and ability to examine a change of standard within a reasonable time frame.

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